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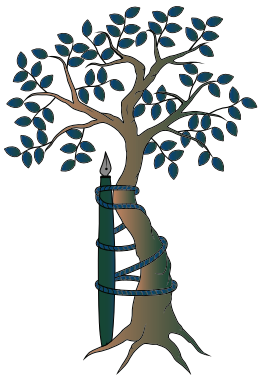

The Philippine Journal of Orthopaedics

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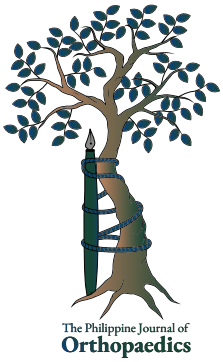

ABOUT THE LOGO: THE TREE OF ANDRY

Nicholas Andry coined the French term “orthopédie” which is derived from the Greek words “orthos” (correct or straight) and “paidion” (child). As implied in its etymology, “orthopédie” was first practiced treating childhood spinal and bone deformities.

The main elements of the logo are the tree of Andry; the Philippine Journal of Orthopaedics wordmark; and the fountain pen. The fountain pen, in replacement of the stake, represents how research has been the backbone of orthopaedic learning and practice.

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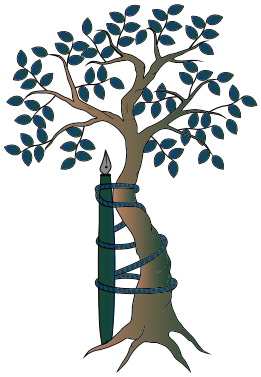

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The **Philippine Journal of Orthopaedics** shall advance the art and science of orthopaedics in the country by publishing high quality original clinical investigations, epidemiological studies, case reports, review articles, evaluations of diagnostic and surgical techniques, and the latest updates on management guidelines. The journal's target audience are local and international practitioners, clinicians, and other scientists, researchers. It shall accept manuscript submissions from consultants, fellows, residents, and other allied medical professions and specialties, not only from the Philippines but also from Asia and the rest of the world as long as these are within scope and relevant to the practice. Non-members of the Association may submit scientific manuscripts to the journal.

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As President of the **Philippine Orthopaedic Association (POA)**, it is with great pride and enthusiasm that I welcome you to the first issue of the **Philippine Journal of Orthopaedics** for 2026.

This marks another milestone in our shared commitment to advancing the art and science of orthopaedic surgery in the Philippines. As the official publication of the POA, the Journal serves as a vital platform for Filipino orthopaedic surgeons, researchers, residents, and allied specialists to share original research, clinical experiences, case studies, and innovations that address the unique musculoskeletal challenges faced by our patients—from trauma and degenerative conditions to pediatric and oncologic orthopedics.

In this era of rapid advancements in surgical techniques, biomaterials, rehabilitation, and evidence-based practice, the Philippine Journal of Orthopaedics stands as an open-access, peer-reviewed resource dedicated to elevating the quality of care nationwide. I encourage our members and the wider orthopaedic community to continue submitting high-quality manuscripts and engaging actively with the content published here.

To our readers, contributors, reviewers, and editorial team—thank you for your dedication and support. Together, let us strive to make this Journal a beacon of excellence that strengthens orthopaedic practice, fosters collaboration, and ultimately improves patient outcomes across the archipelago.

Mabuhay ang Philippine Orthopaedic Association! *Mabuhay ang* Philippine Journal of Orthopaedics!

Marcelino T. Cadag, MD, FPOA
President, Philippine Orthopaedic Association, Inc.

The Philippine Journal of Orthopaedics

Publishing for Practice: Local Evidence and Patient Voices in Philippine Orthopaedics

Medical practice in the last few decades has increasingly moved toward evidence-based care. However, evidence is only as relevant as the context in which it is generated.[1] Much of current orthopedic literature originates from healthcare systems and patient populations different from those encountered in the Philippines.[2] For Filipino clinicians, locally produced research ensures that clinical decisions align with the realities of our patients, disease patterns, and healthcare environment.

I was fortunate to learn this important lesson directly from the late Dr. Antonio Montalban, the first Editor-in-Chief of the Philippine Journal of Orthopaedics and a pioneer of orthopedic research in the country. Dr. Montalban emphasized that advancing orthopedic care in the Philippines requires the systematic documentation and sharing of our own clinical experience. At a time when access to international publications was limited, he recognized the need for a platform where Filipino surgeons could publish local disease patterns, evaluate treatment outcomes, and contribute to knowledge directly relevant to Philippine practice.

While access to international journals has expanded considerably over time, the need for local publications remains. Differences in epidemiology, healthcare resources, and patient expectations mean that findings from other regions cannot always be directly applied to our setting. Local research therefore continues to ensure that clinical practice is guided by evidence that reflects the realities of Filipino patients.

Alongside this expansion in the use of local data, orthopedic research has also increasingly embraced patient-reported outcome measures (PROMs). Traditional clinical outcomes such as radiographic healing, range of motion, and complication rates remain important, but they do not always capture how patients themselves perceive recovery. These PROMs offer direct insight into function and quality of life from the patient's perspective, helping clinicians understand the real impact of treatment on daily activities and well-being.[3]

For PROMs to be meaningful, however, outcome instruments must be culturally and linguistically appropriate for the populations in which they are used.[4] Validating and applying these tools locally allows clinicians to measure recovery in ways that reflect patients' social roles, tendencies, and expectations. As patient-centered care continues to grow in importance, the integration of PROMs into local orthopedic research allows us to evaluate outcomes that matter most to the people we serve.

This latest issue showcases the range of contemporary orthopedic research, from epidemiologic observations and clinical outcomes to systematic reviews and complex reconstructive techniques. Together, these studies highlight the ongoing efforts of Filipino orthopedic surgeons and regional collaborators to generate evidence that informs both clinical decision-making and future research.

More importantly, these studies reflect a shared commitment to strengthening the evidence base that supports orthopedic care in our setting. As the volume of global literature expands, maintaining venues for locally generated scholarships become essential. Supporting and sustaining the Philippine Journal of Orthopaedics ensures that valuable clinical insights from our own institutions remain visible, accessible, and relevant to practitioners across the country.

Nathaniel S. Orillaza, Jr., MD
Associate Editor, Philippine Journal of Orthopaedics

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ORIGINAL ARTICLE

Reliability of the Filipino Translated Disabilities of the Arm, Shoulder and Hand (FIL-DASH) Questionnaire Among Hiligaynon Patients with Forearm Fractures

Kutch V. Yasa, MD, FPOA and Lucille P. Detoyato, MD, FPOA

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ABSTRACT

Background. The Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire is a validated scoring system for distal and diaphyseal forearm fractures. The Filipino translated version (FIL-DASH) is reliable and valid as an outcome measure for adult Filipino patients with brachial plexus injury. However, there is still a paucity of published literature on the reliability of FIL-DASH among Filipinos; hence, this study was conducted to determine its reliability among native Hiligaynon speakers.

Objective. The primary aim of this study was to determine the reliability of the Filipino translated DASH questionnaire (FIL-DASH) among Hiligaynon patients with forearm fractures managed in a public tertiary hospital in Iloilo City, Philippines.

Methodology. A descriptive study was conducted in a public tertiary hospital in Iloilo City, Philippines, from November 2022 to May 2024. Thirty patients with forearm fractures, selected through convenience sampling, were given the FIL-DASH questionnaire twice within 7 to 14 days (mean: 10 ± 3.11 days). Internal consistency was determined using Cronbach's alpha, and test-retest reliability was determined using the intraclass correlation coefficient (ICC).

Results. Internal consistency was high with Cronbach's alpha exceeding 0.8 for all sections: 0.9562 for the overall questionnaire, 0.9469 for the disability/symptom section, 0.8545 for the work module, and 0.9752 for the sport/instrument module. For the test-retest reliability, the intraclass correlation coefficients for each module were: 0.953 for the disability/symptom section, 0.919 for the work module, and 0.982 for the sport/instrument module. Most items within the disability/symptom section of the questionnaire exhibited coefficients exceeding 0.5, with the exceptions of questions 3 and 22 (correlations of 0.472 and 0.471, respectively).

Conclusion. These results showed that the FIL-DASH questionnaire is generally a reliable functional outcome measure for Hiligaynon patients with forearm fractures. However, translation or clarification may be needed for the items with low test-retest ICC.

Keywords. DASH Score, FIL-DASH, Filipino DASH, forearm fractures, patient reported outcome measures, Filipino, Hiligaynon

INTRODUCTION

Background of the study

The Disabilities of the Arm, Shoulder and Hand (DASH) Outcome Measure is a 30-item, self-reported questionnaire designed to measure physical function and symptoms in patients with any or several musculoskeletal disorders of the upper limb. It is effective and useful in assessing disability and symptoms of musculoskeletal disorders of the upper extremity.[1]

This outcome measure has been translated, validated, and culturally adapted to several languages.[2] The Filipino translation was found to be internally consistent, reliable and valid in assessing adult Filipino patients with traumatic brachial plexus injuries.[3]

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Filipino was designated the national language of the Philippines by the 1987 Philippine Constitution. It is defined by the Commission on the Filipino Language as "the native dialect, spoken and written, in Metro Manila, the National Capital Region, and in other urban centers of the archipelago."[4] McFarland estimated that there are 120 languages with distinct ethno-linguistic characteristics spoken in the different regions of the Philippine Archipelago.[5] Hiligaynon, for example, is the primary native language spoken in the Western Visayas Region. Filipino, on the other hand, is structurally based on Tagalog, a language spoken in Manila and in the nearby provinces in Luzon.[6]

There are few studies on the reliability of FIL-DASH among Filipinos whose native dialect is not Tagalog. Hence, this study was conducted to determine the reliability of the Filipino translated DASH Outcome Measure (FIL-DASH) among native Hiligaynon speakers.

OBJECTIVES

General objective

To determine the reliability of the Filipino translated DASH questionnaire (FIL-DASH) among Hiligaynon patients with forearm fractures managed in a public tertiary hospital in Iloilo City, Philippines.

Specific objectives

1. To describe the clinico-demographic profile of Hiligaynon patients with forearm fractures managed in a public tertiary hospital in Iloilo City, Philippines, as to:
   a. Age,
   b. Sex,
   c. Province,
   d. Occupation,
   e. Handedness,
   f. Educational Attainment,
   g. Mechanism of Injury,
   h. Involved Bone,
   i. Laterality of Injured Bone,
   j. Surgery,
   k. Time from injury to FIL-DASH Administration (months).
2. To determine the reliability of the FIL-DASH questionnaire among Hiligaynon patients with forearm fractures managed in a public tertiary hospital in Iloilo City, Philippines, as to:
   a. Internal Consistency,
   b. Test-retest Reliability.

Significance of the study

This study determined the reliability of the FIL-DASH questionnaire among Hiligaynon patients with forearm fractures managed in a public tertiary hospital in Iloilo City, Philippines. This provides baseline data on whether the FIL-DASH is reliable to use for Hiligaynon patients or if a Hiligaynon translation is warranted to offset the cross-cultural and linguistic differences between Tagalog and Hiligaynon speakers.

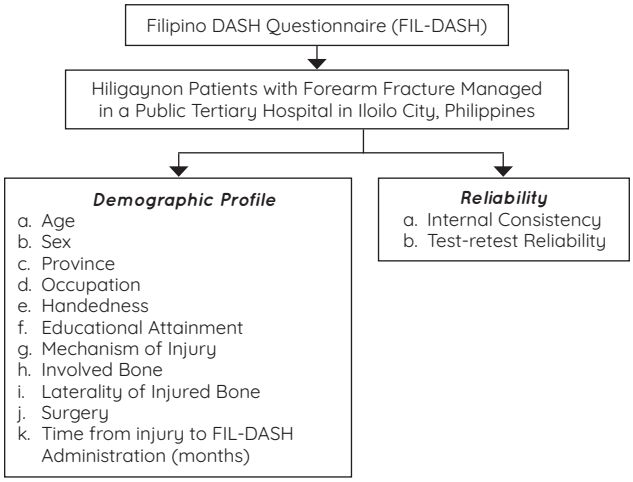

Figure 1. Conceptual framework of the study.

Scope and limitation of the study

We focused on only the reliability of the FIL-DASH questionnaire, and only on Hiligaynon patients with fractures of the radius and/or ulna managed either surgically or conservatively.

METHODOLOGY

Research design

This study used a descriptive research design.

Study population

All patients with radius and/or ulna fractures seen and managed in a public tertiary hospital in Iloilo City, Philippines, were included in the study.

Inclusion criteria

1. Adult patients aged 18 and above with radius and/or ulna fractures
2. Patients seen in the ER or OPD Departments
3. Patients treated either surgically or conservatively
4. Patients born and raised in Western Visayas

Exclusion criteria

1. Patients who refused/failed to return for the second administration of the questionnaire for the test-retest reliability
2. Patients with incomplete responses to the FIL-DASH questionnaire
3. Patients who were unable to fill out the FIL-DASH questionnaire, i.e., patients unable to read, mentally ill patients
4. Patients who refused or were unable to sign consent to participate in the study

Withdrawal criteria

1. Patients who refused to cooperate further in completing the questionnaire
2. Patients who developed pain or discomfort while writing his/her responses

Study setting

This study was conducted in a public tertiary hospital in Iloilo City, Philippines.

Duration of the study

This study was conducted from November 2022 to May 2024.

Sample size and sampling design

The study utilized convenience sampling, recruiting all patients who fulfilled the inclusion criteria during the sampling period.

Instrument

The study used the Filipino translated version of the Disabilities of the Arm, Shoulder and Hand (FIL-DASH) Outcome Measure published by Estrella et al.[3]

Data collection procedure

Patients with radius and/or ulna fractures who consulted at either the emergency department or outpatient department were treated and discharged. Their eligibility for inclusion in the study was assessed upon follow-up at the outpatient department.

The senior orthopaedic resident on duty at the OPD introduced the study to the patient and secured informed consent. The patient was given at least 30 minutes to complete the self-administered FIL-DASH questionnaire.

Respondents were monitored for any pain, anxiety, or stress. Patients with writing difficulties were assisted by a relative or an investigator who transcribed their answers. The assisting kin or investigator were strictly instructed not to give any translations, feedback, or comments, and the respondents were also instructed to answer based only on their own comprehension and assessment of their condition.

Patients were given the questionnaire a second time within the next seven to 14 days for test-retest reliability.

Ethical consideration

Informed consent was secured from all participants. All information, documents and pictures gathered in the study were kept secure and confidential.

Data analysis procedure

Data are presented as mean ± standard deviation (SD), frequencies and percentages. Internal consistency was determined using Cronbach's alpha for internal consistency with a 95% confidence interval. Test-retest reliability was determined using the intraclass correlation coefficient (ICC) with a 95% confidence interval.

RESULTS

A total of 30 patients in a public tertiary hospital in Iloilo City, Philippines, participated in the study. The average patient age was 35 years (± 14.74), and most participants were males (86.7%). Geographically, patients originated mostly from Iloilo Province (46.7%) and Iloilo City (43.3%), and the most common occupation was driver (30.0%). Most

Table 1. Clinico-demographic profile of Hiligaynon patients with forearm fractures managed in a tertiary hospital in Iloilo City, Philippines (n = 30)

Profile	Mean	Std. Dev.	Min	Max
Age	35	14.74	18	71
Injury to FIL-DASH administration (months)	3	2.31	1	11
Profile	***N***		**%**	
Sex				
Male	26		86.67	
Female	4		13.33	
Province				
Aklan	1		3.33	
Capiz	1		3.33	
Iloilo City	13		43.33	
Iloilo Province	14		46.67	
Negros Occidental	1		3.33	
Occupation				
Student	8		26.67	
Driver	9		30.00	
Others	9		30.00	
None	4		13.33	
Handedness				
Left	4		13.33	
Right	26		86.67	
Educational attainment				
Elementary undergraduate	1		3.33	
Senior high school	4		13.33	
High school undergraduate	1		3.33	
High school graduate	9		30.00	
College undergraduate	9		30.00	
College graduate	6		20.00	
Mechanism of injury				
Vehicular accident	16		53.33	
Fall	9		30	
Sports injury	5		16.67	
Involved bone				
Distal radius	17		56.67	
Radius shaft	7		23.33	
Both shaft	4		13.33	
Proximal ulna	2		6.67	
Laterality of injured bone				
Left	15		50.00	
Right	13		43.33	
Bilateral	2		6.67	
Surgery				
No	14		46.67	
Yes	16		53.33	

patients (86.7%) were right-handed and were either high school graduates (30.0%) or college undergraduates (30.0%). Vehicular accidents were the leading cause of injuries (53.3%), with the distal radius being the most frequent site of injury (56.7%), followed by the radial shaft (23.3%), and both bone fractures of the radial and ulnar shafts (13.3%). Injuries were distributed evenly between the left and right forearms. Surgery was indicated and performed for approximately 53.3% of injuries. The average time from injury to FIL-DASH administration was three months (± 2.31).

The questionnaire's reliability was assessed using two methods: Cronbach's alpha for internal consistency with 95% confidence interval and intraclass correlation coefficient (ICC) for test-retest reliability with 95% confidence interval.

Results indicated high reliability with Cronbach's alpha exceeding 0.8 for all sections: 0.9562 for the overall questionnaire, 0.9469 for the disability/symptom section, 0.8545 for the work module, and 0.9752 for the sport/instrument module (Table 2). These high alpha values suggest strong internal consistency among the items in the questionnaire.

Test-retest reliability analysis using the intraclass correlation coefficient (ICC) revealed a range of 0.4 to 0.9 between the two questionnaire administrations. Most items within the disability/symptom section of the questionnaire exhibited coefficients exceeding 0.5, with the exceptions of questions 3 and 22 (correlations of 0.472 and 0.471, respectively). The work module demonstrated consistently high correlations, with coefficients ranging from 0.779 to 0.839. Similarly, the sport/instrument module displayed strong correlations, with coefficients ranging from 0.842 to 0.981. These findings indicate high consistency in responses across the two administrations for items within each module.

Overall, the ICC for each module was: 0.953 for disability/symptom section, 0.919 for the work module, and 0.982 for the sport/instrument module. These high ICC values suggest good reliability for each section of the questionnaire (Table 3).

Table 2. Internal consistency of the FIL-DASH questionnaire using Cronbach's alpha with 95% confidence interval (CI)

Items	Cronbach's alpha	95% CI		No. of items
		LB	UB	
Overall questionnaire	0.9562	0.8703	1.0420	38
Disability/ Symptom section	0.9469	0.8963	0.9975	30
Work module	0.8545	0.7445	0.9646	4
Sport/ Instrument module	0.9752	0.9347	1.0158	4

Table 3. Test-retest reliability of the FIL-DASH questionnaire using intraclass correlation coefficient (ICC) with 95% CI

Item	ICC	95% CI	
		LB	UB
Disability/ Symptom section	0.953	0.904	0.977
Question 1	0.835	0.683	0.918
Question 2	0.907	0.814	0.955
Question 3	0.476	0.145	0.711
Question 4	0.863	0.732	0.932
Question 5	0.610	0.325	0.793
Question 6	0.772	0.574	0.885
Question 7	0.756	0.548	0.876
Question 8	0.809	0.638	0.904
Question 9	0.843	0.696	0.922
Question 10	0.875	0.754	0.938
Question 11	0.916	0.832	0.959
Question 12	0.966	0.930	0.984
Question 13	0.960	0.917	0.981
Question 14	0.895	0.791	0.949
Question 15	0.928	0.855	0.965
Question 16	0.796	0.615	0.898
Question 17	0.865	0.736	0.933
Question 18	0.936	0.871	0.969
Question 19	0.824	0.664	0.912
Question 20	0.942	0.882	0.972
Question 21	0.954	0.904	0.978
Question 22	0.471	0.139	0.707
Question 23	0.772	0.574	0.884
Question 24	0.588	0.295	0.780
Question 25	0.664	0.404	0.824
Question 26	0.699	0.457	0.844
Question 27	0.510	0.189	0.732
Question 28	0.595	0.305	0.785
Question 29	0.749	0.536	0.872
Question 30	0.948	0.894	0.975
Work Module	0.919	0.826	0.964
Question 1	0.839	0.668	0.926
Question 2	0.810	0.615	0.911
Question 3	0.779	0.560	0.896
Question 4	0.832	0.655	0.922
Sport/ Instrument Module	0.982	0.946	0.994
Question 1	0.981	0.942	0.994
Question 2	0.842	0.579	0.947
Question 3	0.927	0.789	0.976
Question 4	0.919	0.768	0.973

DISCUSSION

The DASH scoring system has been validated and used as a scoring system for distal and diaphyseal forearm fractures.[7-11] This study used the Filipino version, which was translated and validated by Estrella et al. in 2019. They determined the validity, reliability and internal consistency of the cross-cultural adaptation of the FIL-DASH questionnaire among Filipino patients with traumatic brachial plexus injuries.

The questionnaire's Cronbach's alpha scores for all domains were greater than 0.8. A Cronbach's alpha greater than 0.70 is considered acceptable.[3] The internal consistency for the overall questionnaire in this study (0.9562) is comparable with Estrella et al.'s results (0.94). These high alpha values suggest a strong average correlation between patients' scores on different items within each module, indicating that they all measure the same disability, symptom and ability to perform certain activities consistently. The intraclass correlation coefficients (ICC) for the 30-item disability/symptom section, the 4-item work module and the sport/musical instrument module were 0.953, 0.919, and 0.982, respectively. An ICC greater than 0.75 is deemed acceptable.[3] Similar to the study by Estrella et al., the questionnaire in this study was given within the period of seven to 14 days. The average test-retest gap in this study was 10 (± 3.11) days.

A reliable DASH questionnaire given to the same group of patients a week apart should have low variability in responses and a high ICC.[1] These overall high ICC findings showed high

consistency between the test and retest administration and suggested good reliability for all sections of the questionnaire. Despite this, items 3 and 22 showed a low test-retest ICC, indicating inconsistent responses for these specific items.

For item number 3, the authors did not find any major nuance in the statement in both context and meaning. The contextual meaning of using (*gumamit*) a key (*susi*) to open (*pagbukas*) a door (*pinto*) or car (*kotse*) is clear. The Tagalog word *susi* (key) also has a direct Hiligaynon translation, which is *yábi*. However, the word *susi* (*súsi'*) is also a Hiligaynon word which means "to investigate, to look into, to try to discover, to research"[12] which may confuse Hiligaynon speakers.

For item number 22, the word *pakikisalamuha* (to socialize) is a deep Tagalog term which has no direct Hiligaynon translation. This may have confused the respondents, leading to a low test-retest ICC. Even if this word were understandable to a native Hiligaynon speaker, it might not directly measure the outcome of interest. Hiligaynon equivalents such as *pakig-upod* meaning "companionship" (*upúd:* companion[12]) and *pakig-istorya* meaning "to converse with" (*istórya:* conversation[12]) are more specific terms.

A limitation of this study is that the authors did not establish the level of comprehension of the subjects of the Filipino language. Most respondents, however, have at least a high school education, with only one respondent having an elementary education. Respondents were expected to have a basic grasp of the Filipino language as a medium of instruction in Philippine schools starting at the elementary level.

However, despite a basic understanding of the Filipino language, specific terms may be difficult to fully comprehend, requiring clarification or translation. Further studies may determine the factors affecting the low test-retest reliability of items 3 and 22.

Other than the Estrella et al. study, there is no other literature on the reliability of the FIL-DASH. This topic should be further explored, taking into account the multi-linguistic and multi-cultural nature of the Philippines.

For example, the Chinese translation of the DASH has different cross-cultural and linguistic versions taking into account the differences among the major Chinese populations. The DASH-HKPWH[13] (Hongkong, Cantonese Chinese: Cronbach's alpha = 0.94; ICC = 0.77; test interval: 1-2 weeks), DASH-CHNPLAGH[14] (Mainland, Mandarin Chinese: Cronbach's alpha = 0.96; ICC = 0.94; test interval: 3 weeks) and Taiwan-DASH[15] (Taiwan, Traditional/Cantonese Chinese: Cronbach's alpha = 0.96; ICC = 0.9; test interval: less than 10 days) have shown very high Cronbach's alpha and intraclass correlation coefficient when tested among specific populations.

CONCLUSION

The FIL-DASH questionnaire had an acceptable Cronbach's alpha for internal consistency and intraclass correlation coefficient (ICC) for test-retest reliability with a 95% confidence interval. The FIL-DASH questionnaire was generally a reliable functional outcome scoring measure for Hiligaynon patients with forearm fractures. However, specific items and terms in the questionnaire may require translation or clarification to native Hiligaynon speakers in the clinical setting, especially the items with low test-retest ICC.

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STATEMENT OF AUTHORSHIP

All authors certified fulfillment of ICMJE authorship criteria.

CREDIT AUTHOR STATEMENT

KVY: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing – original draft preparation, Writing – review and editing, Visualization, Supervision, Project administration; **LPD:** Conceptualization, Methodology, Validation, Writing – review and editing, Visualization, Supervision, Project administration.

DATA AVAILABILITY STATEMENT

The datasets generated and analyzed in this study are included in the published article.

AUTHOR DISCLOSURE

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ORIGINAL ARTICLE

Demographic Profile, Clinical Characteristics, and Short-Term Outcomes of Tuberculous Spondylitis in a Tertiary Medical Center in Southern Philippines: A 10-year Retrospective Review

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ABSTRACT

Background. Tuberculous spondylitis remains a significant cause of morbidity in the Philippines, with limited local outcome data.

Objective. To describe the demographic profile, clinical characteristics, management, and outcomes of patients with tuberculous spondylitis treated at a tertiary-level medical center from 2015 to 2024.

Methodology. This was a 10-year retrospective chart review of patients diagnosed with tuberculous spondylitis. Demographic, clinical, radiographic, and management data were collected and analyzed.

Results. A total of 69 patients were included. Most patients were male (63.6%) and unemployed (63.6%). The mean age was 40 years (range, 19–59). Thoracic involvement was reported in 59% of cases. Back pain was reported at 48.5%, and neurologic deficits were reported at 27.3%. On neurologic assessment at presentation, 50% had incomplete neurologic deficits and 10.6 % had complete deficits. Management consisted of anti-tuberculous therapy alone in 59.1% and anti-tuberculous therapy with bracing in 21.2%. Thirteen patients (19.7%) underwent surgery, performed via a posterior approach. In the surgical cohort, the mean preoperative kyphosis angle was 47.7 degrees (range, 39–79 degrees), and the mean postoperative kyphosis angle was 40.8 degrees (range, 27–55 degrees). Neurologic recovery was documented among patients with incomplete deficits. The mean interval from surgery to discharge was 51 days. At two years, more than 90% of patients were lost to follow-up.

Conclusion. Tuberculous spondylitis in this cohort was observed predominantly among unemployed young to middle-aged males, involving the thoracic spine, with a substantial proportion presenting with neurologic compromise. Among surgically treated patients, posterior surgery was associated with modest deformity correction and neurologic improvement during the early postoperative period. Long-term outcomes could not be reliably assessed due to > 90% loss to follow-up at two years. Strengthened early detection, improved continuity of care, and inclusion of functional outcomes in future studies are recommended.

Keywords. tuberculous spondylitis, Pott's disease, spinal tuberculosis, neurologic deficits, retrospective study, developing country, Philippines

INTRODUCTION

Tuberculosis (TB) remains a major global health burden, with a large proportion of cases occurring in the WHO South-East Asia Region. The Philippines continues to struggle with a high TB burden.[1]

Skeletal tuberculosis contributes to around 10% of extrapulmonary tuberculosis, and tuberculous spondylitis is the most common site (50%).[2,3] Locally, there are few studies on Pott's disease, particularly describing patient presentations, management patterns, and outcomes. If left untreated, tuberculous spondylitis results in kyphotic

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deformity, sinus formation, subluxations, contractures, and neural complications. These patients' defense mechanisms are markedly decreased, which could lead to tuberculous dissemination and eventually death in nearly 1 out of 3 patients.[4] Anti-Koch therapy is the mainstay of treatment for TB spondylitis. Bosworth et al. found a 72.5% reduction in mortality with antitubercular drug use.[5] Pharmacotherapy also prevents sinus formation, one of the dreaded complications of spinal tuberculosis.[4]

Advancements in diagnostics are being made at the frontier of research, but early detection of spinal tuberculosis is still difficult. Spinal tuberculosis, if caught and treated in its earliest stage (inflammatory stage), can heal with a near-normal spine.[6] Doctors still rely on a constellation of characteristic clinical and radiographic findings for diagnosis. Hayes et al. found that nine out of 10 patients presented with back pain, while seven out of 10 presented with constitutional symptoms of malaise, evening rise of temperature, and night sweats.[7]

Spinal tuberculosis only manifests on radiographs after three to four months, or when there is approximately 30% bone loss.[6,8] Other than vertebral changes, pulmonary lesions are found in 60 to 70% of chest radiographs.[9] Jain et al. noted that initial magnetic resonance imaging can forecast patients' prognosis. Patients experiencing paraplegia without indications of instability in their imaging tend to demonstrate favorable neural recovery. Conversely, patients with a combination of extradural compression and a thick dura-arachnoid complex, with diseased tissue surrounding the spinal cord, are more likely to exhibit poor neural outcomes.[6]

A meta-analysis of the top 250 cited articles on spinal tuberculosis found that most studies were focused on surgical techniques. There was also a low citation rate from countries with high disease burdens, including the Philippines.[10] There is a need for Philippine data on clinical presentation and outcomes, and institution-based descriptive studies. Thus, this study aimed to describe our cases in terms of demographic profile, clinical presentation, affected spinal level, treatment approaches, and early outcomes, to help identify local care gaps and inform quality improvement in patient management.

METHODOLOGY

Research design

This was a descriptive retrospective study that reviewed medical records of all patients with tuberculous spondylitis seen and treated at a tertiary-level medical center from January 1, 2015, to December 31, 2024. This study described demographic, clinical, radiographic, management, and outcome variables based on available chart documentation.

Setting

The study was conducted via review of inpatient and outpatient charts at the medical records section at a tertiary-level medical center. Spine radiographs were retrieved digitally via the Synapse PACS Diagnostic Viewer when available.

Definition of terms

Tuberculous spondylitis – a vertebral disease caused by *Mycobacterium tuberculosis.* It was diagnosed via history, clinical examination, and radiographs by a medical officer. In this study, it was equivalent to ICD code A18.0, A18.01 Tuberculosis of the bone and joints, and ICD code M49.0, M49.5, or M48.5 Tuberculosis of the spine. Diagnosis was based on the treating team's charted assessment supported by clinical and radiographic findings, with histologic confirmation when available; this approach was consistent with routine practice and locally used guidance (e.g., PhilCAT CPG/DOH-NTP Manual of procedures). Diagnostic uncertainty due to limited confirmation was acknowledged.[11]

Affected spinal level – level of the vertebrae affected by Pott's disease based on radiographs.

Kyphotic deformity – a radiographic measurement using the sagittal plane of the cervical, thoracolumbar, or lumbosacral area. It was measured using the angle between the superior and inferior end plates of both the upper and lower unaffected vertebrae adjacent to the lesion. This was measured using an established Cobb angle technique; a subset of radiographs was re-measured to ensure consistency of measurements.

Neurologic status – a descriptor of the patient's neurologic deficit. This was categorized as "no deficits," "incomplete deficits," or "complete deficit," based on physical examination findings. Standardized grading systems (e.g., ASIA/Frankel) were not consistently documented in the charts; hence, simplified categories were used.

- "No deficits" – absence of sensory or motor deficit below the affected spinal level
- "Incomplete deficits" – presence of either sensory or motor deficit below the affected spinal level
- "Complete deficit" – absence of sensory (0/2) and skeletal motor activity below the affected spinal level

Participants

All patients with tuberculous spondylitis (ICD codes: ICD code A18.0, A18.01, M49.0, M49.5, M48.4, M48.5) seen and treated at a tertiary-level medical center from January 1, 2015, to December 31, 2024.

Inclusion and exclusion criteria

We included patients who were diagnosed with tuberculous spondylitis upon admission or outpatient consult. We excluded patients with incomplete charts, patients who absconded, patients with other concomitant spine diseases, or who were subsequently determined to have non-tuberculosis spinal pathology (based on final chart diagnosis).

Sampling procedure

The study employed total enumeration of all available charts from January 1, 2015, to December 31, 2024. Based on the average monthly census, an estimated 120 patients were expected to be included in the study. Cases were identified through ICD codes, charts were retrieved and screened against inclusion/exclusion criteria, and eligible cases were included in the final analysis.

Data gathering

Independent variables

- *Demographic profile:* age, sex, civil status, occupation, residence, type of admission, duration of symptoms, treatment, and discharge
- *Clinical profile:* chief complaint, affected spinal level, kyphotic deformity, neurologic status, history of pulmonary tuberculosis, histologic confirmation status
- *Management:* pharmacologic, bracing, surgery
- *Pharmacologic (Anti-TB medications):* regimen components (e.g., isoniazid, rifampicin, pyrazinamide, ethambutol) and duration/schedule when specified in the chart, generally reflecting DOH-NTP-based practice
- *Bracing:* Brace use and, when available, brace type and advised duration
- *Surgery:* Operative notes were reviewed to classify posterior procedures, including posterior decompression (e.g., laminectomy/transpedicular decompression), costotransversectomy (thoracic), debridement/abscess drainage, posterior instrumentation (levels), and fusion. If operative detail was insufficient, cases were coded as "posterior approach-procedure unspecified" and acknowledged as a limitation.

Main outcome measures and other dependent variables

- Correction of deformity
- Neurologic status upon admission, discharge, and at six-month, one-year, and two-year follow-up. Loss to follow-up at each time point was recorded, and outcomes were summarized based on available follow-up data.

Sample size computation

This study employed total enumeration; thus, sampling was not required.

Data handling and analysis

Data were collected and recorded by the investigator and a research assistant from the medical charts. Spine x-rays were retrieved digitally via the Synapse PACS Diagnostic Viewer, and kyphotic deformity was measured by the principal investigator upon the approval of the Department of Diagnostic and Imaging Science. Histologic results were retrieved by the principal investigator upon the approval of the Department of Pathology. The data were tabulated and validated by a statistician. Data were analyzed for measures of central tendency (mean), and other descriptive statistics such as standard deviation and frequency distribution (percentage). Data analysis was done using Strata. Missing variables were treated as "no data" and excluded from denominator-specific summaries. No imputation was performed. Loss to follow-up was reported explicitly at each follow-up interval to contextualize outcome interpretation.

RESULTS

Patient demographics

A total of 142 patient charts with ICD-10 codes of A18.0, A18.01, M49.0, M49.5, M48.4, or M48.5, were reviewed from 2015 to 2024. Of these, 69 charts met the inclusion criteria and were analyzed. Sixty-five charts were excluded because the diagnosis was extrapulmonary tuberculosis but not TB spondylitis; eight charts were incomplete (Figure 1.) Unless otherwise stated, denominators refer to patients (n = 69).

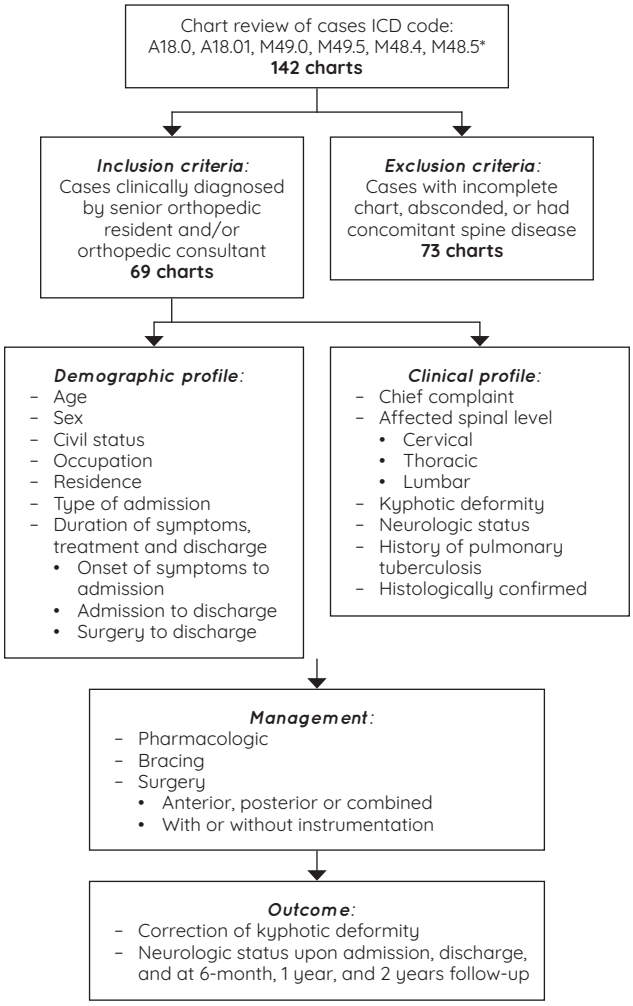

Figure 1. Workflow diagram.

*A18.0 – Tuberculosis of bones and joints; A18.01 – Tuberculosis of spine; M49.0 – Tuberculosis of spine (under Spondylopathies in diseases classified elsewhere); M49.5 – Collapsed vertebra in diseases classified elsewhere; M48.4 – Fatigue fracture of vertebra; M48.5 – Collapse vertebra, not elsewhere classified

Table 1A. Categorical demographics

	N	%
Age (years)		
0–18	12	17.39
19–59	48	69.57
≥ 60	9	13.04
Sex		
Female	24	34.78
Male	45	65.22
Civil status		
Single	33	47.83
Married	35	50.72
Widow	1	1.45
Separated	0	0
Occupation		
Employed	24	34.78
Unemployed	45	65.22
Residence (Region)		
XI	55	79.71
XII	7	10.61
XIII	6	9.09
BARMM	1	1.52
Type of admission/consults		
OPD consult	38	57.58
OPD admission	6	9.09
ER admission	22	33.33
Others	0	0
Total	69	

Table 1B. Continuous variables

	Mean (range), days
Symptom onset (days)[b]	219 (7–1095)
Neurologic deficit	24 (7–60)
Back pain	281 (30–1095)
Constitutional symptoms	302 (30–730)
Thoracic kyphosis	383 (120–300)
Length of hospital stay (days)[c]	
Non-surgical group	
Admission to discharge	21.4 (2–51)
Surgical group	
Admission to discharge	57.33 (9–149)
Admission to surgery	51.11 (4–139)
Surgery to discharge	6.22 (5–11)

[a] Categorical variables are presented by frequency (proportion) while continuous variables are presented in mean (stdev).

[b] Based on available data and on the duration of the first symptom from the first consult to the institution.

[c] Applicable to OPD admission and ER admission groups. The non-surgical group were cases treated with Anti-Koch therapy only, since all cases that underwent bracing were OPD consults.

Most of the 69 patients were male (65.2%) and aged 19 to 59 years old (69.6%), highlighting the disease's impact on the working-age population. Only 17.4% were children or adolescents, while 13.0% were elderly (≥ 60 years). Most patients were unemployed (65.2%) (Table 1).

Regarding healthcare access, most were first seen as outpatient consultations (57.6%), whereas a third presented through the emergency department (33.3%), which may reflect presentation during more severe or disabling symptoms.

The mean duration from symptom onset to diagnosis was 219 days (range, 7–1095 days), underscoring the insidious progression of the disease. Among cases with documented symptom timing, neurologic deficits manifested earliest with a mean onset of 24 days (7–60 days), followed by back pain at 281 days (30–1095 days), constitutional symptoms at 302 days (30–730 days), and thoracic kyphosis, typically the latest to appear, at a mean onset of 383 days (120–300 days).

Hospitalization data revealed that patients managed non-surgically had a mean length of stay of 21.4 days (2–51 days). Notably, all nine cases of the bracing group were OPD consults. In contrast, the surgical cohort demonstrated a substantially longer hospital course, averaging 57.33 days (9–149 days) from admission to discharge. Distinctly, the mean waiting period from admission to surgery was 51.11 days (4–139 days), whereas the postoperative stay from surgery to discharge was relatively short, with a mean of 6.22 days (5–11 days). These findings highlight both the protracted pre-operative optimization and evaluation period, as well as the efficiency of postoperative recovery once surgical management was undertaken (Table 1).

Clinical profile

Back pain was the most common presenting symptom, reported in 50% of patients, followed by neurologic deficits (27.3%). Fewer patients presented with thoracic kyphosis (13.6%) or constitutional symptoms (7.6%) (Table 2). The thoracic spine was the most frequently affected region (59.1%), followed by the lumbar spine (43.9%), while cervical involvement was uncommon (4.6%). Because some patients had multilevel involvement, spinal-region percentages may sum to > 100%. Multilevel vertebral lesions were identified

Table 2. Chief complaint* (*N* = 69)

	Back pain, *N* (%)	Neurologic deficit, *N* (%)	Thoracic kyphosis, *N* (%)	Constitutional symptoms, *N* (%)	Other symptoms, *N* (%)	No data, *N* (%)	Total
Age (years)							
0–18	4 (12. 12)	4 (22.22)	3 (33.33)	0 (0)	0 (0)	1 (50)	12
19–59	25 (75.76)	12 (66.67)	5 (55.56)	3 (60)	2 (100)	1 (50)	48
≥ 60	4 (12.12)	2 (11.11)	1 (11.11)	2 (40)	0 (0)	0 (0)	9
Total	33 (50)	18 (27.27)	9 (13.64)	5 (7.58)	2 (3.03)	2 (3.03)	**69**
Sex							
Female	13 (39.39)	4 (22.22)	4 (44.44)	2 (40)	0 (3)	1 (50)	24
Male	20 (60.61)	14 (77.78)	5 (55.56)	3 (60)	2 (100)	1 (50)	45
Total	33 (50)	18 (27.27)	9 (13.64)	5 (7.58)	2 (3.03)	2 (3.03)	**69**

*Chief complaint reflects the primary presenting complaint recorded at first consult; one category per patient

in eight patients, comprising one case at the cervicothoracic junction and seven at the thoracolumbar junction. Notably, there were eight cases where the spinal level was not mentioned in the charts (Table 3).

Thoracic kyphosis

Among the 40 patients with thoracic involvement, 85% (n = 34) presented with a kyphotic deformity of ≤ 60°, while 15% (n = 6) presented with severe deformity (> 61°) (Table 4).

Neurologic involvement

At presentation, neurologic deficits were identified in 42 patients, of whom half demonstrated incomplete deficits, and 10.6% exhibited complete deficits. Percentages for neurologic categories are based on a population of 69 patients unless otherwise stated. Neurologic impairment was most prevalent among adults aged 19–59 years, whereas no complete deficits were documented in the pediatric population (Table 5).

Pulmonary tuberculosis history

A documented history of pulmonary tuberculosis (PTB) was present in 19.7% of patients, absent in 71.2%, and not available in 9.1%. Across age groups, age- and sex-stratified PTB history is presented in Table 6.

Histopathology

Among the 69 cases of clinically diagnosed tuberculous spondylosis, 13 underwent surgery, and there were only nine retrievable histopathologic results. Seven cases had samples taken during the surgical instrumentation, while two cases' samples were taken using transpedicular biopsy. Five out of nine cases were histologically confirmed to be tuberculous spondylitis. Thus, histologic confirmation was available in a subset of surgical patients, and most cases were diagnosed clinically.

Treatment and outcomes

A total of 69 patients with tuberculous spondylitis were included in this series. The majority (63.6%) were managed with Anti-Koch therapy alone, 13.6% received Anti-Koch therapy with bracing, and 19.7% underwent surgery in addition to medical treatment. Treatment-group distributions and baseline characteristics (spinal level, kyphosis category, neurologic status) are summarized in Table 7.

Among the 69 patients, treatment data were unavailable for five individuals. Neurologic improvement was observed predominantly within the first 12 months across the three treatment groups. In the Anti-Koch group, most patients presented with incomplete deficits and demonstrated gradual recovery, with the earliest recovery occurring six months post-treatment; however, follow-up attrition exceeded 90% by 18 months, limited long-term evaluation. The bracing

Table 3. Affected spinal level

	Cervical, *N* (%)	Thoracic, *N* (%)	Lumbar, *N* (%)	Total
Age (years)				
0–18	0 (0)	8 (20)	3 (10.34)	11
19–59	3 (100)	24 (60)	23 (79.31)	50
≥ 60	0 (0)	8 (20)	3 (10.34)	11
Total	3	40	29	**72***
Sex				
Female	0 (0)	14 (35)	10 (34.48)	24
Male	3 (100)	26 (65)	19 (65.52)	48
Total	3 (4.55)	40 (59.09)	29 (43.93)	**72***

*Patients with multilevel disease spanning more than one spinal region are counted in each involved region; their totals may exceed N=69.

Table 4. Radiographic parameters: Kyphotic deformity upon admission. Thoracic cases with documented kyphosis measurement (*N* = 40)

	≤ 60 degrees, *N* (%)	> 61 degrees, *N* (%)	Total, *N* (%)
Age (years)			
0–18	7 (20.59)	1 (16.67)	8 (20)
19–59	20 (58.82)	5 (83.33)	25 (62.5)
≥ 60	7 (20.59)	0 (0)	7 (17.5)
Total	34 (85)	6 (15)	**40**
Sex			
Female	11 (32.35)	4 (66.67)	13 (32.5)
Male	23 (67.65)	2 (33.33)	25 (62.5)
Total	34 (85)	6 (15)	**40**

Table 5. Neurologic status* (*N* = 69)

	Normal, *N* (%)	Incomplete deficits, *N* (%)	Complete deficits, *N* (%)	No data, *N* (%)	Total, *N* (%)
Age (years)					
0–18	5 (20.83)	6 (17.14)	0 (0)	1 (33.33)	12 (17.39)
19–59	17 (70.83)	24 (68.57)	5 (71.43)	2 (66.67)	48 (69.57)
≥ 60	2 (8.33)	5 (14.29)	2 (28.57)	0 (0)	9 (13.04)
Total	24 (36.36)	35 (50.72)	7 (10.61)	3 (4.55)	**69**
Sex					
Female	8 (34.78)	12 (34.29)	3 (42.86)	1 (33.33)	24 (36.36)
Male	16 (66.67)	23 (65.71)	4 (57.14)	2 (66.67)	45 (65.21)
Total	24 (36.36)	35 (50.72)	7 (10.61)	3 (4.55)	**69**

*Neurologic category derived from chart documentation; standardized grading (e.g., ASIA/Frankel) not consistently recorded.

Table 6. History of pulmonary tuberculosis* (*N* = 69)

	With PTB, *N* (%)	Without PTB, *N* (%)	No data, *N* (%)	Total, *N* (%)
Age (years)				
0–18	2 (15.38)	7 (14.89)	3 (33.33)	12 (17.39)
19–59	9 (69.23)	34 (72.34)	5 (55.56)	48 (69.56)
≥ 60	2 (15.38)	6 (12.77)	1 (11.11)	9 (13.04)
Total	13 (18.84)	47 (68.11)	9 (13.04)	**69**
Sex				
Female	5 (38.46)	17 (36.17)	2 (22.22)	24 (34.78)
Male	8 (61.54)	30 (63.83)	7 (77.78)	45 (65.21)
Total	13 (19.7)	47 (71.21)	9 (9.09)	**69**

*PTB history based on charted history/diagnosis; may be under-reported in retrospective records

Table 7. Management (*N* = 69)

	Anti-Koch only, *N* (%)	Anti-Koch with bracing, *N* (%)	Anti-Koch with surgery		No data, *N* (%)	Total, *N* (%)
			Anterior approach, *N* (%)	Posterior approach, *N* (%)		
Spinal level						
Cervical	1 (2.56)	1 (11.11)	0	0	1 (20)	3 (4.16)
Thoracic	22 (52.38)	5 (55.56)	0	12 (92.31)	1 (20)	40 (55.56)
Lumbar	22 (52.38)	3 (33.33)	0	2 (15.38)	2 (40)	29 (40.27)
Total	45	9	0	14	6	**72***
Kyphosis category						
≤ 60 degrees	20 (50)	4 (9)	0	10 (25)	0	34 (85)
> 61 degrees	2 (5)	1 (1.45)	0	2 (5)	1 (2.45)	6 (15)
Total	22 (55)	9 (22.5)	0	13 (18.84)	5 (12.5)	**40**
Neurologic status						
No deficits	18 (42.86)	5 (55.56)	0	0	1 (20)	24 (34.78)
Incomplete deficits	20 (47.62)	2 (22.25)	0	11 (84.62)	2 (40)	35 (50.72)
Complete deficit	2 (4.76)	2 (22.25)	0	2 (15.38)	1 (20)	7 (10.14)
No data	2 (4.76)	0	0	0	1 (20)	3 (4.34)
Total	42 (63.64)	9 (13.64)	0	13 (19.7)	5 (7.58)	**69**

*Eight charts had multiple lesions (Cervicothoracic – 1, Thoracolumbar – 8)

group exhibited comparable early recovery with better follow-up adherence, permitting documentation of sustained improvement up to 24 months. Given non-random treatment allocation and baseline severity differences, between-group differences are presented descriptively and should not be interpreted as comparative effectiveness. Overall, neurologic recovery was documented across groups, while high attrition in the Anti-Koch group limited long-term interpretation (Table 8).

Of the 69 patients, only 13 underwent surgery. Indications for surgery were the presence of kyphotic deformity (> 30 degrees) and neurologic deficits, with 12 having incomplete deficits. Among patients who underwent posterior surgical correction, the mean pre-operative thoracic kyphotic angle was 47.7° (range, 39–79°), which improved to 40.8° (range, 27–55°) post-operatively, yielding a mean correction of 6.9°. By age group, the greatest correction was achieved in pediatric patients (0–18 years), with a mean reduction of 28° (Table 8). Kyphosis correction values are reported for patients with available pre- and postoperative measurements.

DISCUSSION

This study highlights the profile of patients with tuberculous spondylitis in a high TB-burden region. Globally, tuberculosis remains a major public health concern, with an estimated 9.9 million new cases annually, disproportionately affecting Southeast Asia and Africa.[1] The Philippines is one of the WHO high-burden countries, accounting for 6% of global incident cases.[11] Consistent with worldwide epidemiology, skeletal TB contributes roughly 10% of extrapulmonary tuberculosis, with spinal TB comprising up to 50% of musculoskeletal involvement.[2,3] The predominance of young to middle-aged, unemployed males in this cohort parallels findings in other endemic areas, reflecting the socioeconomic burden of the disease.

Thoracic spine involvement was most frequent, consistent with the rich vascular supply of the vertebrae and the known hematogenous spread of Mycobacterium tuberculosis through the Batson venous plexus.[8,12] The paradiscal pattern of involvement—owing to segmental arteries supplying both endplates—is well-described in the literature.[12] The high rate of neurologic deficits in our cohort (51.28%) indicates delayed presentation, similar to other studies.[13] Neurologic deficit results from both mechanical and inflammatory mechanisms, including internal gibbus deformity, canal compromise, cord edema, and granulation tissue.[4] Because histopathologic confirmation was available in only a minority of cases, diagnostic misclassification remains possible, which may affect our estimates of presentation patterns and outcomes.

Management patterns showed reliance on medical therapy (anti-TB medications) as first-line treatment, consistent with WHO and National Tuberculosis Program recommendations.[13] The "middle-path" approach of Tuli—reserving surgery for non-responders, progressive deformity, or neurologic deterioration—remains consistent with practice in resource-limited settings.[4,14] Unlike international literature, where anterior, posterior, and combined approaches are options, this cohort predominantly underwent posterior-only surgery, likely due to institutional preference, surgeon expertise, and financial constraints, given that PhilHealth case rates for spinal TB exclude implants and many hospitalization costs.[15]

Posterior-only surgery was associated with kyphosis correction and neurologic recovery in this study. The mean kyphosis correction (6.9 degrees) represents modest radiographic change in adults and should be interpreted in the context of surgical goals in this series (primary decompression and stabilization rather than major deformity correction). The clinical relevance of small angular changes may vary by baseline deformity level involved and symptoms. This is supported by evidence showing posterior decompression and instrumentation as a safe and effective option in many cases.[16] Posterior

approaches allow broad exposure, multilevel fixation, and deformity correction while avoiding morbidity associated with anterior thoracotomy or retroperitoneal access.[17,18] However, anterior or combined approaches remain essential in cases with severe anterior column destruction, large paravertebral abscesses, multilevel vertebral body involvement, or kyphosis > 60°, where posterior-only correction may risk further neurologic injury.[19-21]

Table 8.0. Correction of thoracic kyphotic deformity (*N* = 13)

Posterior Approach	Mean Pre-operative kyphotic deformity (range), degrees	Mean Post-operative kyphotic deformity (range), degrees	Mean Deformity correction [Pre – Post], degrees
	47.68 (39–79)	40.8 (27–55)	6.88
Age (years)			
0–18	55	27	28
19–59	46.6 (39–79)	40.6 (35–53)	6
≥ 60	53.5 (52–55)	41.5 (28–55)	12

Table 8.1. Clinical outcomes of Anti-Koch Group (*N* = 42)*

Neurologic status	Admission, *N* (%)	6 mos, *N* (%)	12 mos, *N* (%)	18 mos, *N* (%)	24 mos, *N* (%)
Complete deficit	2 (5.13)	2 (4.76)	2 (4.76)	0	0
Incomplete deficits	20 (46.15)	15 (35.71)	2 (4.76)	0	0
No deficits	18 (42.86)	19 (45.24)	8 (19.05)	0	0
Lost to follow up	2 (4.76)	4 (9.52)	30 (71.43)	42 (100)	42 (100)
Total	42 (100)	42 (100)	42 (100)	42 (100)	42 (100)

Table 8.2. Clinical outcomes of Bracing Group (*N* = 9)*

Neurologic status	Admission, *N* (%)	6 mos, *N* (%)	12 mos, *N* (%)	18 mos, *N* (%)	24 mos, *N* (%)
Complete deficit	2 (22.22)	1 (11.11)	1 (11.11)	0	0
Incomplete deficits	2 (22.22)	3 (33.33)	1 (11.11)	0	0
No deficits	5 (55.56)	5 (55.56)	0	0	0
Lost to follow up	0	0	7 (77.78)	9 (100)	9 (100)
Total	9 (100)	9 (100)	9 (100)	9 (100)	9 (100)

Table 8.3. Clinical outcomes of Surgery Group (*N* = 13)*

Neurologic status	Admission, *N* (%)	6 mos, *N* (%)	12 mos, *N* (%)	18 mos, *N* (%)	24 mos, *N* (%)
Complete deficit	2 (15.38)	1 (7.69)	0	0	0
Incomplete deficits	11 (84.62)	10 (76.92)	6 (46.15)	0	0
No deficits	0	1 (7.69)	5 (38.46)	1 (7.69)	0
Lost to follow up	0	1 (7.69)	2 (15.38)	12 (92.31)	13 (100)
Total	13 (100)	13 (100)	13 (100)	13 (100)	13 (100)

*Percentages at each follow-up time point were calculated using the number of patients with documented neurologic status at that time point (available-case denominator). Lost to follow-up is cumulative from baseline. Missing neurologic documentation at a given time point was coded as no follow-up data

The average hospital stay of 52 days underscores inefficiencies in care delivery—an issue commonly seen in low-resource settings where diagnostic delays and prolonged preoperative evaluation are prevalent.[9] Moreover, the high attrition rate in follow-up (> 90% by two years) severely limits assessment of long-term outcomes. This reflects systemic barriers, including financial constraints, geographic inaccessibility, and limited continuity of care.[22,23] Therefore, this attrition level may bias outcome estimates toward more favorable results, as patients with persistent symptoms, complications, or progression may be less likely to return, while those who improve may not seek further follow-up. Thus, the observed recovery and deformity outcomes should be interpreted cautiously and primarily reflect patients with available follow-up data. Such limitations are clinically significant because 3–5% of patients globally may progress to severe kyphosis despite adequate chemotherapy.[24,25]

Overall, this study reinforces persistent challenges in the Philippine setting: late presentation, high neurologic deficit rates, predominant reliance on posterior-only surgery due to resource constraints, and poor long-term follow-up. These findings parallel global patterns but highlight the urgent need for earlier detection, improved access to imaging and surgical care, and strengthened follow-up systems. In practical terms for Philippine orthopaedic practice, these findings support: (1) early referral pathways from primary care and TB clinics for back pain with neurologic symptoms or deformity; (2) standardized baseline documentation (including neurologic grading and kyphosis measurement) to improve longitudinal assessment; and (3) pragmatic follow-up systems (e.g., scheduled TB-spine clinics, coordination with DOH-NTP treatment hubs, and low-cost SMS/telemedicine check-ins) to reduce attrition and better capture late deformity progression and neurologic outcomes. Finally, given institutional and financial constraints, treatment decisions should remain individualized—balancing disease severity (neurologic compromise, deformity, instability, abscess burden) against access to implants, surgical capacity, and the feasibility of sustained follow-up.

CONCLUSION

Tuberculous spondylitis predominantly affects unemployed young to middle-aged males**,** most commonly involving the thoracic spine and frequently presenting with neurologic deficits. While most patients were managed successfully with anti-Koch therapy alone, those who required surgery, performed exclusively through the posterior approach, achieved modest correction of deformity and documented short-term neurologic recovery.

Despite these observed short-term outcomes, the study highlights persistent challenges, particularly prolonged hospitalization and poor long-term follow-up, which restrict the ability to fully evaluate sustained outcomes. Given the high attrition rate, longer-term treatment success may be overestimated, as outcomes primarily reflect patients who

returned for follow-up. Addressing these gaps through earlier diagnosis, standardized care pathways, and improved patient follow-up systems is essential to optimize outcomes for spinal tuberculosis in high-burden settings.

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STATEMENT OF AUTHORSHIP

All authors certified fulfillment of ICMJE authorship criteria.

CREDIT AUTHOR STATEMENT

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DATA AVAILABILITY STATEMENT

The datasets generated and analyzed in this study are included in the published article.

AUTHOR DISCLOSURE

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ORIGINAL ARTICLE

Clinical and Patient-Reported Outcomes of Braganza-Tan (BT) Pass-Through Stump Incision, Stump-Sparing, and Stump-Sacrificing ACL Reconstruction Techniques Among Filipino Patients: A Randomized Controlled Trial

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ABSTRACT

Background. Anterior cruciate ligament reconstruction (ACLR) aims to restore knee stability and function following ligament injury. Remnant-preserving techniques have gained interest due to their potential benefits in proprioception, graft healing, and early functional recovery.

Objective. To compare the clinical and patient-reported outcomes, knee stability, and complication rates of the Braganza-Tan (BT) pass-through stump incision, the stump-sparing, and the stump-sacrificing techniques in ACLR using hamstring grafts among Filipino patients at the University of Santo Tomas Hospital.

Methodology. A prospective, randomized controlled trial was conducted among 90 Filipino patients aged 18–35 years diagnosed with acute primary anterior cruciate ligament (ACL) tear (< 6 weeks from injury) confirmed by MRI. Participants were block-randomized into three groups: BT pass-through stump incision, stump-sparing, and stump-sacrificing (n = 30 each). All underwent hamstring autograft reconstruction and a standardized rehabilitation protocol. Outcomes were assessed preoperatively and at three, six, nine, and 12 months using the International Knee Documentation Committee (IKDC) Scale, Tegner Activity Scale, Lysholm Score, and Hospital for Special Surgery (HSS) Score. Knee stability was evaluated through the Lachman, pivot shift, and anterior drawer tests, and an instrumented arthrometer. One-way ANOVA, Kruskal-Wallis tests, repeated-measures ANOVA, and mixed-effects models were used for analysis.

Results. All groups showed significant improvement from baseline across all functional scores ($p < 0.001$). However, both the BT and stump-sparing groups consistently demonstrated higher IKDC, Lysholm, HSS, and Tegner scores from three to 12 months compared with the stump-sacrificing group ($p < 0.01$). Knee stability tests showed significantly better early and midterm anterior and rotational control in the BT and stump-sparing groups ($p < 0.05$). Complications were lowest in the BT group, with no graft failures recorded, though this difference did not reach statistical significance. By 12 months, stability outcomes became comparable across all groups, although functional scores remained highest in the BT and stump-sparing groups.

Conclusion. The BT pass-through stump incision and conventional remnant-preserving techniques demonstrated superior early clinical outcomes and improved knee stability within the first 12 months compared with stump-sacrificing reconstruction in acute ACL tears. Longer-term follow-up is required to determine sustained graft durability and functional superiority.

Keywords. anterior cruciate ligament reconstruction, remnant preservation, knee stability, functional outcomes, Filipino patients

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INTRODUCTION

The anterior cruciate ligament (ACL) is essential for knee stability, especially during physical activities such as walking, running, jumping, or rapidly changing direction. It is the most frequently injured ligament in the knee during high-impact movements or sports, which highlights its vital role in proper knee function. The ACL serves as the primary restraint to anterior tibial translation and helps neutralize rotational stresses on the knee when under load.[1]

Besides its stabilizing function, the ACL contributes significantly to proprioception, which allows the brain to recognize the position and movement of the knee. Proprioception is an important part of the sensory-motor system that ensures balance, coordination, and posture during activity involving the knee joint. When the ACL is injured, proprioceptive feedback is disrupted, leading to impaired motor control and balance.[1]

Knee function following an ACL rupture is commonly restored through surgical reconstruction. Surgery remains the most effective means of reconstructing the torn ligament and reestablishing its biomechanical stability. The outcome of ACL reconstruction depends on several factors, including graft type, fixation method, and tunnel positioning. Common graft options include bone-patellar tendon-bone, hamstring, quadriceps tendon, and allografts.[2]

Although reported success rates for ACL reconstruction range from 80% to 90%, biological failure and graft re-rupture still occur in a notable percentage of cases. Failures have been linked to poor graft incorporation, inadequate revascularization, or loss of proprioceptive function—factors potentially addressed by preserving the ACL remnant during reconstruction.[3]

Remnant-preserving or stump-retention techniques have been introduced to enhance biological and functional recovery after ACL reconstruction. Stump retention in ACL reconstruction surgery was originally credited to Adachi et al.[4] Studies have demonstrated that preserving the native stump may promote synovial coverage, graft revascularization, and maintenance of mechanoreceptors such as Ruffini, Pacinian, and Golgi-like endings, all of which contribute to proprioceptive restoration.[5] Despite the technique's proposed biological advantages, there are potential disadvantages. Excessive remnant tissue may obscure visualization during tunnel placement, increase technical difficulty, and potentially contribute to impingement or symptomatic cyclops lesions.[3,6,7] Variability in remnant volume and quality may also lead to inconsistent biomechanical behavior.[8] These concerns underscore the need for controlled comparative studies evaluating the clinical relevance of remnant-preserving techniques.

Stump preservation is also associated with improved quadriceps strength and lower rates of graft failure and revision surgery. The stump-sparing approach retains the entire ACL tibial remnant without incision, maximizing preservation of vascular and sensory structures. The Braganza-Tan (BT) pass-through stump incision technique, developed in the Philippines, represents a distinct modification that involves a controlled incision through the tibial stump to allow graft passage while still preserving its biological and proprioceptive benefits. The BT technique differs from conventional remnant preservation by incorporating controlled stump incision and guided graft passage, aiming to preserve vascular and mechanoreceptor structures while minimizing remnant redundancy. In contrast, the stump-sacrificing technique involves complete removal of the ACL remnant, eliminating potential advantages associated with stump preservation but simplifying graft insertion and tunnel visualization.

Currently, no study has compared the Braganza-Tan (BT) pass-through stump incision, stump-sparing, and stump-sacrificing ACL reconstruction techniques in a single randomized trial. Most orthopedic surgeons in the country continue to perform stump-sacrificing reconstruction as the standard approach for restoring knee stability. However, increasing local interest in stump-preserving methods highlights the need for evidence comparing these evolving techniques. The BT method, first introduced and applied locally, aims to balance remnant preservation with technical feasibility using standard arthroscopic portals. Comparing these three methods in one study will help determine whether the BT technique achieves outcomes comparable to stump-sparing reconstruction and superior to the stump-sacrificing technique in terms of functional recovery and patient satisfaction.

This study hypothesized that the BT and the stump-sparing technique would demonstrate comparable clinical and patient-reported outcomes, both superior to the stump-sacrificing ACL reconstruction among Filipino patients at the University of Santo Tomas Hospital. The study aimed to compare these three techniques in terms of knee stability, functional scores, and complication rates.

To compare the clinical and patient-reported outcomes of the Braganza-Tan (BT) pass-through stump incision, the stump-sparing and the stump-sacrificing techniques in ACLR using hamstring grafts among Filipino patients at the University of Santo Tomas Hospital.

1. To determine significant differences in clinical and functional scores, specifically:
    a. International Knee Documentation Committee (IKDC) Scale
    b. Tegner Activity Scale
    c. Lysholm Score
    d. Hospital for Special Surgery (HSS) Score
2. To determine significant differences in knee stability, specifically:
    a. Lachman Test
    b. Pivot Shift Test
    c. Anterior Drawer Test
    d. Instrumented Arthrometer

3. To compare the complication rates among patients undergoing the Braganza-Tan (BT) pass-through stump incision technique, the stump-sparing technique, and the stump-sacrificing ACLR.

METHODOLOGY

This study was a prospective, randomized controlled trial involving three parallel groups. The participants were Filipino patients at the University of Santo Tomas Hospital diagnosed with anterior cruciate ligament (ACL) tear confirmed through magnetic resonance imaging (MRI). Eligible patients underwent one of three surgical techniques of ACL reconstruction (ACLR): the Braganza-Tan (BT) pass-through stump incision technique, the stump-sparing technique, or the stump-sacrificing technique. All patients were evaluated preoperatively using standardized functional and knee stability tests and reassessed postoperatively at three, six, nine, and 12 months. This was a single-center, patient- and assessor-blinded trial, with the operating surgeons remaining unblinded due to the nature of the surgical interventions.

Subject selection criteria

Inclusion criteria

1. Filipinos diagnosed with Anterior Cruciate Ligament (ACL) tear confirmed by MRI
2. Male or female patients aged 18 to 35 years old
3. Individuals of any occupation and activity level (sedentary to athletic)
4. Patients able to understand and follow verbal instructions
5. Patients who voluntarily agree to participate and sign the informed consent
6. Participants from private or clinical (charity) divisions of the University of Santo Tomas Hospital
7. Patients with an acute primary ACL tear (< 6 weeks from injury)
8. No prior ACL reconstruction or revision surgery in the affected knee

Exclusion criteria

1. Patients diagnosed with other conditions that may affect knee stability (e.g., meniscus tear, posterior cruciate ligament tear, posterolateral corner injury)
2. Chronic ACL tears (> 6 weeks from injury)
3. Previous ligament surgery on the affected knee
4. Patients who cannot comprehend the questionnaires due to cognitive impairment
5. Unable to follow verbal instructions
6. Patients who did not consent to participate in the study

Limiting enrollment to acute ACL tears minimized confounding factors such as chronic instability, secondary meniscal degeneration, and adaptive inflammatory changes.

Data collection

Patients were selected and recruited according to the inclusion and exclusion criteria. Demographic information, including age, sex, occupation, and activity level were documented. After a general evaluation that included clinical history, past medical history, and physical examination, the patient's eligibility to participate was determined. Written informed consent was obtained before enrollment. Participants were recruited from both the clinical (charity) department and private patient services to ensure equitable distribution of research participation across patient populations.

Institutional Review Board and Ethics Committee approvals were secured before commencing participant enrollment. Each enrolled participant was assigned a unique study code to preserve anonymity and confidentiality of data in compliance with the Data Privacy Act of 2012.

Block randomization was employed to generate equal groups, with allocation concealment maintained through a sealed opaque envelope technique. A total of 90 participants were randomized in a 1:1:1 ratio into one of three groups:

1. Braganza-Tan (BT) pass-through stump incision technique
2. Stump-sparing technique
3. Stump-sacrificing technique

The sample size of 90 participants was chosen to match the requirements of a three-group design with equal allocation. Thirty participants per technique provided enough power to detect meaningful differences in functional outcomes based on commonly reported effects in ACL reconstruction research. This number kept the comparisons reliable while staying realistic for the recruitment capacity of the study site. The adjustment also reflected the shift from the original two-group structure to a three-arm comparison, which prioritized balanced representation across procedures. The revised size supported valid statistical analysis without compromising the study's ability to detect clinically important results. The reduction from 126 participants was therefore a methodological recalibration suited to the updated design.

Randomization was determined on the day of surgery by drawing a sealed envelope to ensure allocation concealment. This three-arm design allowed comparison among stump-preserving and stump-sacrificing techniques, thereby minimizing confounding variables and enabling more comprehensive conclusions regarding the clinical and functional outcomes of the BT method.

All operative procedures were performed by two orthopedic surgeons, both highly experienced in stump-preserving and stump-sacrificing ACL reconstructions. To ensure unbiased evaluation of outcomes, all clinical and functional assessments were conducted by independent consultants who were not part of the surgical team. A single primary assessor evaluated all participants throughout the study, assisted

by a trained research fellow to ensure consistency in data collection. Since Dr. Braganza was the developer of the BT technique, this potential conflict of interest was formally disclosed. To mitigate bias, all postoperative assessments were performed exclusively by blinded, independent assessors with no financial or academic interest in any of the compared techniques.

The primary outcome of this trial was functional recovery, measured using the Lysholm score. Secondary outcomes included other patient-reported measures such as the International Knee Documentation Committee (IKDC) scale, Tegner Activity Scale, and Hospital for Special Surgery (HSS) score, as well as knee stability tests, including the Lachman test, pivot shift test, anterior drawer test, and instrumented arthrometer measurements.

Before surgery, all patients underwent detailed clinical evaluation and magnetic resonance imaging (MRI) to confirm ACL injury and assess for concomitant meniscal or ligamentous lesions. Clinical and functional assessments were conducted preoperatively and postoperatively at three, six, nine, and 12 months.

Possible complications were systematically monitored and recorded throughout the study, including graft failure, infection, knee stiffness or arthrofibrosis, persistent instability, hardware-related issues, neurovascular injury, donor site morbidity, and cyclops lesion formation. Both intraoperative and postoperative complications were documented to enable safety comparisons.

Surgical procedure

All procedures were performed with the patient in the supine position under regional or spinal anesthesia and pneumatic tourniquet control. An examination under anesthesia was conducted to confirm the diagnosis and rule out any concomitant multi-ligamentous injuries.

Hamstring autografts were harvested in all patients. Diagnostic knee arthroscopy was performed using standard anterolateral and anteromedial portals. The intercondylar notch was prepared using an arthroscopic shaver to ensure adequate visualization and graft placement. In Group A (Braganza-Tan pass-through stump incision [BT]) and Group C (stump-sparing), tibial stump fibers were preserved. Specifically, in Group A, the graft was passed through a small incision within the remnant stump to incorporate the native fibers, while in Group C, the tibial tunnel was directed over the center of the remnant without incision or disruption. In Group B (stump-sacrificing), the tibial stump was completely debrided to create a clear tunnel path for conventional ACL reconstruction.

Anatomic drilling of the femoral tunnel preceded tibial tunnel preparation. With the knee flexed beyond 90°, the femoral insertion was marked approximately at 40% of the proximal-to-distal distance of the lateral notch, centered between the lateral intercondylar ridge and the posterior edge of the lateral femoral condyle. The ACL remnant stump and lateral femoral condyle were visualized during this step (Figure 2). The femoral tunnel was then created (Figure 3).

In Group A (BT), the tibial tunnel was directed toward the center of the tibial stump. A stab incision using a No. 11 blade was made over the ACL remnant stump to prepare the site (Figure 4). The tibial tunnel was then created through the ACL remnant stump, allowing the graft to pass through and maintain continuity with the preserved fibers (Figure 5). In Group B (stump-sacrificing group), where the stump was resected, the tibial tunnel was directed toward the posterior border of the anterior horn of the lateral meniscus, approximately 7 mm anterior to the posterior cruciate ligament (PCL). In Group C (stump-sparing group), the tibial tunnel

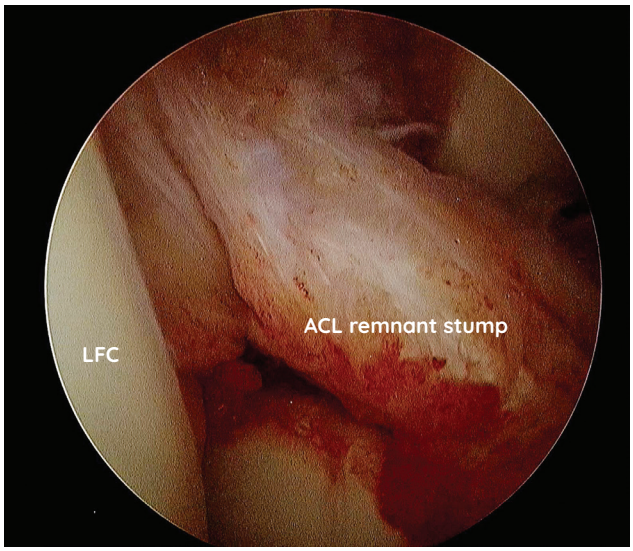

Figure 1. Arthroscopic view of the knee showing the remnant stump adjacent of the anterior cruciate ligament (ACL) adjacent to the lateral femoral condyle (LFC).

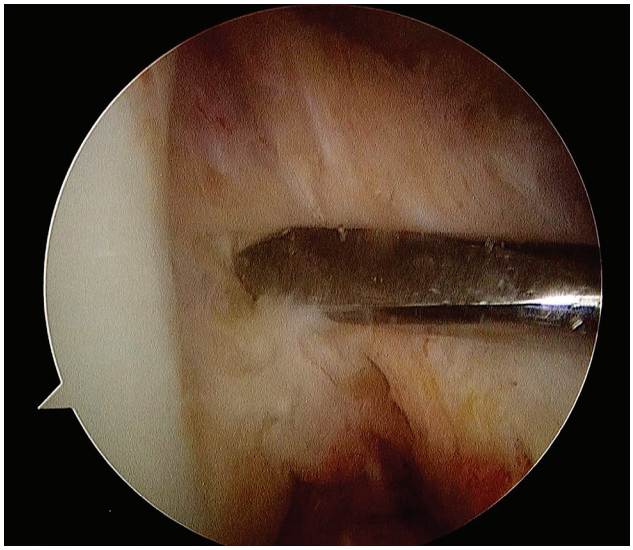

Figure 2. Arthroscopic view demonstrating femoral tunnel creation at the anatomic ACL footprint using a drill guide.

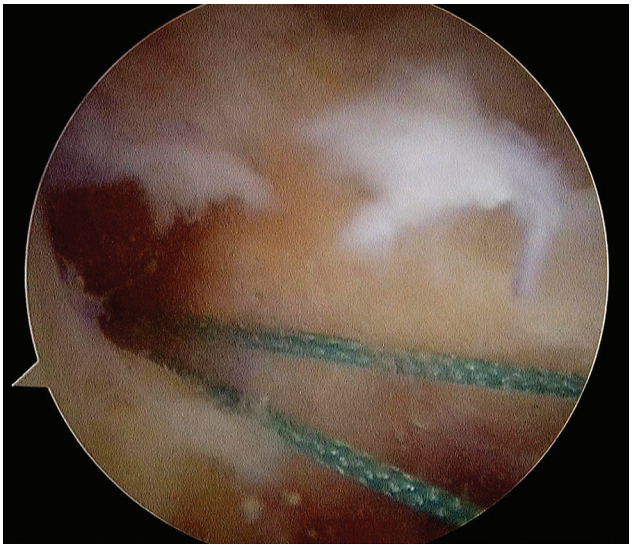

Figure 3. Arthroscopic view of the prepared femoral tunnel before graft passage.

was directed over the center of the tibial stump without incising or disturbing the remnant fibers, preserving the native attachment and proprioceptive elements of the ACL stump.

The tibial tunnel was prepared (Figures 6 and 7). The graft was then passed through both tunnels (Figure 8). The graft was fixed with bioabsorbable interference screws on both the femoral and tibial sides (Figure 9).

Post operative regimen

After surgery, patients were discharged on the same day or within 24 hours. Both groups underwent a uniform rehabilitation program guided by the latest evidence-based protocols to minimize differences in recovery. The initial phase of rehabilitation focused on achieving full active knee extension and allowing full weight-bearing as tolerated, supported with a knee immobilizer. Flexion exercises were limited to less than 90° during the first two weeks, with progressive increases

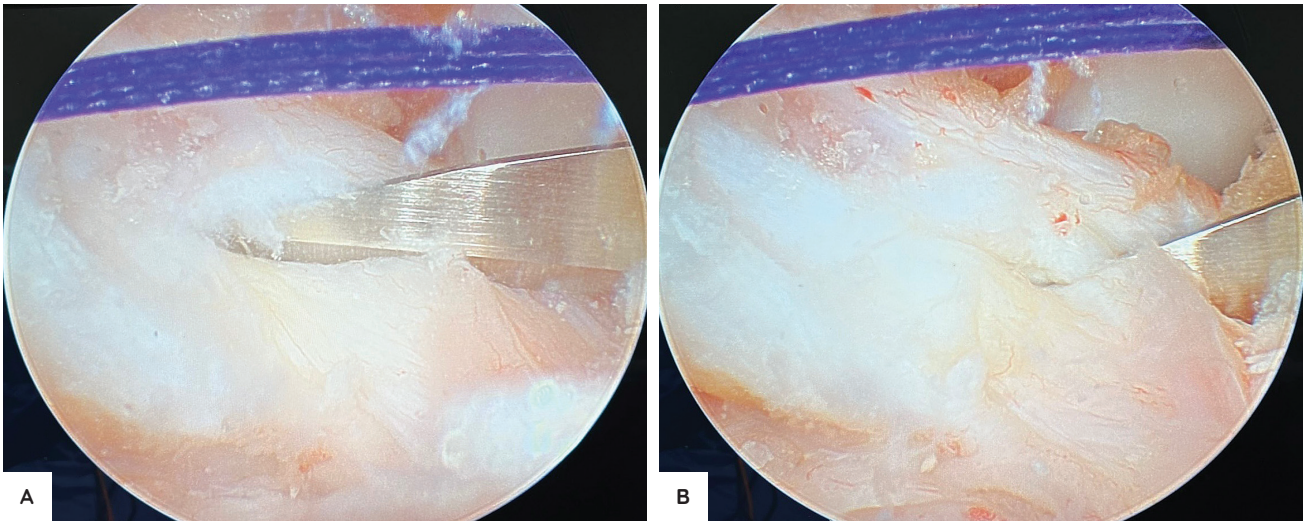

Figure 4. Stab incision using a No. 11 blade over the ACL remnant stump in the Braganza–Tan (BT) stump incorporation technique: initial stab incision over the ACL remnant stump **(A)**; completion of the incision through the remnant tissue **(B)**.

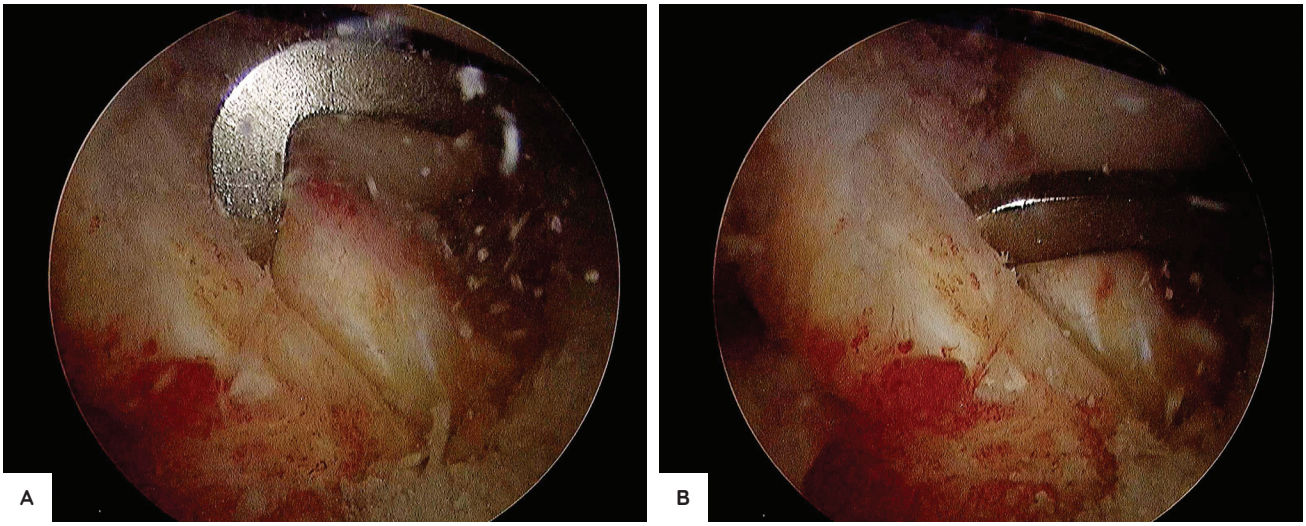

Figure 5. Tibial tunnel creation over the ACL remnant stump: positioning of the tibial guide over the ACL remnant stump **(A)**; drilling of the tibial tunnel through the remnant stump **(B)**.

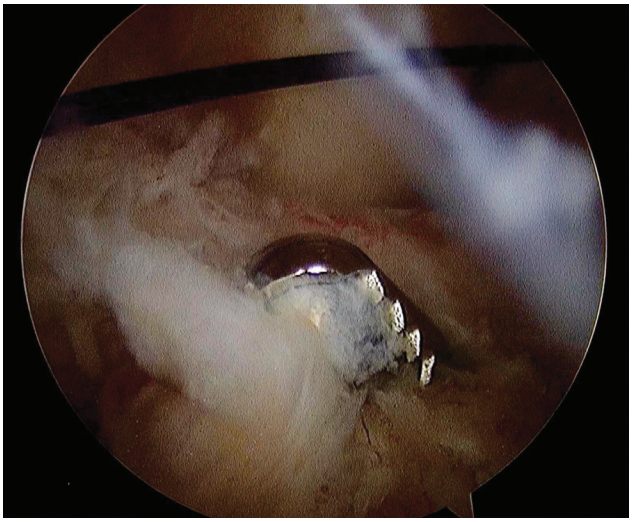

Figure 6. Arthroscopic view of tibial tunnel creation.

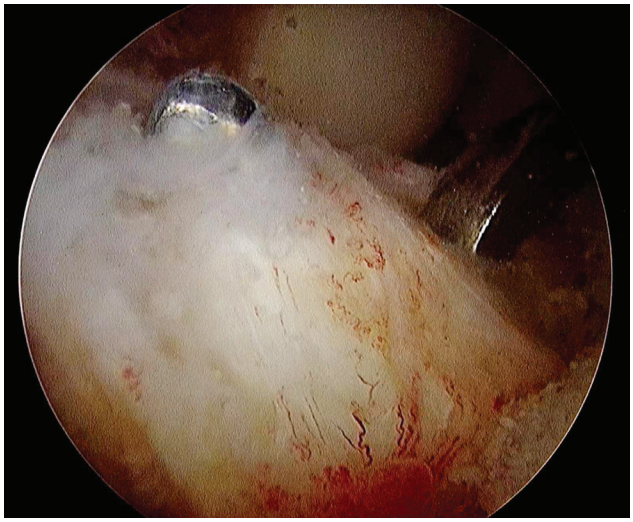

Figure 7. Arthroscopic view demonstrating preparation of the tibial tunnel.

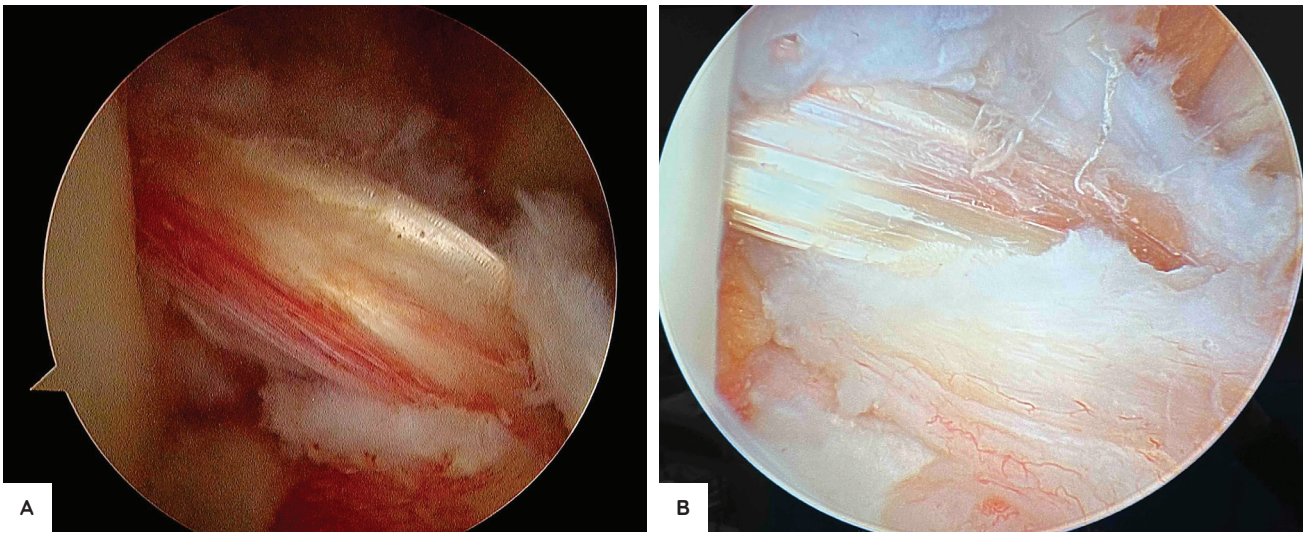

Figure 8. Arthroscopic view demonstrating passage of the ACL graft through the tibial tunnel: initial passage of the ACL graft through the tunnel **(A)**; advancement of the graft within the tunnel **(B)**.

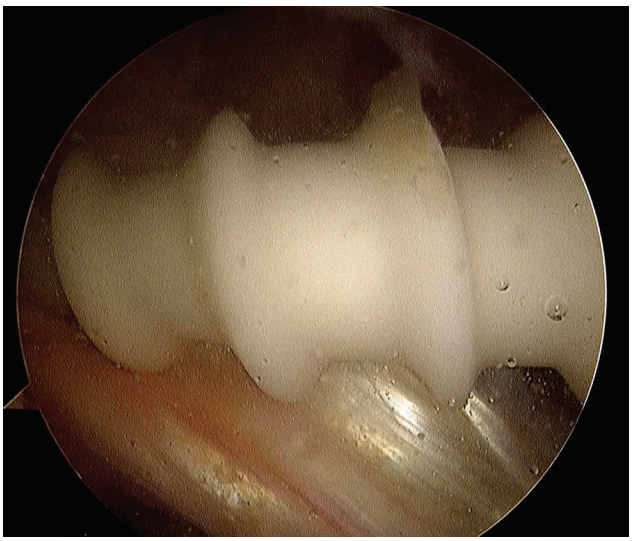

Figure 9. ACL graft fixation using bioabsorbable interference screw.

introduced thereafter until full flexion was attained. Sutures were removed after two weeks, and follow-up visits were scheduled every two weeks throughout the first 12 weeks. Therapy prioritized regaining complete range of motion, progressive weight-bearing, and strengthening the quadriceps and hamstrings.

Four to five months after surgery, patients were allowed to start straight-line running once sufficient strength and stability were demonstrated. Participation in contact or pivoting sports was permitted at nine months post-surgery, contingent upon functional recovery and results of stability assessments.

Stability and standardized outcome scores were assessed at three, six, nine, and 12 months following surgery.

Statistical methods

Descriptive statistics, including mean, standard deviation (SD), frequency, and percentage, were used to summarize the demographic and baseline characteristics of participants, such as age, height, weight, gender, and employment status. Continuous variables are presented as mean ± SD, while categorical variables are expressed as counts and percentages.

To determine differences in continuous outcome scores among the three surgical techniques, a one-way analysis of variance (ANOVA) was performed. The *F* value indicates the ratio of between-group to within-group variance, and a *p*-value less than 0.05 was considered statistically significant. A repeated measures ANOVA was used to evaluate within-group changes in clinical and functional scores over time from preoperative assessment to 12 months postoperatively. The *F* statistic measured overall change across timepoints, and η^2 (eta squared) was used to determine the effect size, representing the magnitude of observed improvements within each group.

For ordinal or non-normally distributed data (such as the Tegner Activity Scale and knee stability tests), the Kruskal-Wallis test was applied. The *H* statistic indicates group variance, while the *p*-value identified significant differences. The η^2 value is reported to show the strength of association and relative effect size.

To account for repeated ordinal data and correlated observations, particularly for changes in activity level over time, an ordinal mixed-effects model was employed. This model simultaneously considers both time and group effects for the Tegner Activity Scale, providing more accurate estimates of progression. The estimate (β) shows the degree of score change per month or per surgical group, and the Z-value tested whether each estimate differed significantly from zero.

For categorical outcomes such as infection, graft failure, stiffness, and other complications, the Chi-square (χ^2) test was used to assess associations between the type of surgical technique and the occurrence of complications. The χ^2 value indicates the strength of association, while the *p*-value determines whether differences were statistically significant.

Statistical significance was set at $p < 0.05$, and all analyses were conducted using standard statistical software.

RESULTS

All three groups had more males than females. All participants were young adults, and most were employed. All groups had similar mean heights and weights (Table 1).

Preoperative IKDC scores were similar across the three groups (*F*-value = 0.03, *p*-value = 0.972) (Table 2). The BT and stump-sparing groups consistently had statistically significantly higher scores than the stump-sacrificing group at three, six, nine, and 12 months postoperatively (Table 2). All groups, however, had significant improvements in scores over time ($p < 0.001$), with the effect sizes being largest for the

Table 1. Demographic profile for both groups

	BT (*N* = 30)	Stump-sacrificing (*N* = 30)	Stump-sparing (*N* = 30)
Age (mean ± SD)	25.6 ± 4.2 years	26.1 ± 4.5 years	25.8 ± 4.0 years
Gender (male/female)	28 / 14	27 / 15	26 / 16
Employment (employed/unemployed)	30 / 12	29 / 13	28 / 14
Height (cm)	168.5 ± 7.4	169.2 ± 6.9	168.8 ± 7.1
Weight (kg)	65.8 ± 8.1	66.4 ± 7.6	65.9 ± 8.3

Table 2. Between-group comparison of International Knee Documentation Committee (IKDC) using one-way analysis of variance (*N* = 30 per group)

Timepoint	BT, Mean ± SD	Stump-sacrificing, Mean ± SD	Stump-sparing, Mean ± SD	*F* value	*p*-value	Interpretation
Pre-op	38.8 ± 5.9	38.5 ± 6.2	38.7 ± 6.0	0.03	0.972	No significant difference at baseline
3 months	71.6 ± 6.5	65.4 ± 7.1	70.2 ± 6.8	6.72	0.002	Significant; *BT and stump-sparing higher than ACLR*
6 months	80.5 ± 6.9	74.2 ± 6.8	79.1 ± 7.2	8.41	< 0.001	Significant; *BT and stump-sparing higher than ACLR*
9 months	84.9 ± 6.3	78.1 ± 7.0	83.8 ± 6.5	9.15	< 0.001	Significant; *BT and stump-sparing higher than ACLR*
12 months	87.7 ± 6.7	81.0 ± 7.4	86.9 ± 6.8	8.98	< 0.001	Significant; *BT and stump-sparing higher than ACLR*

Table 3. Longitudinal changes in IKDC Scale

Group	*F* statistic	*p*-value	Effect Size (η^2)	Interpretation
BT Group	68.5	< 0.001	0.62	Significant improvement over time
Stump-sacrificing Group	54.3	< 0.001	0.55	Significant improvement over time
Stump-sparing Group	66.1	< 0.001	0.60	Significant improvement over time

BT group ($\eta^2 = 0.62$) (Table 3). Preoperative Tegner Activity Scale scores were identical across the three groups (median = 3, range 2–3, $H = 0.12$, $p = 0.942$), indicating no significant difference at baseline. At three, six, nine, and 12 months, the BT and stump-sparing groups had statistically significantly higher scores than the stump-sacrificing group (Table 4). When analyzed over time, Tegner scores significantly increased for all patients ($p < 0.001$) (Table 5). When comparing longitudinal improvement between groups, BT was superior to stump-sacrificing ($\beta = +0.82$, $Z = 3.56$, 95% CI = 0.36 to 1.28, $p < 0.001$), stump-sparing was superior to stump-sacrificing ($\beta = +0.75$, $Z = 3.10$, 95% CI = 0.28 to 1.22, $p = 0.002$), and BT was comparable to stump-sparing ($\beta = +0.07$, $Z = 0.33$, 95% CI = -0.34 to 0.48, $p = 0.739$) (Table 5).

Preoperative Lysholm scores were similar across all groups ($F = 0.07$, $p = 0.932$). At three, six, nine, and 12 months, the BT and stump-sparing groups outperformed the stump-sacrificing group ($p < 0.001$) (Table 6). All groups presented significant improvement over time ($p < 0.001$), with the BT group showing the largest effect size ($\eta^2 = 0.64$) (Table 7).

Preoperative HSS scores were similar across the groups ($F = 0.03$, $p = 0.970$). At three, six, nine, and 12 months, the BT and stump-sparing groups had higher scores than the stump-sacrificing group (Table 8). All groups had significant improvement over time ($p < 0.001$), with the BT group having the highest effect size ($\eta^2 = 0.64$).

At baseline, there was no significant difference in Lachman testing among the groups ($H = 0.41$, $p = 0.815$, $\eta^2 = 0.01$). At three, six, nine, and 12 months postoperatively, the BT and stump-sparing groups showed better stability on Lachman testing than the stump-sacrificing group, with the effect size decreasing over time (Table 10).

At baseline, there was no significant difference in pivot shift testing among the groups ($H = 46.0$, $p = 0.694$, $\eta^2 = 0.07$). At three, six, nine, and 12 months postoperatively, the BT and stump-sparing groups showed better stability on pivot shift testing than the stump-sacrificing group (Table 11).

At baseline, there was no significant difference in anterior drawer test results among the groups ($H = 0.47$, $p = 0.789$, $\eta^2 = 0.01$). At three, six, and nine months postoperatively, the BT and stump-sparing groups showed better stability than the stump-sacrificing group. At 12 months, the effect size was small ($\eta^2 = 0.09$), showing comparable stability among the three groups (Table 12).

Table 4. Between-group comparison of Tegner Activity Scale using Kruskal–Wallis test (*N* = 30 per group)

Timepoint	BT, Mean ± SD	Stump-sacrificing, Mean ± SD	Stump-sparing, Mean ± SD	*F* value	*p*-value	Interpretation
Pre-op	3 (2–3)	3 (2–3)	3 (2–3)	0.12	0.942	No significant difference at baseline
3 months	5 (4–6)	4 (3–5)	5 (4–6)	9.25	0.010	Significant; *BT and stump-sparing superior to ACLR*
6 months	6 (5–7)	5 (4–6)	6 (5–7)	11.46	0.004	Significant; *BT and stump-sparing outperform ACLR*
9 months	7 (6–7)	5 (4–6)	7 (6–7)	16.32	< 0.001	Significant; *BT and stump-sparing best*
12 months	7 (6–7)	6 (5–6)	7 (6–7)	13.58	0.001	Significant; *BT and stump-sparing highest Tegner scores*

Table 5. Study characteristics

Fixed Effect	Estimate (β)	SE	*Z*-value	95% CI	*p*-value	Interpretation
Time (months)	+0.43	0.08	5.25	0.27 – 0.59	< 0.001	Significant increase in Tegner scores over time
Group (stump-sacrificing vs BT)	+0.82	0.23	3.56	0.36 – 1.28	< 0.001	BT significantly higher than stump-sacrificing
Group (stump-sacrificing vs stump-sparing)	+0.75	0.24	3.10	0.28 – 1.22	0.002	SSP significantly higher than stump-sacrificing
Group (BT vs stump-sparing)	+0.07	0.21	0.33	-0.34 – 0.48	0.739	No significant difference between BT and stump-sparing

Table 6. Between-group comparison of Lysholm score using one-way analysis of variance (*N* = 30 per group)

Timepoint	BT, Mean ± SD	Stump-sacrificing, Mean ± SD	Stump-sparing, Mean ± SD	*F* value	*p*-value	Interpretation
Pre-op	41.9 ± 6.1	42.3 ± 5.8	42.0 ± 6.0	0.07	0.932	No significant difference at baseline
3 months	74.5 ± 6.9	68.2 ± 7.4	73.1 ± 6.8	8.14	< 0.001	Significant; *BT and stump-sparing better than stump-sacrificing*
6 months	84.2 ± 7.1	77.9 ± 6.8	83.0 ± 7.0	9.72	< 0.001	Significant; *BT and stump-sparing better than stump-sacrificing*
9 months	88.1 ± 6.5	82.6 ± 7.2	87.0 ± 6.4	7.88	< 0.001	Significant; *BT and stump-sparing better than stump-sacrificing*
12 months	91.4 ± 6.2	84.8 ± 7.5	90.3 ± 6.6	10.25	< 0.001	Significant; *BT and stump-sparing better than stump-sacrificing*

At baseline, there was no significant difference in instrumented arthrometer results among the groups ($H = 0.58$, $p = 0.749$, $\eta^2 = 0.01$). At three, six, and nine months postoperatively, the BT and stump-sparing groups showed better stability than the stump-sacrificing group. At 12 months, the effect size was small ($\eta^2 = 0.08$), showing comparable stability among the three groups (Table 12).

Individual complications—including infection, joint stiffness, graft failure, and cyclops lesion—were generally low across all groups with no statistically significant differences. When evaluating the overall complication rate, the BT group had the lowest incidence at 20%, followed by the stump-sparing group at 26.7%, and the stump-sacrificing group at 43.3% ($\chi^2 = 5.42$, $p = 0.066$). Although the difference is not statistically significant, it indicates a clinically meaningful trend, with the BT group demonstrating fewer complications overall.

In summary, while individual complications did not differ significantly, the BT technique shows a favorable safety profile with fewer overall complications.

DISCUSSION

This study evaluated the clinical, functional, and mechanical outcomes of patients undergoing anterior cruciate ligament reconstruction (ACLR) using three techniques: the Braganza-Tan (BT) pass-through stump incision technique, the stump-sparing technique, and conventional stump-sacrificing ACLR. Outcomes were assessed using functional scales, knee stability tests, and complication rates.

Functional and clinical scores

International Knee Documentation Committee (IKDC) scale

Patients who underwent the BT or stump-sparing reconstruction had better overall knee function, improved confidence during movement, and likely a safer return to higher levels of activity or sports. Tibial stump preservation may accelerate functional recovery, may enhance knee stability, and may have superior short-term outcomes compared with conventional ACLR.

Table 7. Longitudinal changes in Lysholm score

Group	*F* statistic	*p*-value	Effect Size (η^2)	Interpretation
BT Group	73.1	< 0.001	0.64	Significant improvement over time
ACLR Group	59.4	< 0.001	0.58	Significant improvement over time
Stump-sparing Group	70.2	< 0.001	0.62	Significant improvement over time

Table 8. Between-group comparison of Hospital for Special Surgery score (HSS) using one-way analysis of variance (*N* = 30 per group)

Timepoint	BT, Mean ± SD	Stump-sacrificing, Mean ± SD	Stump-sparing, Mean ± SD	*F* value	*p*-value	Interpretation
Pre-op	41.0 ± 5.7	41.3 ± 5.9	41.2 ± 5.5	0.03	0.970	No significant difference at baseline
3 months	76.3 ± 7.0	75.1 ± 7.2	70.6 ± 7.8	6.51	0.002	Significant; *BT and stump-sparing better than stump-sacrificing*
6 months	84.8 ± 6.6	83.6 ± 6.8	78.9 ± 7.1	8.12	<0.001	Significant; *BT and stump-sparing better than stump-sacrificing*
9 months	89.6 ± 6.8	88.3 ± 6.5	83.2 ± 7.3	7.85	< 0.001	Significant; *BT and stump-sparing better than stump-sacrificing*
12 months	92.2 ± 6.4	91.0 ± 6.6	86.1 ± 7.0	7.19	0.001	Significant; *BT and stump-sparing better than stump-sacrificing*

Table 9. Longitudinal changes in HSS

Group	*F* statistic	*p*-value	Effect Size (η^2)	Interpretation
BT Group	73.3	< 0.001	0.65	Significant improvement over time
Stump-sacrificing Group	71.1	< 0.001	0.63	Significant improvement over time
ACLR Group	61.1	< 0.001	0.58	Significant improvement over time

Table 10. Kruskal–Wallis test for Lachman test results

Group	*H* statistic	*p*-value	Effect Size (η^2)	Interpretation
Pre-op	0.41	0.815	0.01 (negligible)	Not Significant at baseline
3 months	7.25	0.027	0.14 (medium)	Significant; *BT and stump-sparing better than stump-sacrificing*
6 months	6.68	0.035	0.12 (small–medium)	Significant; *BT and stump-sparing better than stump-sacrificing*
9 months	8.54	0.014	0.16 (medium)	Significant; *BT and stump-sparing better than stump-sacrificing*
12 months	5.02	0.018	0.09 (small)	Significant; *Stability becomes comparable across all groups*

Table 11. Kruskal-Wallis test for pivot shift test results

Group	*H* statistic	*p*-value	Effect Size (η^2)	Interpretation
Pre-op	46.0	0.694	0.07 (small)	No difference at baseline
3 months	23.0	0.039	0.31 (medium)	Significant; *BT and stump-sparing better than stump-sacrificing*
6 months	21.0	0.027	0.36 (medium)	Significant; *BT and stump-sparing better than stump-sacrificing*
9 months	32.0	0.049	0.28 (small)	Significant; *BT and stump-sparing better than stump-sacrificing*
12 months	26.0	0.048	0.34 (medium)	Significant; *BT and stump-sparing better than stump-sacrificing*

Table 12. Kruskal–Wallis test for anterior drawer test results

Group	*H* statistic	*p*-value	Effect Size (η^2)	Interpretation
Pre-op	0.47	0.789	0.01 (negligible)	Not Significant at baseline
3 months	6.95	0.031	0.13 (medium)	Significant; *BT and stump-sparing better than stump-sacrificing*
6 months	7.64	0.023	0.14 (medium)	Significant; *BT and stump-sparing better than stump-sacrificing*
9 months	8.48	0.015	0.16 (medium)	Significant; *BT and stump-sparing better than stump-sacrificing*
12 months	5.16	0.016	0.09 (small)	Significant; *Stability outcomes are comparable*

Table 13. Kruskal–Wallis test for instrumented arthrometer results

Group	*H* statistic	*p*-value	Effect Size (η^2)	Interpretation
Pre-op	0.58	0.749	0.01 (negligible)	Not Significant at baseline
3 months	7.82	0.020	0.14 (medium)	Significant; *BT and stump-sparing better than stump-sacrificing*
6 months	9.03	0.011	0.16 (medium)	Significant; *BT and stump-sparing better than stump-sacrificing*
9 months	10.21	0.006	0.19 (medium–large)	Significant; *BT and stump-sparing better than stump-sacrificing*
12 months	4.69	0.013	0.08 (small)	Significant; *Comparable among all groups*

Table 14. Comparison of complication rates

Complication	BT, (*n* = 30)	Stump-sacrificing, (*n* = 30)	Stump-sparing, (*n* = 30)	χ^2 (Chi-square)	*p*-value	Interpretation
Infection	1 (3.3%)	3 (10.0%)	2 (6.7%)	$\chi^2 = 1.24$	0.537	Not significant
Joint stiffness	2 (6.7%)	5 (16.7%)	3 (10.0%)	$\chi^2 = 1.89$	0.389	Not significant
Graft failure	0 (0%)	3 (10.0%)	1 (3.3%)	$\chi^2 = 4.26$	0.119	Not significant
Cyclops lesion	2 (6.7%)	0 (0%)	3 (10.0%)	$\chi^2 = 1.52$	0.310	Not significant
Overall complication rate	6 (20.0%)	13 (43.3%)	8 (26.7%)	$\chi^2 = 5.42$	0.066	Not significant; favoring BT

Tegner activity scale

Remnant-preserving techniques enabled a faster and higher rate of return to activity compared with stump-sacrificing ACL reconstruction. These findings underscore the functional advantage of maintaining tibial stump integrity.

Lysholm score

ACL tibial stump preservation provided lasting improvements in pain control, knee stability, and overall functional capacity compared with conventional stump-sacrificing reconstruction. While all three surgical techniques led to significant improvements in Lysholm scores over time, the stump-preserving techniques consistently provided higher functional gains and more robust recovery.

Hospital for Special Surgery (HSS) score

Remnant-preserving ACL reconstruction provided better overall functional restoration, improved knee stability, and more effective pain control compared with the stump-sacrificing technique.

These patients achieved faster, greater, and more sustained functional recovery throughout the first postoperative year.

Although statistically significant differences were observed among groups, the between-group differences in IKDC and Lysholm scores did not consistently reach the established minimal clinically important difference (MCID) threshold of 10–15 points.[9,10] Therefore, while remnant-preserving techniques demonstrated measurable statistical benefit, the clinical relevance of these differences within the first postoperative year should be interpreted cautiously.

Knee stability

Lachman test

The BT and stump-sparing groups demonstrated significantly better anterior knee stability than the stump-sacrificing group from three to nine months postoperatively, with the difference diminishing by twelve months. Early gains in stability are clearly more pronounced in the stump-preserving groups, though conventional ACL reconstruction catches up in mechanical stability as healing and rehabilitation progress.

Pivot shift test

BT and stump-sparing groups showed superior rotational stability compared with stump-sacrificing ACLR from three to twelve months, demonstrating consistent preservation of rotational control throughout the first postoperative year.

Anterior drawer test

BT and stump-sparing groups maintained better anterior stability than stump-sacrificing ACLR from three to nine months, reflecting superior graft control and anterior knee stability. Differences decreased by one year.

Instrumented arthrometer

Knee laxity was lower in the BT and stump-sparing groups compared with stump-sacrificing ACLR during early and midterm follow-up, confirming improved mechanical stability with tibial stump preservation. Advantages diminished slightly by twelve months.

The BT technique may have offered potential advantages over conventional remnant-preserving approaches by allowing controlled incision and guided graft passage through the tibial stump. This approach may optimize graft-remnant contact while preventing excessive remnant bulk, theoretically balancing biological preservation with mechanical precision. Several remnant-preserving techniques have been described, including selective tibial stump preservation and tensioned remnant-retaining reconstruction. Lee et al. reported improved graft synovialization in remnant-preserving ACL reconstruction.[11] Kim et al. demonstrated improved anterior stability and early functional recovery without increased complication rates.[12] A systematic review by Takazawa et al. concluded that remnant preservation may enhance early knee stability and graft maturation, although long-term outcomes remain comparable to conventional techniques.[3] Nevertheless, some authors have noted an increased risk of cyclops lesions when excessive remnant tissue is retained.[7] Overall, evidence suggests that remnant preservation is at least non-inferior to stump-sacrificing reconstruction when performed with meticulous technique.

Complication rates

Postoperative complications were generally low across all groups. Overall complication rates were lowest in the BT group (20%), followed by stump-sparing (26.7%), and stump-sacrificing ACLR (43.3%). These results indicate that tibial stump preservation may reduce postoperative complications through enhanced graft protection and biological healing.

While early postoperative outcomes in this study are promising, medium- and long-term follow-up (5–10 years) will be necessary to determine graft durability and re-rupture rates. The degree of remnant retention has been proposed as a factor influencing both biological integration and the risk of cyclops lesion formation. Excessive remnant bulk may theoretically predispose to anterior impingement and fibrous nodule development. In our surgical technique, controlled remnant incision and guided graft passage were performed to preserve biologically valuable tissue while minimizing redundancy. Importantly, direct arthroscopic visualization of the remnant stump in full knee extension was routinely undertaken before graft fixation to confirm the absence of anterior impingement. This technical step may have contributed to the low incidence of symptomatic cyclops lesions observed and may explain the non-inferior early clinical outcomes of the BT technique.

LIMITATIONS OF THE STUDY

First, the follow-up period was limited to 12 months and therefore reflects early clinical and functional outcomes. Long-term graft durability, re-rupture rates, and potential degenerative changes could not be evaluated within this timeframe. Medium- and long-term follow-up studies are necessary to determine whether the observed early findings are sustained.

Second, although this was a prospective randomized controlled trial, it was conducted at a single tertiary referral center with procedures performed by a limited number of surgeons. While this enhances surgical consistency, it may limit generalizability to other practice settings.

Lastly, the study was powered primarily for functional outcome measures and may not have been sufficiently powered to detect small differences in less frequent complications such as cyclops lesions or graft failure. In addition, variability in remnant tissue volume and quality was not quantitatively assessed, which may influence biological incorporation and mechanical behavior. Future studies incorporating objective remnant grading and longer follow-up are warranted.

CONCLUSION

The study showed that tibial stump-preserving techniques, including the Braganza-Tan (BT) and stump-sparing methods, produced better outcomes than conventional stump-sacrificing ACL reconstruction. Patients who had BT or stump-sparing surgery consistently scored higher on IKDC, Lysholm, Tegner Activity, and HSS assessments throughout the first postoperative year, showing faster and greater recovery. Knee stability was also better in these groups, as measured by Lachman, pivot shift, anterior drawer, and instrumented arthrometer tests. Complications were lowest in the BT group, suggesting that preserving the tibial stump reduced postoperative risks, though this difference was not statistically significant. Overall, tibial stump preservation improved functional recovery, stability, and long-term clinical outcomes compared with traditional ACL reconstruction. Longer-term (5–10 year) follow-up studies are warranted to evaluate graft survival, re-rupture rates, and sustained functional outcomes.

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STATEMENT OF AUTHORSHIP

All authors certified fulfillment of ICMJE authorship criteria.

CREDIT AUTHOR STATEMENT

DST: Conceptualization, Methods, Software, Validation, Formal Analysis, Investigation, Resources, Data Curation, Writing, Visualization, Supervision, Project Administration, Funding Acquisition; **CLB:** Conceptualization, Investigation, Resources, Supervision, Funding Acquisition; **BSA:** Conceptualization, Investigation, Resources, Supervision, Funding Acquisition; **CFF:** Conceptualization, Investigation, Supervision, Funding Acquisition.

DATA AVAILABILITY STATEMENT

The datasets generated and analyzed in this study are included in the published article.

AUTHOR DISCLOSURE

The authors declared no conflict of interest.

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None.

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ORIGINAL ARTICLE

Long-Term Outcomes of Nerve Transfers in Adult Patients with C5–C7 and C5–C8 Brachial Plexus Injuries

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ABSTRACT

Background. Nerve reconstructions for C5 to C8 brachial plexus injuries are challenging due to the extent of injury and paucity of nerve donors.

Objective. The objective of this paper was to determine the long-term clinical outcomes of nerve transfers for shoulder and elbow function in patients with C5–C7 or C5–C8 brachial plexus injuries.

Methodology. We retrospectively reviewed the charts of all patients with C5–C7 or C5–C8 brachial plexus injuries treated with nerve transfers from January 1, 2005, to December 31, 2022, with at least 24 months follow-up. Filipino Version of the Disability of the Arm, Shoulder and Hand (FIL-DASH) scores, range of motion (ROM), and muscle strength were compared between single and double nerve transfers, and between early (within six months of injury) and delayed (more than six months) surgery.

Results. A total of 21 patients with a mean age of 29.9 years old were included. The mean surgical delay was 6.4 ± 3.0 months, while the mean follow-up was 58.5 ± 29.7 months. There were 11 patients with C5–C7 injuries, and 10 patients with C5–C8 injuries. FIL-DASH scores were available for eight patients, with a mean postoperative improvement of 25 points. There were no significant differences between single (SNT) and double nerve transfers (DNT) in terms of elbow flexion and shoulder function. Early surgery (within six months of injury) resulted in higher mean shoulder abduction range (110° vs 51°) compared to delayed surgery (more than six months).

Conclusion. Good elbow flexion and shoulder abduction recovery can be expected in nerve transfers for patients with C5–C7 or C5–C8 brachial plexus injuries. A higher ROM for shoulder abduction can be expected if surgery is done within six months of injury.

Keywords. nerve transfer, nerve reconstruction, extended upper type brachial plexus, long-term outcomes, brachial plexus injuries

INTRODUCTION

Upper type brachial plexus injuries account for approximately 25% to 30% of all brachial plexus injuries, with 14% of these injuries involving the C5 to C7 nerve roots.[1,2] Patients with involvement of the middle trunk and parts of the lower trunk of the brachial plexus lose the ability to control shoulder abduction and external rotation, elbow flexion and extension, and to some degree, wrist and finger extension.[2] However, Bertelli and Ghizoni reported in 2013 that loss of control of triceps, wrist, and finger extension likely involves the C8 nerve root, since injuries involving purely the C5 to C7 nerve roots tend to spare the triceps, wrist and finger extensors. Patients with decreased grasp, and wrist and elbow extension may also have an additional C8 injury.[3]

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Nerve transfers for shoulder abduction and external rotation result in fair to good outcomes, with most patients reporting improved shoulder stability and patient reported outcomes.[3–7] Brachial plexus injuries involving the C5 to C8 nerve roots limit options for nerve transfers, especially for the shoulder and elbow. In contrast, those with only C5 to C6 injuries have better outcomes in terms of muscle recovery of the elbow and shoulder.[8–10]

The objective of this study was to present the results of nerve transfers for the restoration of shoulder and elbow function in patients with C5–C7 or C5–C8 nerve injuries.

METHODOLOGY

This was a retrospective study that reviewed patient charts to determine the clinical outcomes of patients with C5–C7 or C5–C8 nerve root injuries treated at a single Microsurgery Unit from January 1, 2005 to December 31, 2022. The data were collected from the unit's database. Included were all adult patients aged ≥ 18 years with a diagnosis of C5–C7 or C5–C8 injury who underwent primary nerve transfer surgery for the restoration of shoulder and elbow function, with a minimum follow-up of 24 months. Excluded were patients with bilateral injuries, complete C5–T1 injuries, primary nerve repair, severe joint contractures, and disorders that would otherwise affect the clinical evaluation of brachial plexus recovery.

The diagnosis of C5–C7 nerve root injury was made based on paralysis or weakness (≤ M3) of the flexor carpi radialis with or without reduced function of the pronator teres, triceps, or latissimus dorsi. The diagnosis of C5–8 injuries was based on weakness of the triceps, wrist extensors, with or without weakness of finger extension.

The protocol was approved by the ethics review board of the authors' institution.

Outcomes measurement

Outcomes were measured using the following: disability score using the Filipino Version of the Disability of the Arm, Shoulder and Hand (FIL-DASH) score, manual muscle testing using the British Medical Research Council (BMRC) grading system of M0–M5, range of motion (ROM) in degrees, and pain using the visual analog scale. The shoulder's range of motion and muscle strength were tested in abduction and external rotation (from full internal rotation, with elbow flexed and forearm parallel to the abdomen), and the elbow in flexion and extension. Recovery for elbow extension was considered when the BMRC grade was ≥ M3. The final measurements were considered on their latest follow-up.

Outcomes were compared between single nerve transfers (SNT) and double nerve transfers (DNT), and early (within six months) and delayed surgery (six months or later).

Operative procedures

Nerve transfer procedures included those that reconstructed shoulder and elbow function. Target recipient nerves were the suprascapular nerve (SSN) and/or the axillary nerve (AXN) for the shoulder and biceps, and/or the brachialis branch of the musculocutaneous nerve (MCN) for the elbow. Donor nerves to the musculocutaneous were the intercostal nerve and the medial pectoral nerve. The most commonly used nerve donors were the ulnar and/or median nerve for elbow flexion, and the partial radial nerve to the axillary nerve. Additional tendon or nerve transfers were also done as needed to restore wrist, finger or thumb extension.

Statistical analysis

The statistical testing software used was STATA Version 14.0 (Stata Corp. LLC, College Station, Texas, USA). Descriptive statistics used were frequencies and proportions for categorical data. Measures of central tendency used were means with their corresponding standard deviations and/or 95% confidence intervals, and medians with their interquartile range for continuous variables. Means were compared using the Kruskall-Wallis test for nonparametric data and Fisher's exact test for categorical data. The level of significance for all statistical tests was set at $p < 0.05$.

RESULTS

A total of 21 patients were included (Table 1). The mean surgical delay was 6.4 ± 3.0 months, while the mean follow-up was 58.5 ± 29.7 months. There were 11 patients with C5–7 injuries and 10 patients with C5–8 injuries.

Outcome Measures

FIL-DASH scores

Both pre- and postoperative FIL-DASH scores were available in eight patients. In these patients, there was a significant improvement in the FIL-DASH score with a mean difference of 25 (95% CI: 10, 40), (p-value < 0.05, Table 2).

Functional outcomes

Table 3 shows the outcomes of nerve transfers on the restoration of elbow and shoulder function. In two cases, the MCN was selected as a direct target nerve (donors: intercostal nerves and medial pectoral nerves). Both patients had M4 elbow flexion strength and 140° of flexion.

The overall results for the remaining 19 patients with either single or double nerve transfer showed that strong elbow flexion of ≥ M4 was achieved in 16 of 19 patients (84%) with a mean ROM of 131°. Double nerve transfers for elbow and shoulder function had greater muscle strength, higher chances of achieving ≥ M4 strength, and greater ROM for elbow flexion, but the difference did not achieve statistical significance ($p > 0.05$).

Table 1. Demographic Characteristics (*n* = 21)

	Mean (SD) [a]	Median (IQR) [b]	95% CI [c]	*N* (%)
Age, years	29.9 (8.5)	28 (24, 34)	26.1, 33.8	35.8 ± 9.97
Sex				
Male				19 (90.5)
Female				2 (9.5)
Surgical delay (months)	6.4 (3.0)	5.4 (4.7, 6.7)	5.1, 7.8	
FIL-DASH [d]				
Pre-operative (*n* = 8)	59.5 (21.5)	63.3 (63.3, 75.8)	41.6, 77.5	
Post-operative (*n* = 16)	34.0 (18.4)	30 (24.2, 50)	24.2, 43.8	
Pain Score (VAS) [e]				
Pre-operative (*n* = 21)	3.6, 3.6	3.0 (0, 6)	2.0, 5.2	
Post-operative (*n* = 21)	2.6 (2.9)	2.0 (0, 5)	1.3, 3.9	
Follow-up (months)	58.5 (29.7)	54.7 (35, 84)	45.0, 71.2	
Nerve Procedures				
Shoulder				
Single [f]				16 (71)
Double [g]				5 (29)
Elbow				
Single				6 (28)
Double				13 (62)
ICN-MCN [h]				1 (5)
MPN-MCN [i]				1 (5)

a) SD – Standard Deviation; b) IQR – Interquartile range; c) CI – Confidence interval; d) FIL-DASH – Filipino Disability of the Arm, Shoulder and Hand; e) VAS – Visual analog scale; f) Single nerve transfer: Shoulder (spinal accessory nerve to the suprascapular nerve); Elbow (ulnar nerve fascicle to biceps branch [Oberlin procedure] or median nerve fascicle to biceps branch; g) Double nerve transfer: Shoulder (spinal accessory nerve to suprascapular nerve + triceps branch to the axillary nerve); Elbow (single nerve transfer [ulnar nerve] + median nerve fascicle to brachialis branch; h) ICN- MCN - intercostal nerves to musculocutaneous nerve, i) MPN-MCN; medial pectoral nerve to musculocutaneous nerve.

Table 2. Results of pre and post-operative FIL-DASH scores (*n* = 8)

FIL-DASH [a] Score	Mean (SD) [b]	95% CI [c]	*p*-value [d]
Pre-operative	59.5 (21.5)	41.6, 77.5	
Post-operative	34.5 (15.6)	21.4, 47.6	
Difference	25 (18)	10, 40	0.006

[a] FIL-DASH – Filipino Disability of the Arm, Shoulder and Hand; [b] SD – Standard deviation; [c] CI – Confidence interval; [d] Paired t-test, significant at $p < 0.05$.

There was no significant difference in shoulder and elbow strength recovery between those who underwent nerve transfer within six months and six months or later post-injury. However, those who underwent earlier surgery (within six months) recovered more shoulder abduction ROM (110° vs 51°, $p = 0.01$). A mean shoulder abduction of 85° and mean external rotation of 67° was achieved for all transfers to the shoulder (Tables 3 and 4).

In the 21 patients, elbow extension was present at the time of surgery with least M4 in three patients. Spontaneous recovery during the follow-up period of at least M3 elbow extension was observed in six patients (≥ M4 in five). Nerve transfer for elbow extension was done for one patient using the intercostal nerve, with only M2 recovery. The rest ($n = 11$) had no recovery and no reconstruction of the triceps muscle.

Postoperative FIL-DASH scores were available in 16 patients. Overall, the postop FIL-DASH scores were better for those with elbow extension ($n = 8$) with a mean score of 26 compared to those with no elbow extension ($n = 8$) with a mean score of 43 ($p = 0.048$). Elbow extension was present in seven of the 11 patients with C5–C7 injuries, and in only one of nine patients in the C5–C8 group.

Pain scores

There was no significant difference in the pain scores in all patients before and after nerve transfers (3.6 vs. 2.6; $p = 0.1$).

DISCUSSION

In patients with C5–C7 or C5–C8 injuries, nerve transfers can restore elbow flexion, and shoulder abduction and external rotation. Among patients with C5–C7 injuries, 64-67% of patients regain ≥ M4 elbow flexion strength following biceps reinnervation.[6–10] In terms of shoulder function, Chu et al.[11] reported dual nerve transfers in 19 patients (16 with C5–C7 injuries) achieving 94° shoulder abduction and 54° external rotation in the long-term. Patients who received surgery within three months post-injury, were younger, and had longer follow-ups and had greater shoulder function. In 2022, Bertelli and Ghizoni[12] reported that in 52 patients with C5–8 brachial plexus injuries, 81% recovered ≥ M4 strength full elbow flexion, and 88% recovered a median shoulder abduction of 80° and external rotation of 120°.

Double nerve transfer in extended injuries is controversial because of the possibility of transferring injured or recovering fascicles from donor nerves. An animal study on elbow flexion in rat models has shown that partial C8 injuries may still benefit from DNT, especially when no other donors are available. Lower trunk injuries with 25% and 75% intact fascicles had similar function at both donor and recipient sites when assessed with the grooming test, muscle mass, retro-

Table 3. Outcomes for elbow and shoulder function in patients by type of transfer (*n* = 21)

	Type of transfer		*p*-value
Elbow flexion [a]	**Single (*n* = 6)**	**Double (*n* = 13)**	
Mean MMT (95% CI)	3.7 (2.1, 5.2)	4.0 (3.9, 4.0)	0.5 [b]
≥ M4 (%)	4 of 6 (67%)	12 of 13 (92%)	0.2 [c]
Mean ROM (°), 95% CI	129 (108, 149)	131 (121, 142)	0.5 [b]
Combined ROM (°), 95% CI	131 (122, 139)		
Postop FIL-DASH (mean, 95% CI)	43.2 (24.7, 61.7) (*n* = 6)	26.4 (13.3, 39.5)	0.06 [b]
Shoulder function abduction	**Single (*n* = 16)**	**Double (*n* = 5)**	
Mean MMT (95% CI)	3.3 (2.4, 4.1)	3.8 (3.2, 4.4)	0.6
≥ M4 (%)	8 of 16 (50%)	4 of 5 (80%)	0.2
Mean ROM (°), 95% CI	78 (50, 106)	106 (66, 146)	0.3
Combined ROM (°), 95% CI	85 (62, 107)		
External rotation			
Mean MMT (95% CI)	2.9 (2.0, 3.7)	3.5 (2.9, 3.7)	0.6
≥ M4 (%)	7 of 16 (44%)	2 of 5 (40%)	0.7
Mean ROM (°), 95% CI	64.2 (37.0, 91)	75 (23, 126)	0.8
Combined ROM (°), 95% CI	66.7 (44.8, 88.4)		
Postop FIL-DASH (mean, 95% CI)	35.8 (23.2, 48.3) (*n* = 11)	30.1 (6.4, 53.9) (*n* = 5)	0.5

[a] Donor nerves intercostal and medial pectoral nerves were excluded (*n* = 2); [b] Kruskal-Wallis test; [c] Fisher's Exact test, 1-sided

Table 4. Outcomes for elbow and shoulder function by surgical delay (*n* = 21)

	Surgical delay		*p*-value
Elbow flexion [a]	**< 6 months (*n* = 12)**	**≥ 6 months (*n* = 9)**	
Mean MMT (95% CI)	3.8 (3.2, 4.4)	3.9 (3.5, 4.4)	0.6 [b]
≥ M4 (%)	11 of 12 (92%)	7 of 9 (78%)	0.3 [c]
Mean ROM (°), 95% CI	126 (99, 152) [d]	125 (110, 139)	0.2 [b]
Combined ROM (°), 95% CI	132 (123, 139)		
Postop FIL-DASH (mean, 95% CI)	43.2 (24.7, 61.7) (*n* = 6)	26.4 (13.3, 39.5)	0.06 [b]
Shoulder function abduction	**< 6 months (*n* = 12)**	**≥ 6 months (*n* = 9)**	
Mean MMT (95% CI)	3.8 (2.4, 4.1)	2.7 (3.2, 4.4)	0.2
≥ M4 (%)	8 of 12 (67%)	4 of 9 (44%)	0.3
Mean ROM (°), 95% CI	110 (50, 106)	51 (66, 146)	0.01
Combined ROM (°), 95% CI	85 (62, 107)		
External rotation			
Mean MMT (95% CI)	3.1 (2.0, 3.7)	2.9 (2.9, 3.7)	0.4
≥ M4 (%)	6 of 12 (50%)	3 of 9 (33%)	0.4
Mean ROM (°), 95% CI	77 (37.0, 91)	53 (23, 126)	0.3
Combined ROM (°), 95% CI	66.7 (44.8, 88.4)		
Postop FIL-DASH (mean, 95% CI)	35.8 (23.2, 48.3) (*n* = 11)	30.1 (6.4, 53.9) (*n* = 5)	0.2 [b]

[a] Donor nerves intercostal and medial pectoral nerves were included (*n* = 2); [b] Kruskal-Wallis test; [c] Fisher's Exact test, 1-sided; [d] Only 1 of 12 patients had failed elbow flexion recovery

grade neuron labelling of regenerated axons and immunohistochemical staining of regenerated axons.[13] In 2023, Chang et al.[14] using double fascicular transfers, achieved ≥ M4 elbow flexion strength for patients with C5–C7 (73%) and C5–C8 (71.9%) acute brachial plexus injuries. This study concluded that double fascicular transfers can achieve good elbow flexion recovery in partial upper-type brachial plexus injuries.

For shoulder function, two other studies[5,11] showed similarly good results with shoulder abduction (73–81°) and external rotation (43–69°). Our results were similar, achieving ≥ M4 strength of elbow flexion with a mean range of 132° in 84% of patients, shoulder abduction of 85° in 57% of patients, and shoulder external rotation of 67° in 56% of patients.

There is still controversy whether single or double nerve transfers are better for restoring elbow function. Some studies have shown similar results[5,15,16] while other reported the superiority of double nerve transfers.[6,17] In this study, double nerve transfers showed superior results compared to single transfers in achieving M4 muscle strength, both for elbow and shoulder function; however, this difference did not reach statistical significance. The additional nerve transfer for the shoulder (triceps branch to axillary nerve) provided additional strength for shoulder abduction, but a moderate effect on external rotation. Double nerve transfers result in greater motor strength and shoulder abduction range compared to single nerve transfers as reported by other authors.[18–20]

Few donor nerves are available for the shoulder in patients with C5–C7 or C5–C8 injuries. The triceps branch of the radial nerve is usually not available or too weak in dual nerve reinnervation of the shoulder. In such cases, augmentation can be done using a nerve graft where a proximal nerve stump is available. The distal C5 root or the posterior or anterior division of the upper trunk can be used, depending on which deficit is to be restored. However, in our setting, we are unable to document the presence of nerve root avulsion, since we don't have intraoperative monitoring (such as spinal evoked potential), or MRIs. Presently, our institution's surgeons rely on inspecting the nerve for normal-looking fascicles after sectioning, or stimulating the long thoracic nerve to determine viability of the root.[21]

Early surgical intervention, whether for nerve grafting or transfer, has been recommended by many authors.[5,8,11,22] In this study, the surgical delay was not a factor in nerve transfers for elbow flexion and shoulder function, as most were done within 12 months of the injury. More patients in the group receiving early surgery (within six months) achieved ≥ M4 strength of elbow flexion, and shoulder abduction and external rotation, but this difference did not reach statistical significance. Early surgery did, however, yield better ROMs for shoulder abduction (Table 4).

In terms of DASH scores, Liu et al.[23] reported significant improvements following nerve transfers using the phrenic nerve (DASH score improved from 90.1 to 66.8) and partial ulnar nerve (88.1 to 57.4). Similarly, Dolan et al.[24] reported that those treated early (within six months) with nerve transfers had better DASH scores compared to those treated late (62.1 vs. 76.3). Carlsen et al. also reported significant post-operative improvement in DASH scores using either single or double nerve transfers.[15]

Among the limitations of the study were the retrospective nature and the small sample size. Although the minimum follow-up was 24 months, a longer follow-up may show continued improvement in terms of strength and ROM. Also, some authors showed that reinnervated biceps and brachialis muscles fatigue early.[25] These outcomes may be included in future assessments of these patients.

CONCLUSION

In summary, good elbow flexion and shoulder function and improved FIL-DASH scores can be achieved after surgery for patients with C5–C7 or C5–C8 brachial plexus injuries. Double nerve transfers and early surgery (within six months) resulted in better elbow flexion range and shoulder strength ≥ M4), but these differences did not reach statistical significance. A significantly higher shoulder abduction range can be expected with early surgery.

STATEMENT OF AUTHORSHIP

All authors certified fulfillment of ICMJE authorship criteria.

CREDIT AUTHOR STATEMENT

EPE: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing – review and editing, Visualization, Supervision, Project administration, Funding acquisition; **EFDD:** Software, Validation, Investigation, Data Curation, Writing – original draft preparation, Writing - review and editing, Project administration.

DATA AVAILABILITY STATEMENT

The datasets generated and analyzed in this study are included in the published article.

AUTHOR DISCLOSURE

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ORIGINAL ARTICLE

Comparison of Sinus Tarsi Approach with Screws vs Lateral Extensile Approach with Plates in Sanders Type Two and Three Calcaneal Fractures: A Non-Randomized Study

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ABSTRACT

Background. Intra-articular calcaneal fractures, particularly of the joint depression type, present significant surgical challenges. The traditional lateral extensile approach (LEA), although providing excellent exposure, is associated with notable soft tissue complications, such as wound necrosis and infection. The sinus tarsi approach (STA), a minimally invasive technique, aims to minimize these complications while maintaining comparable outcomes. This study aimed to compare the functional, radiological outcomes, and complications of STA with cannulated cancellous (CC) screw fixation versus LEA with plating in the management of joint depression-type intra-articular Sanders Type 2 and 3 calcaneal fractures.

Methodology. A prospective, non-randomized comparative study was conducted at a tertiary care center (BSTRH and MIMER Medical College, Talegaon Dabhade), involving 56 adult patients (aged > 18 years) with acute (< three weeks) intra-articular joint depression (Sanders Type 2 and 3) calcaneal fractures, diagnosed via radiographs and CT scan. All surgeries were performed by a senior orthopaedic trauma surgeon with more than 10 years of experience. Patients were allocated into two groups of 28 each: Group A underwent STA with CC screw fixation, while Group B received LEA with plate fixation. Surgical intervention was performed after soft tissue readiness, followed by standard postoperative care. Patients were evaluated at one, three, six, nine, and 12 months postoperatively using the American Orthopaedic Foot and Ankle Society hindfoot score (AOFAS), Visual Analogue Scale (VAS), and radiological parameters including Bohler's angle, Gissane angle, and calcaneal height and width. Complication rates, operative time, and hospital stay were also analyzed.

Results. STA resulted in significantly shorter operative times (59.1 vs. 98.4 minutes, $p < 0.001$) and hospital stays (4.7 vs. 7.42 days, $p < 0.001$). AOFAS scores at 12 months were comparable between STA (mean 80.57) and LEA (mean 77.33). Postoperative VAS scores were significantly better in the STA group (1.67 vs. 2.04; $p = 0.044$). Radiographic outcomes were similar between groups. STA demonstrated fewer complications, including superficial infection (3 vs. 5), deep infection (0 vs. 2), and sural nerve injury (0 vs. 1).

Conclusion. The sinus tarsi approach with cannulated screw fixation offers equivalent functional and radiological outcomes to the lateral extensile approach while significantly reducing soft tissue complications, operative time, and hospitalization. It presents a safe and effective minimally invasive alternative for treating intra-articular calcaneal fractures with joint depression (Sanders Type 2 and 3).

Keywords. calcaneal fracture, sinus tarsi approach, lateral extensile approach, cannulated screw fixation, AOFAS score, minimally invasive surgery

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INTRODUCTION

Calcaneal fractures are the most common fractures of the tarsal bones and represent approximately 1% to 2% of all adult fractures, with nearly 75% being intra-articular.[1–3] Among these, joint depression-type fractures, as per the Essex-Lopresti classification,[4,5] are particularly challenging due to their complex anatomy and the potential for long-term disability. Among these, joint depression-type fractures classified by the Sanders CT-based system (Types 2, 3, and 4) require adequate reduction and fixation. Restoration of the articular congruity, calcaneal height, width, and alignment is essential to achieving favorable outcomes.[6–8]

The lateral extensile approach (LEA) has traditionally been the standard surgical method for treating displaced intra-articular calcaneal fractures.[9–13] While this approach provides excellent visualization and facilitates anatomic reduction and plate fixation, it is associated with significant soft tissue complications, including wound edge necrosis, infection, and sural nerve injury. These complications are attributed to the disruption of the lateral calcaneal artery and extensive soft tissue handling.

The sinus tarsi approach (STA) has emerged as a less invasive alternative that aims to minimize soft tissue morbidity. It allows adequate access for reduction and fixation of the posterior facet while preserving the vascular supply and reducing the risk of wound complications.[14–19] However, concerns remain about whether this limited exposure permits adequate reduction and stabilization, particularly when using cannulated cancellous screws rather than plates.[20,21]

Figure 1. Preoperative X-ray showing calcaneus fracture. Lateral view of the right heel demonstrating a displaced intra-articular calcaneal fracture **(A)**; Axial (Harris) view showing widening of the heel and lateral wall blowout **(B)**; Oblique view illustrating comminution of the calcaneal body **(C)**; Lateral view highlighting collapse of the posterior facet and decreased Böhler's angle **(D)**.

Because of the limited data comparing functional and radiological outcomes between these two approaches, there remains uncertainty regarding the optimal surgical technique for Sanders Type 2 and 3 calcaneal fractures.[14,16,22–32] Therefore, this study was conducted to compare the sinus tarsi approach with cannulated screw fixation versus the lateral extensile approach with plating in terms of post-operative recovery, radiological parameters, functional outcomes, and complication rates.

METHODOLOGY

This was a prospective, non-randomized comparative study conducted in the Department of Orthopaedics at BSTRH and MIMER Medical College, Talegaon Dabhade (a tertiary care center), between June 2022 and June 2025. The study aimed to evaluate and compare the outcomes of two surgical approaches for treating Sanders Type 2 and 3 calcaneal fractures: the sinus tarsi approach (STA) using cannulated cancellous (CC) screw fixation, and the lateral extensile approach (LEA) using plate fixation.

Ethics statement

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

A total of 56 patients were included in the study, with 28 patients in each group. The sample size was determined based on the estimated patient inflow for the given fracture pattern over three years. Patients were selectively enrolled based on the presence of specific fracture characteristics and their informed written consent to participate in the study. Preoperative X-ray radiographs and CT scans were taken for all the patients (Figure 1).

Inclusion criteria: adult patients (age > 18 years AND < 65 years) presenting within three weeks of trauma with closed, Sanders Type 2 and 3 calcaneal fractures.

Exclusion criteria: open fractures, extraarticular fractures, Sanders Type 1 and 4 fractures, pathological fractures, polytrauma, and patients with uncontrolled diabetes or peripheral vascular disease.

Patients underwent surgery once the soft tissue condition was deemed appropriate, typically indicated by the presence of the wrinkle sign.

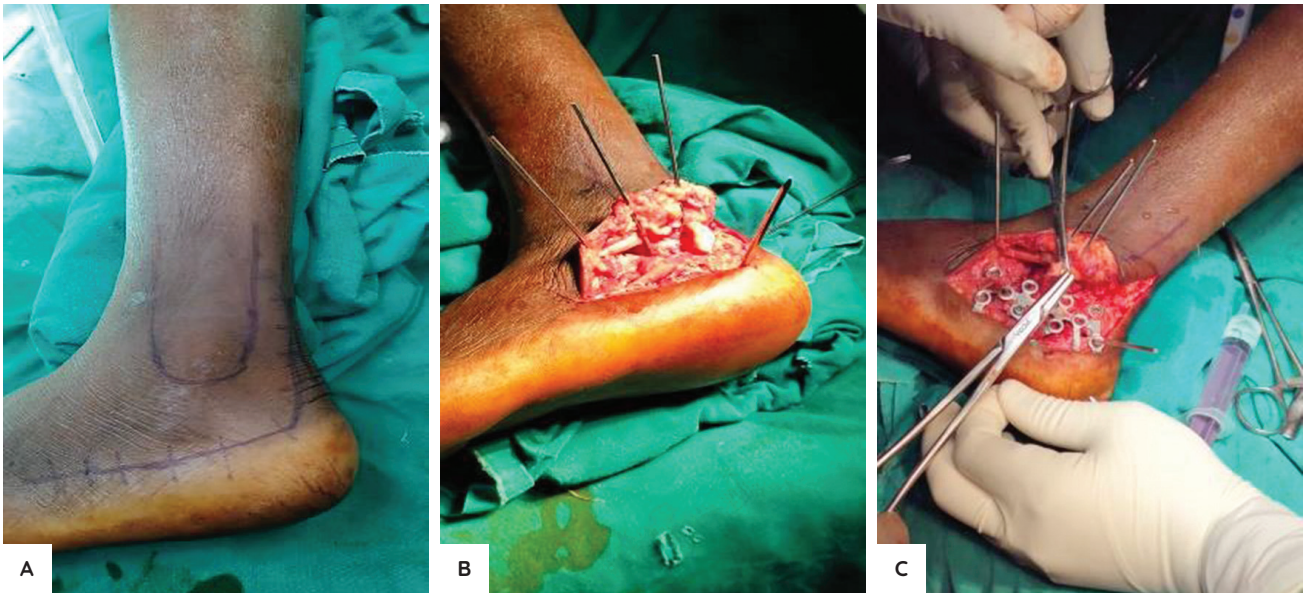

Figure 2. Intraoperative photos showing the lateral extensile approach (LEA) for calcaneal fracture fixation. Skin marking of the extensile lateral L-shaped incision **(A)**; elevation of the full-thickness fasciocutaneous flap with Kirschner wire retraction exposing the lateral wall and posterior facet **(B)**; fracture reduction and internal fixation under direct visualization **(C)**.

Lateral Extensile Approach (LEA)

The patient was positioned in a lateral decubitus position. A thigh tourniquet was applied, and the limb was prepared and draped. A standard L-shaped lateral incision was made. The vertical line was placed midway between the lateral malleolus and the Achilles tendon, and the horizontal line was positioned just below the peroneal tendons, extending towards the base of the fourth metatarsal. A full-thickness fasciocutaneous flap was elevated subperiosteally to expose the entire lateral surface of the calcaneus, the calcaneocuboid joint, and the posterior facet of the subtalar joint (Figure 2A and 2B). Care was taken to protect the sural nerve and the peroneal tendons, which were retracted superiorly.

The fracture fragments were anatomically reduced using reduction clamps and provisionally fixed with K-wires. The reduction was confirmed, under fluoroscopic guidance, to restore Böhler's and Gissane's angles, as well as the height and width of the calcaneus. An L-shaped pre-contoured calcaneal locking plate was then applied and secured with screws in a step-by-step fashion to achieve stable internal fixation (Figures 2C and 3).

Sinus Tarsi Approach (STA)

The patient was placed in a lateral decubitus position, and a tourniquet was applied to the thigh. The skin was prepared and draped.

A small, approximately 3 to 5 cm incision was made within the sinus tarsi, extending from a point 1 cm distal to the tip of the lateral malleolus towards the base of the fourth metatarsal. The incision allowed access to the subtalar joint and the lateral wall of the calcaneus, minimizing soft tissue

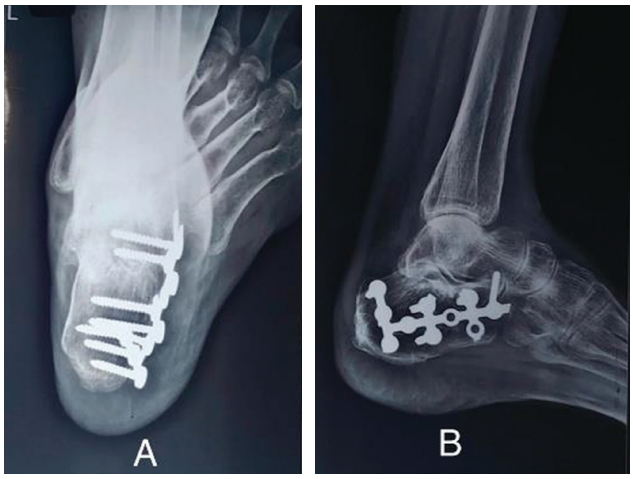

Figure 3. Immediate postoperative X-rays following calcaneal fracture fixation via lateral extensile approach (LEA). Antero-posterior view showing anatomical alignment and screw placement **(A)**; lateral view demonstrating restoration of calcaneal height and contour with plate and screw fixation **(B)**.

disruption. The peroneal tendons and the sural nerve were identified and protected by gentle retraction (Figure 4).

A small distractor was placed in the sinus tarsi to open the subtalar joint and provide visualization of the depressed posterior facet fragment. The fragment was disimpacted and elevated using a specific elevator, restoring the articular surface. The reduction was then held with a provisional K-wire. The reduction and restoration of Böhler's angle were checked using fluoroscopy (Figure 5).

Final fixation was achieved with cannulated cancellous screws. The screws were inserted percutaneously from the posterior tuberosity or lateral calcaneal wall, passing through

Figure 4. Intraoperative photos showing the sinus tarsi approach (STA).

Figure 5. Intraoperative C-arm fluoroscopic image in the supratrochlear axial (STA) view demonstrating instrument positioning across the fracture site.

the elevated fragment to hold the reduction and support the posterior facet. The number and position of screws were determined by the fracture pattern and the stability achieved. This minimally invasive technique aimed to provide stable fixation while reducing the risk of wound complications.

Postoperatively, all patients followed a standardized rehabilitation protocol that included non-weight-bearing mobilization for eight weeks, followed by partial to full weight-bearing as tolerated. Sutures were removed on postoperative day 14. Clinical and radiological assessments were performed at one, three, six, nine, and 12 months.

Primary outcome measures included the American Orthopaedic Foot and Ankle Society (AOFAS) hindfoot score and the Visual Analogue Scale (VAS) for pain.

Radiological parameters such as Bohler's angle, Gissane angle, calcaneal height, and width were evaluated on lateral and axial X-rays at each follow-up. We did not do postoperative CT scans routinely if we were satisfied with postoperative X-rays alone.

Secondary outcomes included operative time, length of hospital stay, and the incidence of complications such as infection, sural nerve injury, and wound edge necrosis.

Minimum follow-up was 12 months for all patients. No patients were lost to follow-up.

Statistical analysis was performed using SPSS version 26.0. Continuous variables were presented as means with ranges and compared using independent-samples t-tests or paired t-tests, as appropriate. Categorical variables were expressed as counts and percentages and analyzed using the Chi-square test. A p-value of < 0.05 was considered statistically significant. Although a formal power analysis was not performed, the sample size was deemed sufficient based on previous similar comparative studies and clinical experience.

Efforts were made to minimize selection and treatment bias by using uniform inclusion criteria and standardized operative protocols. While patient allocation was not randomized, consecutive eligible cases were included to limit referral and diagnosis bias.

RESULTS

A total of 61 patients were assessed for eligibility during the study period. Five patients were excluded due to the presence of open fractures (n = 2), uncontrolled diabetes (n = 1), pathological fracture (n = 1), and refusal to participate (n = 1). Fifty-six patients who met the inclusion criteria were enrolled and completed follow-up, with 28 patients in the sinus tarsi approach (STA) group and 28 in the lateral extensile approach (LEA) group. The distribution of fracture severity (Sanders classification) was assessed for both groups. In the LEA group, 16 patients were classified as Sanders Type 2 and 12 patients as Type 3. In comparison, the STA group had 18 patients with Type 2 and 10 patients with Type 3 fractures. The mean follow-up period was 11.4 months (range, 11 to 12 months).

Table 1. Outcomes of the two groups

Parameter	STA Group	LEA Group	*p*-value
Operative time (mins)	59.1 ± 8.2	98.4 ± 10.11	$p < 0.001$*
Hospital stay (days)	4.7 ± 1.73	7.42 ± 2.26	$p < 0.001$*
AOFAS at 9 months	80.57 ± 7.8	77.33 ± 8.29	$p = 0.142$
Post-op VAS	1.67 ± 0.97	2.04 ± 0.97	$p = 0.044$
Bohler's angle	27.27 ± 3.98	28.60 ± 4.71	$p = 0.267$
Gissane angle	124.69 ± 6.88	126.60 ± 4.58	$p = 0.348$
Calcaneal height	45.03 ± 4.65	44.88 ± 4.75	$p = 0.853$
Calcaneal width	46.04 ± 4.01	46.84 ± 4.77	$p = 0.569$
Superficial infection	3	5	$p = 0.041$*
Deep infection	0	2	$p = 0.150$
Sural nerve injury	0	1	Absent in STA

*$p < 0.05$; significant

Demographic and operative data

The average age in the STA group was 39.1 years (range, 21–56 years), while the LEA group had a mean age of 37.3 years (range, 23–55 years) ($p = 0.432$).

The mean operative time was significantly lower in the STA group at 59.1 minutes (range, 48–72 minutes) compared to 98.4 minutes (range, 83–112 minutes) in the LEA group ($p < 0.001$).

The average length of hospital stay was also shorter in the STA group at 4.7 days (range, 3–8 days), compared to 7.42 days (range, 5–11 days) in the LEA group ($p < 0.001$).

Functional outcomes

At 12 months follow-up, the mean AOFAS hindfoot score was 80.57 (range, 67–93) in the STA group and 77.33 (range, 62–90) in the LEA group. The difference was not statistically significant ($p = 0.142$).

The mean postoperative VAS score was significantly better in the STA group at 1.67 (range, 0–3) compared to 2.04 (range, 1–4) in the LEA group ($p = 0.044$).

Radiological outcomes

Postoperative radiographs demonstrated restoration of key parameters in both groups. Bohler's angle, Gissane angle, calcaneal height, and calcaneal width were comparable (Table 1). The double dome sign of the posterior facet was eliminated from postoperative radiographs, suggesting anatomical or near-anatomical reduction, which is essential for minimizing the risk of post-traumatic subtalar arthritis.

Complications

The STA group had fewer soft tissue complications compared to LEA. In the STA group, three patients (10.7%) developed superficial wound infections, all of which resolved with daily dressing and oral antibiotics under IPD care. In the LEA group

Figure 6. Immediate postoperative radiographs showing stable internal fixation with multiple screws: supratrochlear axial (STA) view **(A)** and lateral view **(B)**.

Figure 7. Post op picture showing superficial wound infection (LEA).

(25%), five patients developed superficial wound infections and two developed deep wound infections (Figure 7). Superficial wound infections were treated with daily dressing and oral antibiotics under IPD care. Deep wound infections required debridement with antibiotic cover. Multiple debridements and culture-guided antibiotics were given. None of the patients required plastic surgery or flap coverage. Wound edge necrosis was seen in two patients in the LEA group and none in the STA group. Sural nerve injury occurred in one patient (manifesting as paresthesia or dysesthesia) only in the LEA group, probably due to excessive retraction during surgery. This was managed with physiotherapy and neurogenic medications and eventually recovered in three months.

No cases of nonunion, hardware failure, or loss of reduction were observed in either group at the final follow-up.

The primary surgical objective remained the achievement of anatomical congruity of the posterior subtalar facet. If good articular reduction were not achieved, the long-term functional outcomes will likely be poor, resulting in post-traumatic arthritis. As the follow-up period was less than a year, post-traumatic arthritis could not be assessed.

DISCUSSION

This study was conducted to evaluate whether the sinus tarsi approach (STA) with cannulated cancellous (CC) screw fixation can provide comparable outcomes to the traditional lateral extensile approach (LEA) with plating for joint depression-type intra-articular calcaneal fractures, while offering advantages in terms of reduced soft tissue complications, operative time, and hospital stay.

The shorter operative time and decreased hospital stay in the STA group are consistent with previous research that highlights the efficiency of minimally invasive techniques. The sinus tarsi approach, with its limited incision and reduced dissection, allows earlier surgical intervention (once soft tissue edema resolves), whereas the extensile lateral approach often necessitates longer waiting periods (once wrinkle sign appears). These operative advantages align with findings reported by Shuler et al.[13] and Kwon et al.,[25] who demonstrated reduced operative times and hospitalizations with STA compared to LEA.

The primary concern with STA has been whether it allows adequate visualization for anatomical reduction, especially when relying on screw fixation instead of plating. In our study, radiological outcomes, including Bohler's angle, Gissane angle, calcaneal height, and width, were satisfactorily restored in both groups, with no statistically significant differences. These findings mirror those of Ma et al.[28] and Yeo et al.,[30] suggesting that STA can achieve anatomical restoration equivalent to that of the LEA.

Functional outcomes, as assessed by the AOFAS score, were slightly better in the STA group, but the difference did not reach statistical significance. The postoperative VAS scores were significantly lower in the STA group, indicating better subjective pain relief and potentially greater patient comfort. This may be attributed to less tissue trauma and reduced implant-related irritation. The absence of sural nerve injuries and wound-related complications in the STA group further supports this.

Our results reinforce the growing consensus in orthopedic literature that minimally invasive approaches can deliver comparable outcomes with fewer complications in selected fracture patterns.[14,15,27,29] However, one must be cautious in generalizing these results. LEA still holds importance in more comminuted or Sanders Type 4 fractures where full visualization is necessary for complex reconstructions, which were not the focus of our study.[31]

The primary limitation of the study was the non-randomized, comparative design. Patient allocation was not randomized, but patient grouping was based on shared decision-making between the patient and surgeon, following a detailed explanation of both procedures & choice of patients. We also used uniform inclusion criteria and standardized operative protocols from an experienced senior surgeon at a single institute to further minimize selection and treatment biases. The sample size was considered sufficient based on similar comparative studies, with a standard sample formula from our statistician. We acknowledge that future randomized controlled trials with larger sample sizes are warranted to validate and extend these findings. Finally, we only used CC screws in the STA group and did not compare outcomes of plating via the sinus tarsi approach, which is becoming increasingly popular.[16,22]

Despite these limitations, this study adds valuable prospective data to the ongoing discussion regarding the optimal approach for intra-articular calcaneal fractures (Sanders Type 2 and 3). The sinus tarsi approach with screw fixation appears to be a safe, effective, and less morbid alternative to the extensile lateral approach for joint depression-type fractures. Future randomized controlled trials with larger sample sizes, including Type 4 fractures, are warranted to validate and extend these findings.

CONCLUSION

The sinus tarsi approach with cannulated screw fixation provides functional and radiological outcomes comparable to the lateral extensile approach with plating in the management of joint depression-type intra-articular calcaneal fractures (Sanders Type 2 and 3). Additionally, it significantly reduces operative time, hospital stay, and soft tissue complications. These findings support the use of the sinus tarsi approach as a safe and effective minimally invasive alternative for appropriately selected fracture patterns.

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All authors reviewed and approved the final manuscript.

STATEMENT OF AUTHORSHIP

All authors certified fulfillment of ICMJE authorship criteria.

CREDIT AUTHOR STATEMENT

SB: Conceptualization, Validation, Writing – original draft preparation, Visualization, Supervision**; RM:** Methodology, Validation, Writing – original draft preparation, Writing – review and editing, Visualization, Project administration; **SG:** Software; **SD:** Validation, Funding acquisition**; RT:** Formal analysis, Data curation, Writing – original draft preparation; **BA:** Investigation; **SA:** Resources.

DATA AVAILABILITY STATEMENT

The datasets generated and analyzed in this study are included in the published article.

AUTHOR DISCLOSURE

The authors declared no conflict of interest.

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SYSTEMATIC REVIEW

A Systematic Review and Meta-Analysis of Surgical Site Infections in Older Adults Undergoing Total Knee Arthroplasty: Incidence Rate and Risk Factors

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ABSTRACT

Background. Total knee arthroplasty (TKA) effectively improves joint function and quality of life, but carries the risk of surgical site infection (SSI). SSIs most affect older adult patients with comorbidities. Thus, we evaluated the incidence of SSIs following TKA in older adult populations (≥ 65 years) and explored the association of SSIs with male sex, morbid obesity, and other comorbidities.

Methodology. A systematic review and meta-analysis were conducted according to PRISMA guidelines. Data were extracted from prospective and retrospective studies evaluating the incidence and risk factors for SSIs following TKA in older adults aged ≥ 65 years. Studies were found through MEDLINE/PubMed, Cochrane Library, and other databases up to 31 July 2024. Risk factors included male sex, morbid obesity, type 2 diabetes, rheumatologic disease, peripheral vascular disease, heart failure, and anaemia. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated using a random-effects model. Heterogeneity was assessed using the I^2 statistic.

Results. Twenty studies with a total population of 29,20,681 patients were included. The pooled prevalence of SSIs following TKA was estimated at 1.19% (95% CI: 0.84–1.68%). Male sex was associated with a higher SSI risk (OR: 1.79, 95% CI: 1.45–2.21%). Morbid obesity showed the strongest association with SSIs (OR: 1.47, 95% CI: 1.16–1.86%), followed by type 2 diabetes (OR: 1.28, 95% CI: 1.05–1.56%), and rheumatologic disease (OR: 1.72, 95% CI: 1.09–2.69%). Significant heterogeneity was observed across studies (I^2 > 50%).

Conclusion. This meta-analysis highlights the burden of SSIs among older adult patients following TKA, particularly male patients and those with comorbidities. These results indicate the need for individualized risk assessment and preventive strategies to optimize surgical outcomes in this population. Future research should focus on developing tailored interventions for this vulnerable population.

Keywords. anemia, heart failure, males, morbid obesity, peripheral vascular disease, rheumatologic disease, surgical site infection, total knee arthroplasty, type 2 diabetes

INTRODUCTION

Total knee arthroplasty (TKA) is one of the most effective, economical, and consistently successful surgeries indicated for treating patients with severe osteoarthritis of the knee. TKA improves joint function, relieves pain, and corrects deformities, thereby improving patients' quality of life.[1,2] The global demand for TKA is rising rapidly due to the growing prevalence of knee arthritis. It is estimated that the number of primary TKA procedures will increase by 85%, i.e., 1.26 million procedures, by 2030.[3,4]

Despite these promising trends, challenges remain, as 11% to 20.8% of patients develop perioperative complications.

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The most common complications include thromboembolic disease, infection, periprosthetic fracture, extensor mechanism injury, surgical wounds, joint stiffness, and neurovascular lesions.[2] Among these, infections pose a particularly significant challenge. Recent data suggest that peri-prosthetic joint infection, in particular, occurs in 0.8% and 1.9% of all TKAs.[5]

Early surgical site infections (SSIs) are more common than late (≥ 3 months post-TKA) SSIs.[6,7] Wilson et al. concluded that patients who were morbidly obese (BMI ≥ 40 kg/m^2) were at the highest risk of SSIs after knee surgeries.[8] Werner et al. categorized 891,567 patients who underwent total hip arthroplasty into four BMI-based cohorts: non-obese (BMI < 30 kg/m^2), obese (BMI 30–39.9 kg/m^2), morbidly obese (BMI 40–49.9 kg/m^2), and super-obese (BMI ≥ 50 kg/m^2). The study demonstrated a progressive increase in the risk of SSIs with rising BMI, with SSI rates reported as 0.8% in non-obese patients, 2.6% in obese patients, 5.2% in morbidly obese patients, and 12.4% in super-obese patients.[9,10] Fu et al. demonstrated the same trend in 71,599 patients,[9,11] emphasizing the need to address BMI.

The impact of age on TKA outcomes remains a contentious topic of discussion. In clinical research, individuals aged 65 years and above are commonly classified as older adults, a group prone to comorbidities, physiological decline, and increased vulnerability to postoperative complications.[2] While some studies suggest that age alone is not a risk factor for SSI after total joint arthroplasty (citing 65 years old as the cut-off),[12] other studies indicate a significantly higher risk in patients aged 76 to 80 years as compared to those aged ≤ 50 years.[13] Numerous studies support the use of primary TKA in appropriately selected elderly patients, but these studies often suffer from limitations such as incomplete datasets, diverse patient populations, and inconsistent outcome measures.[14]

In addition, comorbidities such as type 2 diabetes, rheumatologic disease, peripheral vascular disease, heart failure, and anemia also influence TKA outcomes. Baseline comorbidities increase the risk of postsurgical mortality and SSIs in the older adult population undergoing TKA. Congestive heart failure, chronic pulmonary disease, preoperative anemia, depression, diabetes, renal disease, pulmonary circulation disorders, rheumatologic disease, psychoses, metastatic tumour, valvular disease, and peripheral vascular disease were associated with increased risk of SSIs.[14,15] With regard to timing, early SSIs were associated with hypertension, heart failure, coagulopathies, depression, and peripheral vascular disease, while delayed and late SSIs were associated with alcohol abuse, congestive heart failure, depression, diabetes, renal failure, and iron-deficiency anemia.[7,16]

While recent studies demonstrated age and other comorbidities as risk factors in TKA, no single study has evaluated the risk of post-TKA SSIs in the older adult population and its association with gender and comorbidities. Elucidating these relationships will help prevent SSIs and achieve better surgical outcomes after TKA in this high-risk population.

METHODOLOGY

Study design

The objectives of this study were to evaluate the risk factors for SSI after TKA in the older adult population (≥ 65 years old) and to assess the association of SSI with male sex, morbid obesity, type 2 diabetes, rheumatologic disease, peripheral vascular disease, heart failure, and anemia. We included published prospective and retrospective observational studies, cohort studies, surveillance studies, and database analyses that evaluated the incidence rate of infection after TKA and/or evaluated the risk factors including male sex, morbid obesity, type 2 diabetes, rheumatologic disease, peripheral vascular disease, heart failure, and anemia associated with SSIs in patients aged ≥ 65 years of either sex. We excluded non-English publications, case reports, and studies lacking SSI data in the relevant population (Figure 1).

Search strategy

This systematic review and meta-analysis followed the 2020 PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.[17] A comprehensive search was conducted across MEDLINE/PubMed, WHO International Clinical Trials Registry Platform, IndMED, ClinicalTrials.gov, and the Cochrane Library [Cochrane Central Register of Controlled Trials (CENTRAL), Cochrane Database of Systematic Reviews, and Cochrane Methodology Register] from study inception to 31 July 2024. The search terms used in different combinations were: "incidence," "infection," "total," "knee," "arthroplasty," "postoperative," "rates," "surgical," "site," "replacement," "periprosthetic," "joint," "risk," "factors," "epidemiology," "prevalence," "deep," "statistics," "trends," "management," "complications," "antibiotic," "prophylaxis," and "revision." We refined our search by adapting the search terms and filtering the results. Two authors independently screened the found abstracts and subsequently retrieved the full texts, if necessary. Disagreements were settled by a third author.

Data extraction and management

Data were extracted independently by the two authors and tabulated in a custom spreadsheet, making no assumptions or simplifications to ensure accuracy and reproducibility.

Both authors independently evaluated the studies' risk of bias. Observational studies were assessed using the Newcastle–Ottawa Scale. Discrepancies were resolved by a third author when necessary.

A random-effects model accounted for variability among studies and ensured robustness against potential outliers. The primary outcome, "incidence rate of SSI following TKA", and the secondary outcome "association of SSI following TKA with male sex, morbid obesity, type 2 diabetes, rheumatologic disease, peripheral vascular disease, heart failure, and

anemia" were assessed by calculating odds ratios (ORs) with corresponding 95% confidence intervals (CIs). Heterogeneity was analyzed with the $\chi 2$ test on n−1 degrees of freedom (with an α error of 5% for statistical significance) and the test. The values of 25% corresponded to low, 50% to medium, and 75% to high levels of heterogeneity.

Attrition rates, such as losses to follow-up, withdrawals, and dropouts, were documented. We critically assessed the studies' methods for handling missing data.

All statistical analyses were performed using MetaXL v 4.0.

RESULTS

A total of 127 studies were retrieved. After removing 32 duplicate records, we screened the titles and abstracts of 95 unique studies. During this screening phase, 18 studies were excluded. After evaluating the full-text articles of the remaining 37 studies, 20 studies were deemed eligible for inclusion in the analysis.[2,7,14-16,18-32] Data from 19 studies were used for quantitative analysis (one study lacked pooled prevalence data). A detailed overview of the search and selection process is provided in Figure 1.

Characteristics of the included studies

A total of 29,20,681 patients were included in our meta-analysis (range 38 to 12,27,244 patients). The percentage of males ranged from 16% to 94.8% (Table 1).

Incidence rate of surgical site infections following TKA

Data from 28,37,670 patients in 19 studies were included for quantitative analysis of data to estimate the pooled prevalence rate of SSI following TKA (Figure 2).[2,7,14,16,18-32] We excluded one study since it lacked data to estimate the pooled prevalence.[15] This was estimated to be 1.19% (95% CI: 0.84%-1.68%).

Incidence rate of surgical site infections following TKA in male patients

Data from seven studies were included for quantitative analysis to estimate the pooled prevalence rate of SSI following TKA in male patients (Figure 3). This was estimated to be 1.79% (95% CI: 1.45%-2.21%).[14,16,21,22,27,28,30]

Incidence rate of surgical site infections in patients with comorbidities

Data from seven studies were included for quantitative analysis to estimate the pooled prevalence rate of SSI following TKA in patients with morbid obesity (Figure 4A). This was estimated to be 1.47% (95% CI: 1.16%-1.86%).[7,15,16,20-22,31]

Data from five studies were included for quantitative analysis to estimate the pooled prevalence of SSI following TKA in patients with type 2 diabetes (Figure 4B). This was estimated to be 1.28% (95% CI: 1.05%-1.56%).[15,16,21,27,31]

Data from three studies were included for quantitative analysis to estimate the pooled prevalence of SSI following TKA in patients with rheumatologic disease (Figure 4C). This was estimated to be 1.72% (95% CI: 1.09%-2.69%).[7,15,30]

Table 1. Characteristics of the included studies

Study	Design	Country	Total population	Males	Mean age	Newcastle-Ottawa Scale
Souza GGA,[2] 2020	Prospective	Brazil	70	23.6%	73.0	6
Weinstein EJ,[7] 2023	Retrospective	USA	61701	94.8%	Median: 65	7
Bischoff P,[14] 2023	Retrospective	Germany	286074	27%	Median: 70	7
Bozic KJ,[15] 2012	Retrospective	USA	83011	NA	NA	5
Sodhi N,[16] 2020	Retrospective	USA	275717	35%	NA	6
Babkin Y,[18] 2007	Retrospective	Israel	180	34%	72.4	6
Chesney D,[19] 2008	Prospective	UK	1509	42.68%	NA	6
Pulido L,[20] 2008	Retrospective	USA	4185	NA	NA	5
Dowsey MM,[21] 2009	Retrospective analysis of prospectively collected data	Australia	1214	36.99%	Median: 72	7
Suzuki G,[22] 2011	Retrospective	Japan	1146	NA	Median: 72	5
Belmont PJ Jr,[23] 2014	Prospective	USA	15321	35.5% (n = 15,287)	67.3	7
Yun ST,[24] 2018	Retrospective	Korea	79	16%	82.8	5
Kodaira S,[25] 2019	Retrospective	Japan	679	23%	82	6
Sezgin EA,[26] 2019	Retrospective	Sweden	329	31%	92	6
Ravi B,[27] 2019	Retrospective	Canada	92343	38.5%	Median: 68	7
Baier C,[28] 2019	Retrospective	Germany	2439	32.1%	Median: 69	7
Yang QF,[29] 2021	Retrospective	China	1227244	NA	NA	6
Fricka KB,[30] 2023	Retrospective	USA	525887	37.9%	73.0	7
Li H,[31] 2024	Retrospective	China	650	34.46%	NA	5
Lenguerrand,[32] 2019	Prospective	UK	340903	43.15%	Median: 70	8

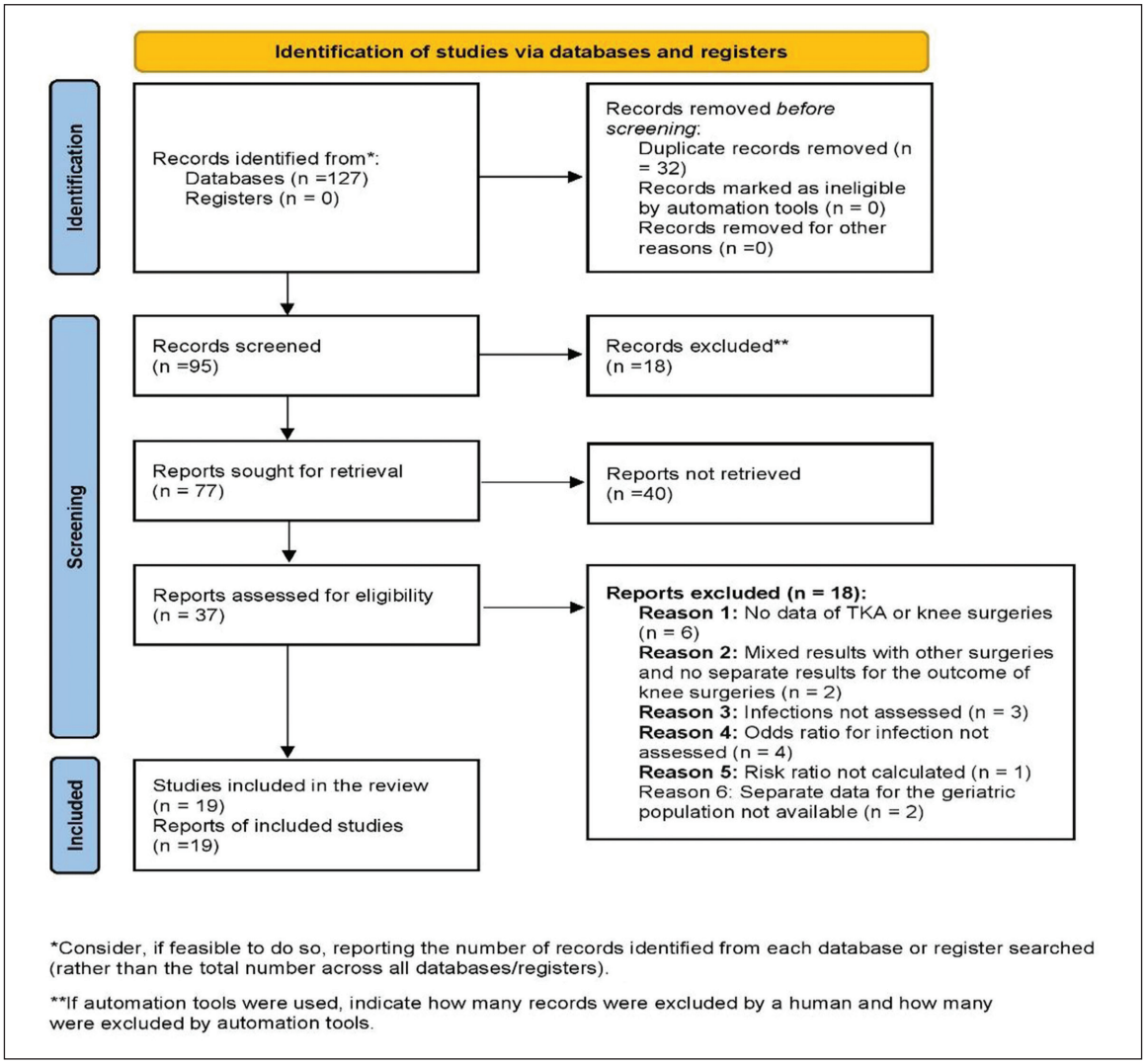

Figure 1. PRISMA 2020 flow diagram for study selection.

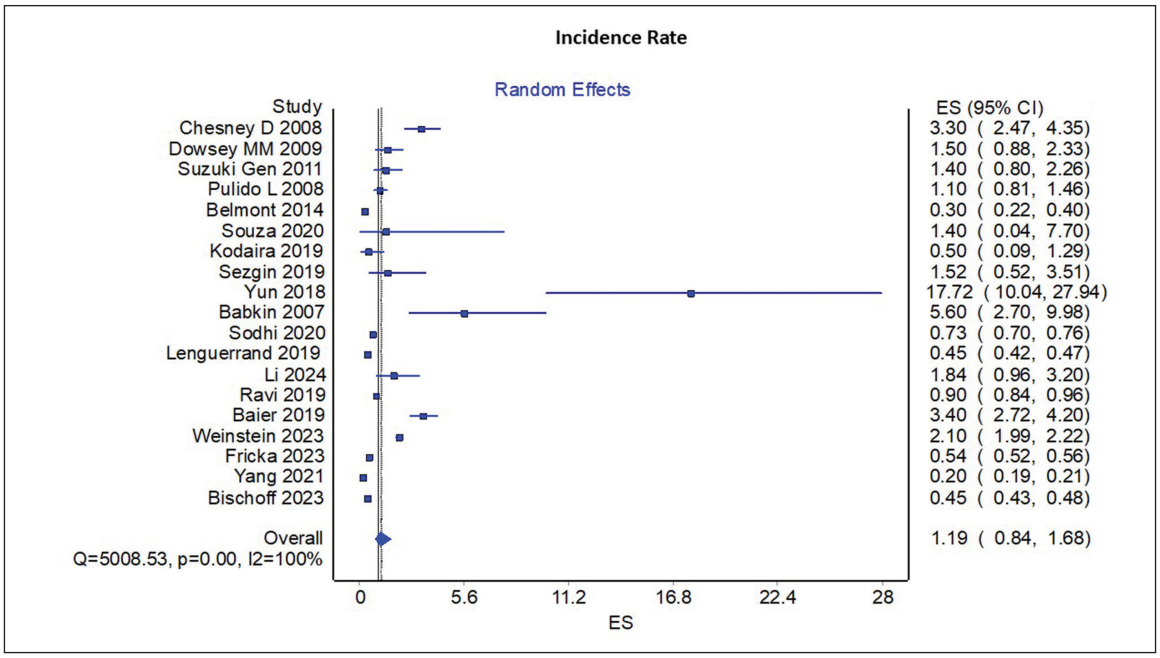

Figure 2. Forest plot showing pooled prevalence of surgical site infections (SSIs) in older adult patients post-total knee arthroplasty (TKA).

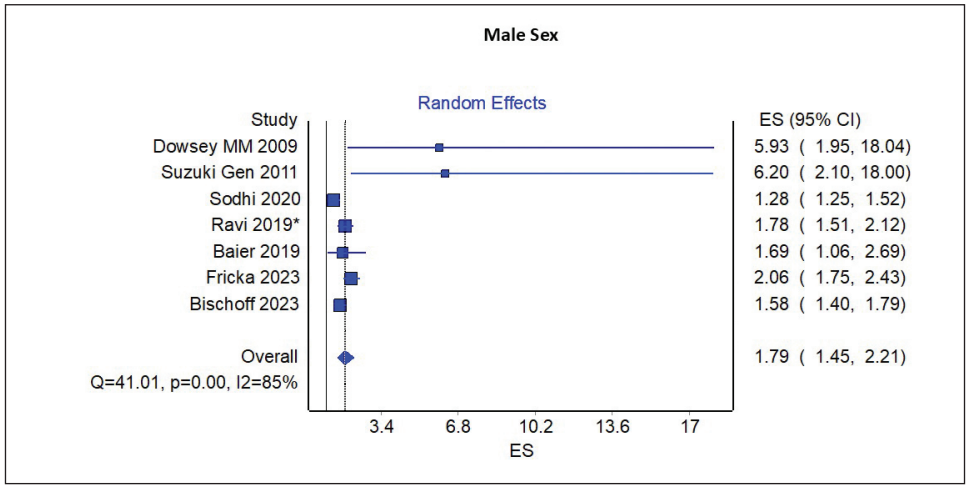

Figure 3. Forest plot of odds ratios estimating SSI risk associated with male sex post-TKA.

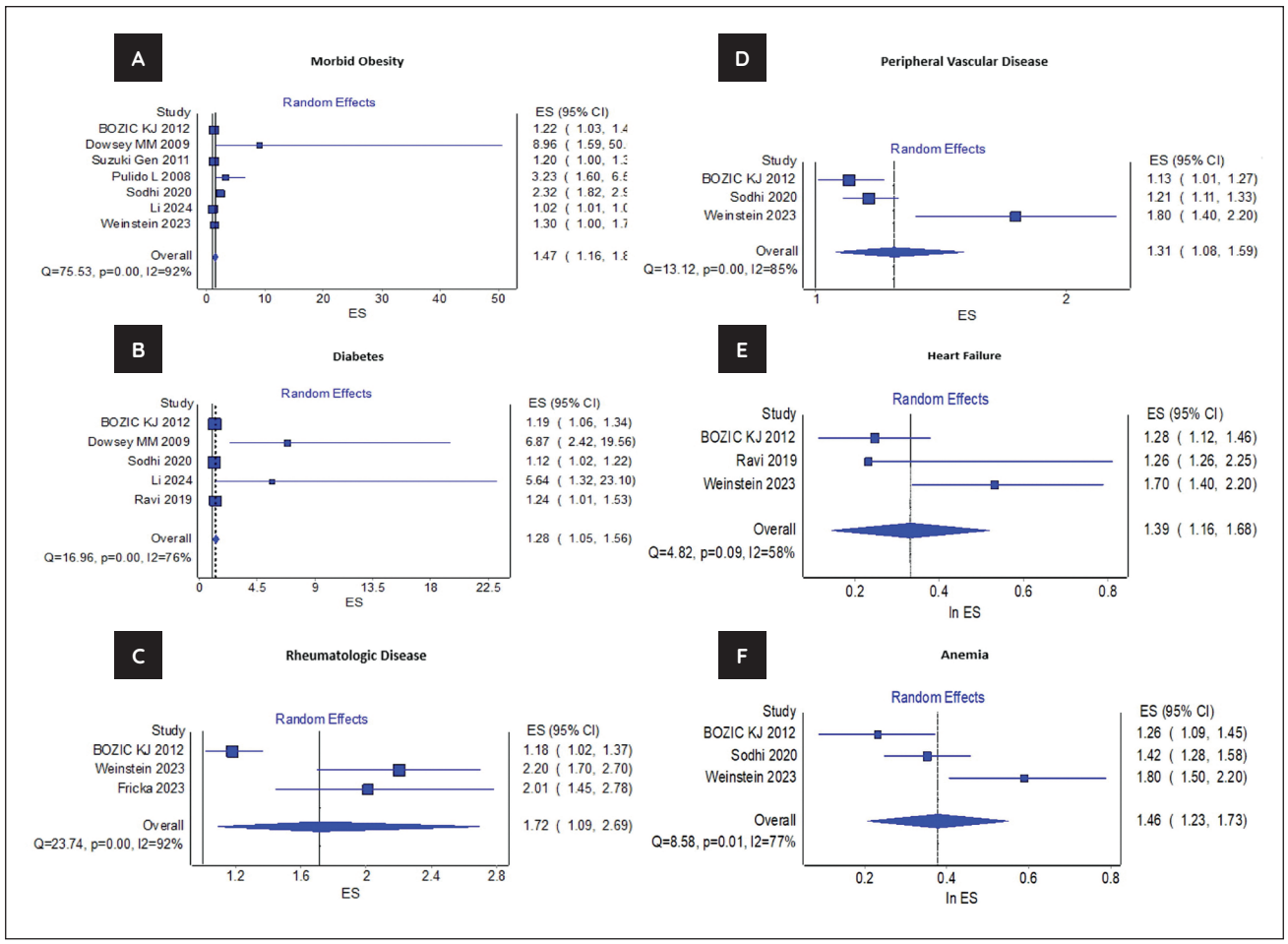

Figure 4. (A) Forest plot estimating SSI risk in older adult patients with morbid obesity. (n = 7 studies; random-effects model; I^2 = 92%). **(B)** Forest plot estimating SSI risk in older adult patients with type 2 diabetes. (n = 5 studies; random-effects model; I^2 = 76%). **(C)** Forest plot estimating SSI risk in older adult patients with rheumatologic disease. (n = 3 studies; random-effects model; I^2 = 92%). **(D)** Forest plot estimating SSI risk in older adult patients with peripheral vascular disease. (n = 3 studies; random-effects model; I^2 = 85%). **(E)** Forest plot estimating SSI risk in older adult patients with heart failure. (n = 3 studies; random-effects model; I^2 = 58%). **(F)** Forest plot estimating SSI risk in older adult patients with anemia. (n = 3 studies; random-effects model; I^2 = 77%).

Data from three studies were included for quantitative analysis to estimate the pooled prevalence rate of SSI following TKA in patients with peripheral vascular disease (Figure 4D). This was estimated to be 1.31% (95% CI: 1.08%-1.59%).[7,15,16]

Data from three studies were included for quantitative analysis to estimate the pooled prevalence of SSI post-TKA in patients with heart failure (Figure 4E). This was estimated to be 1.39% (95% CI: 1.16%-1.68%).[7,15,27]

Data from three studies were included for quantitative analysis to estimate the pooled prevalence of SSI following TKA in patients with anemia (Figure 4F). This was estimated to be 1.46% (95% CI: 1.23%-1.73%).[7,15,16]

Test for heterogeneity

There was significant heterogeneity (> 50%) in all analyses conducted in this study.

DISCUSSION

We intended to estimate the prevalence rate of SSI following TKA by systematically reviewing recent publications with relevant data. Our findings demonstrated a significant incidence rate of SSIs in older adult patients undergoing TKA. Additionally, various modifiable and non-modifiable risk factors, such as male sex and comorbidities, were found to independently contribute to the increased risk of SSIs. Following a comprehensive screening process, 20 studies were included in our meta-analysis, with an overall population of 29,20,681 patients. The pooled prevalence of SSIs post-TKA in the older adult population was estimated to be 1.19% (95%, CI: 0.84%-1.68%), and in older adult men was 1.79% (95%, CI: 1.45%-2.21%. The incidence was also high in patients with comorbidities. However, these results remain non-definitive due to the studies' heterogeneity and our analysis's low power.

To our knowledge, this meta-analysis is the first to assess the incidence rate of surgical site infections (SSIs) following total knee arthroplasty (TKA) in the older adult population with various comorbidities, while also evaluating the outcomes specifically in males. The strengths of our study include its large cohort, a diverse age range within the older adult population, various comorbidities, and the variety of participants' ethnic origins. The major drawback of this meta-analysis is the dearth of high-quality and sufficiently powered data. We also did not account for the different postoperative wound management methods used, which could have affected the outcome.

Sezgin et al. found that in 329 nonagenarians (mean age = 92 years) who underwent TKA, 8 (2.4%) patients experienced knee complications requiring revision surgery. After 5 and 10 years, over 50% and 10% of patients, respectively, did not need revision.[26] Our incidence rate aligns with previously reported data, indicating that older adult patients undergoing TKA are at risk of developing SSIs. Factors include a weakened immune system, organ failure, and other comorbidities.[25,26,31]

Sodhi et al. reported a higher risk of 90-day SSIs in men (OR 1.28 [95% CI 1.25 to 1.52]; $p < 0.001$), patients with comorbidities, and overweight patients (BMI > 25 kg/m^2, $p < 0.001$). Our results were similar, suggesting a sex difference in immune response.[16]

Among the comorbidities, morbid obesity has emerged as one of the most significant risk factors for deep and superficial SSIs following TKA. Excess adipose impacts tissue vascularity, potentially delaying wound healing and increasing the risk of infection.[21] Type 2 diabetes also inhibits wound healing by reducing collagen synthesis, impairing angiogenesis, and attenuating neutrophil and macrophage functions, thereby raising the risk of infection and microvascular complications.[31]

Recent studies indicate that patients with autoimmune rheumatic diseases (including systemic lupus erythematosus and rheumatoid arthritis) face a higher risk of infection following surgery. Factors contributing to the risk of post-operative infections include immunosuppression, disease activity, comorbidities, patient demographics, surgeon experience, and the volume of surgeries performed at the hospital.[32]

Peripheral vascular disease (OR 1.21 [95% CI 1.11 to 1.33]; $p < 0.001$) increased the risk of SSIs post-TKAs.[16]

Heart failure and anemia also significantly increase SSI risk following TKA. Reduced tissue perfusion and tissue hypoxia both compromise wound healing.[33,34]

Patient selection and comorbidity control could help reduce SSI incidence rates in the older adult population. Male patients and those with rheumatologic disease or cardiovascular comorbidities may benefit from individualized wound management therapies.

CONCLUSION

This meta-analysis highlights a significant incidence of SSIs following TKA in older adult patients and identifies risk factors. The results should guide clinical practice and help develop targeted interventions aimed at minimizing infection risks for this vulnerable population.

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STATEMENT OF AUTHORSHIP

All authors certified fulfillment of ICMJE authorship criteria.

CREDIT AUTHOR STATEMENT

CH: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing – original draft preparation, Writing – review and editing, Supervision, Project administration; **BS:** Conceptualization, Software, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing – original draft preparation, Writing – review and editing, Visualization, Funding acquisition; **PS:** Methodology, Software, Validation, Formal analysis, Data Curation, Writing – review and editing, Visualization, Project administration.

DATA AVAILABILITY STATEMENT

The datasets generated and analyzed are included in the published article.

AUTHOR DISCLOSURE

The authors declared no conflict of interest related to the research, authorship, or publication of this manuscript.

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SYSTEMATIC REVIEW

Correlation of WOMAC Score with Functional Recovery in Patients with Osteoarthritis Following Total Knee Replacement

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ABSTRACT

Background. Total knee replacement (TKR) is an established procedure for advanced knee osteoarthritis, offering pain relief and improved mobility. The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) is widely applied to measure pain, stiffness, and functional limitation.

Objective. This study investigated the relationship between WOMAC scores and overall functional recovery in patients after TKR.

Methodology. A prospective observational study was performed in patients who underwent primary TKR at the Government Medical College and Hospital, Kallakurichi, Tamil Nadu, India, between January 2023 and June 2025. WOMAC scores were documented preoperatively, at six weeks, three months, and six months postoperatively. Recovery was further assessed using the Timed Up-and-Go (TUG) test, range of motion (ROM), and patient satisfaction levels. Statistical analysis included paired t-tests and Pearson correlation.

Results. Eighty patients (52 females, 28 males; mean age 64.2 ± 6.8 years) were enrolled. The average baseline WOMAC score was 72.4 ± 9.6, decreasing to 34.8 ± 7.2 at 3 months and 21.5 ± 5.6 at 6 months ($p < 0.001$). Improvements in TUG and ROM correlated significantly with WOMAC changes ($r = 0.68$ and -0.55, respectively; $p < 0.01$). Patient satisfaction also showed a strong positive association with WOMAC outcomes ($r = 0.72$, $p < 0.001$).

Conclusion. This study concludes that significant WOMAC improvements within six months are correlated with high patient satisfaction and functional gains. Clinicians should consider early interventions if scores plateau. Longer-term studies are needed to confirm sustained benefits. The key take-home message is that WOMAC monitoring after TKR can enhance personalized recovery strategies.

Keywords. osteoarthritis; recovery of function; patient satisfaction; pain measurement; range of motion

INTRODUCTION

Knee osteoarthritis (OA) is among the leading causes of disability globally, affecting over 250 million people and contributing to significant socioeconomic burden through reduced mobility and chronic pain.[1] Total knee replacement (TKR) has become the treatment of choice for patients with end-stage OA, aiming to alleviate pain, restore mobility, improve function, and enhance quality of life.[2,3] Previous research has demonstrated that TKR leads to substantial improvements in pain and function, with success rates exceeding 80% in most cohorts.[4] For instance, studies from Western populations report mean WOMAC score reductions of 40 to 50 points post-TKR, correlating with better daily activities.

However, the trajectory of postoperative recovery depends on surgical precision, physiotherapy, and patient-related factors such as age, BMI, and comorbidities. Evaluating

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outcomes in TKR requires validated assessment tools. The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) is a disease-specific instrument extensively validated for quantifying pain, stiffness, and functional limitation in OA patients. WOMAC consists of 24 items scored from 0 to 96, with higher scores indicating worse symptoms. It includes subscales for pain (0–20), stiffness (0–8), and physical function (0–68), with changes of 12 points or more considered clinically meaningful.

Despite abundant literature on TKR outcomes, gaps remain in understanding WOMAC's correlation with functional metrics in diverse populations, particularly in developing countries like India, with varying access to rehabilitation and limited follow-up data. Most studies focus on short-term pain relief, with few exploring long-term functional recovery or patient satisfaction. This creates a need for localized evidence to guide clinical practice and predict outcomes. This study was designed to assess the correlation between WOMAC score improvements and functional recovery among TKR recipients. This study hypothesized that improvements in WOMAC scores would positively correlate with functional recovery metrics post-TKR.

The novelty of this study lies in its prospective design in a tertiary Indian hospital, assessing WOMAC alongside tests like TUG and ROM to provide actionable insights for rehabilitation tailoring.

METHODOLOGY

This was a prospective observational study conducted in the Department of Orthopaedics, Government Medical College and Hospital, Kallakurichi, Tamil Nadu, India, from January 2023 to June 2025. The study was approved by the Institutional Ethics Committee GMCK/IEC/5/25.

Inclusion criteria

- Age 50–80 years with primary knee OA
- Underwent unilateral or bilateral TKR
- Willingness for follow-up

Exclusion criteria

- Revision TKR
- Inflammatory arthritis (e.g., rheumatoid arthritis)
- Post-traumatic arthritis
- Neurological conditions affecting ambulation

Sample size calculation

Sample size was calculated using the formula for paired t-tests: $n = (Z_{\alpha/2} + Z_{\beta})^2 \times (SD^2) / d^2$, where $Z_{\alpha/2} = 1.96$ ($\alpha = 0.05$), $Z_{\beta} = 1.28$ (power = 90%), SD = 15 (from pilot WOMAC data), $d = 20$ (expected mean difference). This yielded $n = 64$; adding 25% for potential dropouts resulted in a sample size of 80 patients.

All procedures used a standardized surgical technique: cemented posterior-stabilized prosthesis via medial parapatellar approach, performed by a single experienced surgeon (> 10 years experience). Postoperative rehabilitation followed a standardized protocol (daily physiotherapy for six weeks, including range exercises and gait training). Pain management involved multimodal analgesia (NSAIDs, opioids as needed, ice therapy). No surgical complications, infections, or revisions occurred during follow-up. All 80 patients completed the six-month follow-up with no dropouts. Assessors were not blinded but used standardized protocols to minimize bias. For bilateral cases (all simultaneous), both knees were assessed, and scores averaged; subgroup analysis confirmed no trajectory differences ($p > 0.05$).

Outcome measures

1. ***WOMAC score:*** The WOMAC scoring system is a widely used tool for assessing osteoarthritis symptoms, particularly in the hip and knee. It consists of 24 items divided into three subscales: Pain: 5 items, scored from 0 (none) to 4 (extreme), (score range, 0 to 20) Stiffness: 2 items, scored from 0 (none) to 4 (extreme), (score range, 0 to 8) and Physical Function: 17 items, scored from 0 (no difficulty) to 4 (maximum difficulty), (score range, 0 to 68).
   The total WOMAC score is the sum of the scores from all three subscales, with a maximum score of 96. Higher scores indicate worse pain, stiffness, and functional limitation. WOMAC score was assessed at baseline, six weeks, three months, and six months.
2. ***Functional tests:*** The Timed Up and Go (TUG) test[5] is a simple assessment used to evaluate an individual's mobility, balance, and fall risk. The test involves timing how long it takes a person to rise from a seated position, walk three meters, turn around, walk back to the chair, and sit down again. It is commonly used in clinical settings to identify changes in mobility that may require further attention. Knee ROM was assessed using a goniometer; > 110° indicates good recovery.
3. ***Patient satisfaction*** was assessed using a 5-point Likert scale (1 = very dissatisfied, 5 = very satisfied; higher scores better).[6]

Statistical analysis

Paired t-tests compared pre- and postoperative values, while Pearson correlation determined associations between WOMAC and functional parameters (at six-month follow-up). Significance was set at $p < 0.05$.

RESULTS

Eighty patients were included (Table 1). The cohort was predominantly female (65%), with a mean age of 64.2 ± 6.8 years and BMI of 27.5 kg/m^2, typical for OA patients undergoing TKR.[7] Unilateral procedures dominated ($n = 62$, 77.5%), and all bilateral cases were performed simultaneously.

Table 1. Demographic characteristics of patients (n = 80)

Variable	Value
Mean age (years)	64.2 ± 6.8
Gender	52 Female (65%), 28 Male (35%)
Laterality	62 unilateral, 18 bilateral
Mean BMI (kg/m²)	27.5 ± 3.2

Table 2. Changes in WOMAC scores

Time Point	WOMAC scores (Mean ± SD)	*p*-value (vs baseline)
Pre-op	72.4 ± 9.6	-
6 weeks	54.3 ± 8.1	< 0.001
3 months	34.8 ± 7.2	< 0.001
6 months	21.5 ± 5.6	< 0.001

Table 3. Changes in TUG, ROM, and Patient Satisfaction

Parameter	Baseline	6 months	*p*-value
TUG (seconds)	18.2 ± 4.1	9.8 ± 2.3	< 0.001
ROM (degrees)	92.5 ± 10.2	118.4 ± 8.1	< 0.001
Satisfaction (1-5)	-	4.3 ± 0.7	-

Table 4. Correlation of WOMAC with recovery parameters (at 6 months)

Parameter	Correlation (r)	*p*-value
TUG Test	0.68	< 0.01
ROM	-0.55	< 0.01
Patient Satisfaction	0.72	< 0.001

No significant baseline differences existed between unilateral and bilateral cases ($p > 0.05$). Table 1 demonstrates a balanced cohort suitable for assessing TKR outcomes. Bilateral patients showed similar baseline WOMAC scores (73.4 ± 8.9) to unilateral (72.1 ± 9.8, $p = 0.42$), supporting combined analysis.

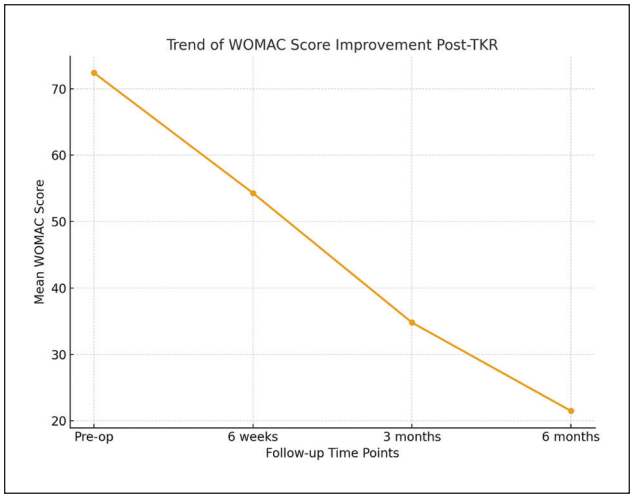

Figure 1. Line chart showing progressive decline in WOMAC score from baseline to six months (demonstrating steady improvement, plateauing after three months).

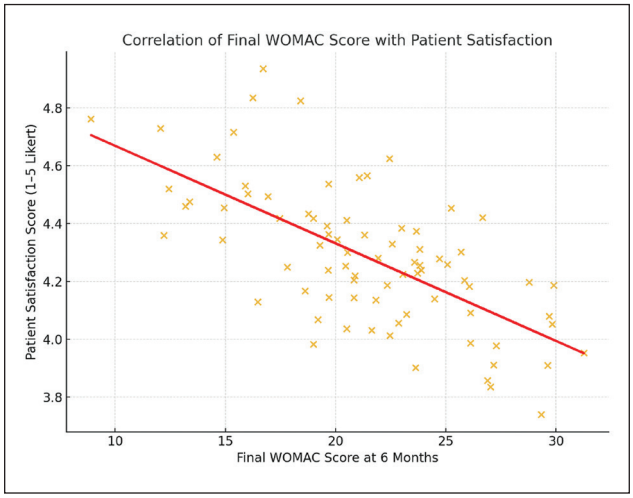

Figure 2. Scatter plot showing correlation between WOMAC and patient satisfaction (strong linear trend, r = 0.72).

DISCUSSION

This study demonstrated significant improvements in WOMAC scores[8] post TKR, with a mean reduction of 50.9 points over six months, reflecting enhanced pain control and functional recovery.[9] Strong correlations were observed between WOMAC changes and TUG (r = 0.68), ROM (r = -0.55), and patient satisfaction (r = 0.72), validating WOMAC's sensitivity as an outcome measure. The strongest relationship with satisfaction highlights that WOMAC reflects not only physical recovery but also patient-perceived well-being. This means improvements in objective functional performance (TUG and ROM) were significantly associated with better WOMAC scores, which reflect pain reduction, improved stiffness, and better physical function.

A large-scale study by Choi et al.[10] echoed these findings, reporting that performance-based physical function tests (TUG, 6-Minute Walk Test, Stair Climb Test) were significantly associated with self-reported WOMAC scores and quality of life at three months after TKA. The correlation between WOMAC pain and physical function was high (r = 0.71, $p < 0.001$, $r = 0.71$, $p < 0.001$), comparable to the current study. Additionally, pre- and postoperative pain control was found to be crucial for functional outcomes, and quadriceps as well as hamstring strength were also significant predictors for postoperative function. Witvrouw et al.[11] found moderate correlations between objective assessment and WOMAC subscales (r = 0.343 for function, r = 0.246 for stiffness, and r = 0.269 for pain), generally lower than the current study's findings, possibly due to differences in patient population or protocols. A more recent review indicated that the magnitude of WOMAC score improvement post-TKR closely predicts better functional daily activity and satisfaction, aligning with the present study's ~50-point reduction. Furthermore, Walker et al.[12] highlighted that worse preoperative WOMAC scores independently predicted greater improvements after surgery.

Postoperative satisfaction was best predicted by improvements in the WOMAC pain and physical function subscales,

supporting the use of WOMAC as a reliable indicator for patient-centered recovery, as seen in previous studies. The correlation between WOMAC pain and physical function was highly comparable to that of the current study.

The study findings imply that WOMAC can guide clinical decisions; for example, scores > 30 at three months may warrant intensified rehabilitation to optimize outcomes. The WOMAC improvement magnitude (50.9 points) in this study aligns with the 40–50 point improvements reported in recent cohorts, though the correlation coefficients (0.55–0.72) were slightly higher in this study than the 0.5–0.6 in obesity-focused research, possibly due to the standardized protocol in this study. Bilateral cases showed similar trajectories, consistent with literature suggesting simultaneous procedures recover similarly to unilateral if rehab is uniform.[13]

Clinical implications include using WOMAC thresholds (e.g., < 25 at six months) to predict satisfaction > 4/5, and treating bilateral TKR[14] patients similarly unless complications arise. These results are consistent with earlier reports identifying WOMAC as a robust tool for monitoring postoperative outcomes and satisfaction.[15]

This study is limited by its single-center design, potentially reducing generalizability. The six-month follow-up is relatively short; a longer evaluation could reveal sustained trends or late complications. There was no control group (e.g., non-surgical OA patients), and assessor non-blinding may introduce bias. The sample, while adequate, was not powered for subgroup analyses beyond bilaterality.

CONCLUSION

The WOMAC score was a reliable and practical tool for assessing functional recovery following TKR. Incorporating routine WOMAC evaluations in postoperative care can assist clinicians in monitoring progress, tailoring rehabilitation, and predicting patient satisfaction. This study confirms strong correlations with objective metrics like TUG and ROM, with implications for early intervention. In Indian settings, where resources vary, WOMAC offers a cost-effective way to enhance outcomes. Future multicenter studies with longer follow-up are recommended. The key take-home message is that WOMAC-driven care personalizes recovery, improving patient-centered results.

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STATEMENT OF AUTHORSHIP

All authors certified fulfillment of ICMJE authorship criteria.

CREDIT AUTHOR STATEMENT

RR: Conceptualization, Methodology, Validation, Writing – original draft preparation; **BP and DS:** Writing – review and editing.

DATA AVAILABILITY STATEMENT

The datasets generated and analyzed in this study are included in the published article.

AUTHOR DISCLOSURE

The authors declared no conflict of interest.

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CASE REPORT

Lateral Tibial Plateau Reconstruction using a Pedicled Patellar Transplant in a Male Patient with a Recurrent Fungating Giant Cell Tumor: A Case Report

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ABSTRACT

Reported here is a surgical approach to a recurrent fungating giant cell tumor in a 35-year-old male. The patient presented with a lytic lesion on the epiphysis extending to the metaphyseal area of the lateral tibial plateau. Reconstruction was done using a pedicled patellar transplant following an extended curettage of the affected area. This was augmented with a suture anchor, a non-vascularized fibular strut graft, synthetic bone grafts, and soft tissue reconstruction.

Keywords. D'Aubigne, pedicled patellar transplant, lateral tibial plateau reconstruction, recurrent giant cell tumor

INTRODUCTION

This case report describes the treatment of a giant cell tumor (GCT) in the proximal tibia of a male adult, utilizing the D'Aubigne procedure. GCTs in weight-bearing areas like the proximal tibia are challenging because removing the tumor must be balanced with preserving joint functionality.[1] The D'Aubigne procedure, involving a pedicled patellar transplant, uniquely addresses these challenges by eradicating the tumor and reconstructing the joint, thereby maintaining limb functionality and reducing recurrence risk.[2] This case highlights the importance of specialized surgical techniques in orthopedic oncology, particularly for tumors in critical locations, emphasizing the need for both functional preservation and effective tumor management.

CASE

A 35-year-old male construction worker noted a progressively enlarging mass on the lateral aspect of his right knee beginning eight years before the consultation. There was no pain or limitation of motion. Eight months before being seen at our institution, he consulted a local clinic and underwent an excision biopsy of the mass. After two months, the wound dehisced, and the mass recurred and subsequently increased in size. After another four months, he consulted another tertiary hospital, where an MRI was requested and an incisional biopsy was performed, revealing a giant cell tumor. One week before admission, he suddenly experienced generalized body weakness and dizziness, accompanied by occasional blurring of vision. The patient was seen by the internal medicine service and was diagnosed with severe anemia, prompting admission to our institution.

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Patient was then referred to the orthopaedic oncology service for co-management of his right knee mass.

Physical examination revealed a 12 x 15 x 23 cm mixed soft to firm, non-mobile, non-tender, fungating mass on the lateral aspect of the patient's right knee with minimal bleeding and foul-smelling discharge (Figure 1). No sensory and motor deficits were noted on the right lower extremity, and the distal pulses were full and equal.

On radiographs, there was a large osteolytic lesion on the epi-metaphyseal region of the right lateral proximal tibia, with neocorticalization, a cortical break, and no matrix. There was also a large soft tissue shadow on the lateral aspect of the right knee (Figure 1D and 1E). Magnetic resonance imaging of the same knee showed involvement of the articular margin of the lateral proximal tibia with soft tissue extension of the mass (Figure 2).

A repeat incisional biopsy on the soft tissue was performed, revealing a keratinous cyst, infiltrated with foreign body giant cell reaction and granulation tissue formation. A chest CT scan with IV contrast revealed no abnormal enhancements or pulmonary nodules.

He was then diagnosed with a giant cell tumor of the right proximal tibia, Campanacci grade III, Enneking stage 3. His pre-operative musculoskeletal tumor society score was 1, denoting poor function (Table 1).[2,3]

SURGICAL TECHNIQUE

The patient was induced via general anesthesia and positioned supine with a tourniquet on the ipsilateral thigh. A wide resection of the mass was performed, identifying and preserving the common peroneal nerve. The cavitary lesion was curetted. The articular surface of the lateral tibial plateau up to the lateral aspect of the lateral tibial spine was excised. An extension of the mass to the fibular head was found and resected. The anterior cruciate ligament and lateral meniscus were also removed. Local adjuvant treatment was performed with a high-speed burr and 10% phenol (Figure 3). Instruments, drapes, and gloves were changed to avoid contamination prior to reconstruction.

Figure 1. Pre-operative assessment of the right knee: **(A)** Anterior, **(B)** posterior, and **(C)** lateral views of the right knee, displaying a 12 x 15 x 23 cm fungating necrotic mass on the lateral aspect of the proximal tibia. Radiographic images including **(D)** anteroposterior and **(E)** lateral views, reveal a large osteolytic lesion on the epiphysis extending into the metaphysis of the lateral proximal tibia, characterized by neocorticalization and a pronounced soft tissue shadow.

Table 1. Musculoskeletal Tumor Society (MSTS) Scoring System for Functional Assessment in Orthopedic Oncology, indicating the preoperative score of the patient at 1 out of 30, denoting poor function

	Pain	Function	Emotional	Support	Walking	Gait
5	No Pain	No restriction	Enthused	None	Unlimited	Normal
4	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
3	Modest/Non-disabling	Recreational restriction	Satisfied	Brace	Limited	Minor cosmetic
2	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
1	Moderate/Disabling	**Total restriction**	Accepts	One cane or crush	Inside only	Major cosmetic
0	**Severe disabling**	Total restriction	**Dislikes**	**Two canes of crutches**	**Not independently**	**Major handicap**

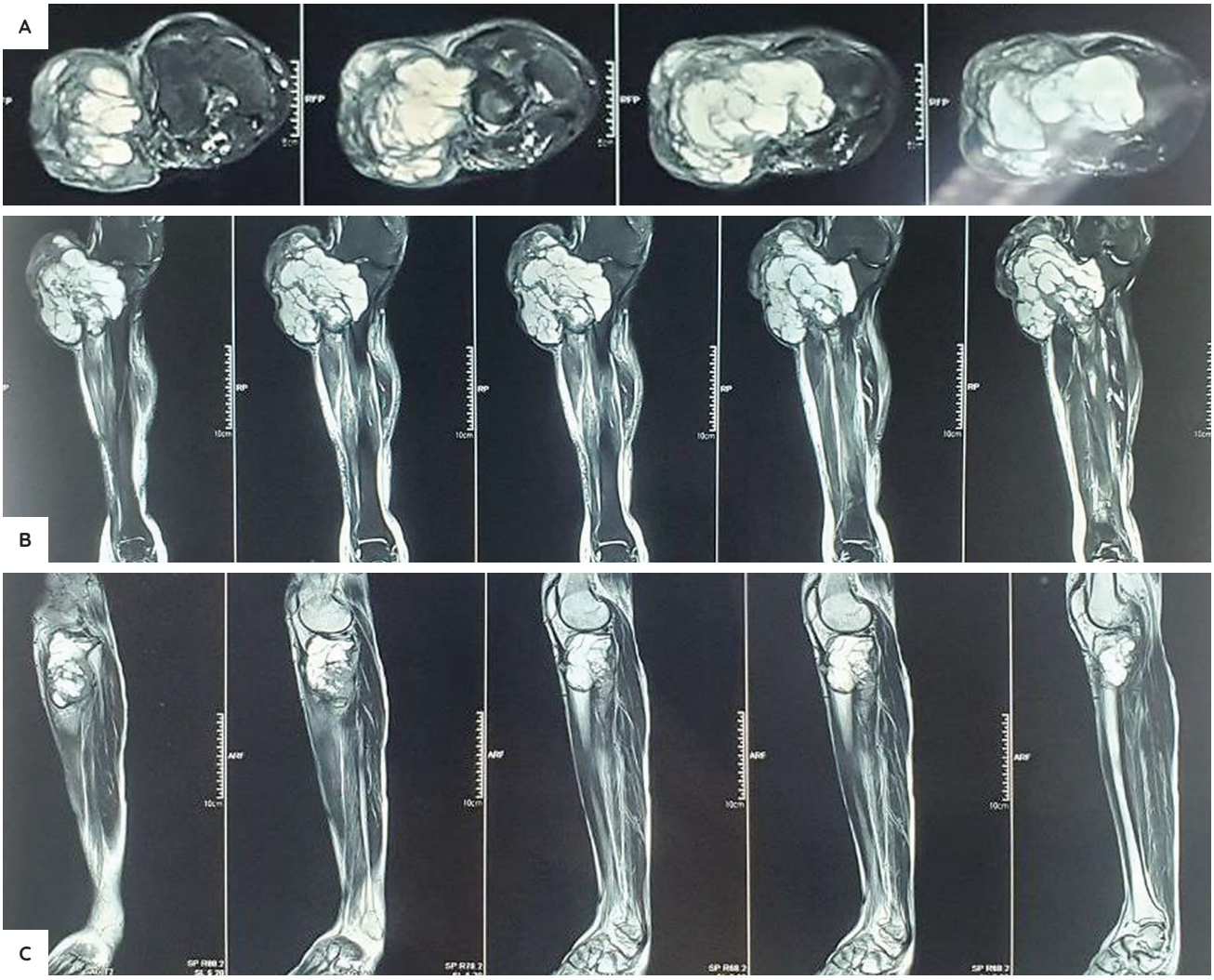

Figure 2. MRI with contrast of right knee in axial **(A)**, coronal **(B)**, sagittal **(C)** planes, showing an edematous marrow signal involving the lateral metaphyseal-diaphyseal region of the proximal tibia, measuring approximately 8 x 10 x 13 cm. The full extent of the lesion is illustrated: axial cuts **(A)** show cross-sectional spread, coronal cuts **(B)** show extent of involvement of the lateral proximal tibia, and sagittal cuts **(C)** reveal the anteroposterior extent.

The lateral tibial plateau was reconstructed using a pedicled patellar transplant. A midline incision exposed the quadriceps tendon, patella, and patellar tendon. The patella was separated from the quadriceps tendon, patellar tendon, and medial retinaculum with a 3-cm-wide cuff, leaving a 3-cm-wide muscular pedicle attachment to the vastus lateralis (Figure 4). The inferior pole of the patella was freshened and placed adjacent to the medial aspect of the proximal tibia, with the superior pole oriented laterally. The articular surface of the patella acted as the new weight-bearing lateral surface of the tibia. Two 4.0-mm cannulated cancellous tip threaded screws with washers were inserted from lateral to medial to fix the patella to the medial tibial plateau. The remaining fibula was harvested, leaving a distal length of 5 cm from the distal tibiofibular joint. Four fibular strut grafts were inserted and fixed with cortical screws in the gap between the patella and the tibial diaphysis. Synthetic bone graft with iliac crest bone graft was also inserted between the strut grafts and the tibia (Figure 5).

For the extensor mechanism repair, we isolated a 3 cm wide x 10 cm long distally based strip of rectus femoris from the quadriceps. We then used an absorbable suture to approximate the gap within the rectus femoris strip. We flipped the rectus femoris and attached it to the patellar tendon with a Krackow suturing technique, then augmented it with a suture anchor into the tibia shaft with the knee in 30 degrees of flexion.

The soft tissue defect was closed using a lateral gastrocnemius flap and a split-thickness skin graft from the contralateral thigh. We placed a drain and immobilized the lower extremity for six weeks in a half-cylinder splint with the knee flexed at 30 degrees (Figure 6). The patient was advised not to bear weight on the limb until radiologic signs of healing were seen.

Seven days post-operatively, the gastrocnemius flap was viable, with 90% take of the split-thickness skin graft, no wound dehiscence, and no signs of infection. The patient was sent home after one more week. The histopathology report of

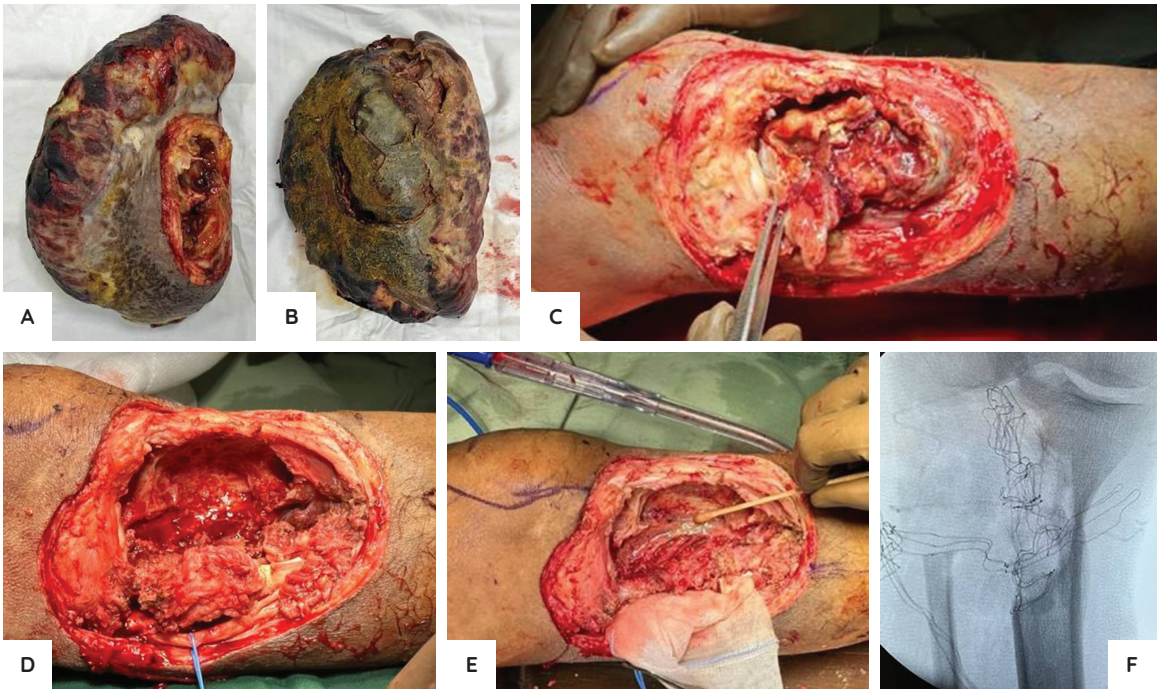

Figure 3. Surgical procedure overview: **(A)** and **(B)** show the resected soft tissue mass measuring 12 x 15 x 23 cm, featuring necrotic foci. **(C)** Removal of the necrotic portion of the bone tumor. **(D)** Resection of the fibular head. **(E)** Application of phenol to the tumor cavity following curettage. **(F)** Intraoperative imaging was captured after the tumor resection.

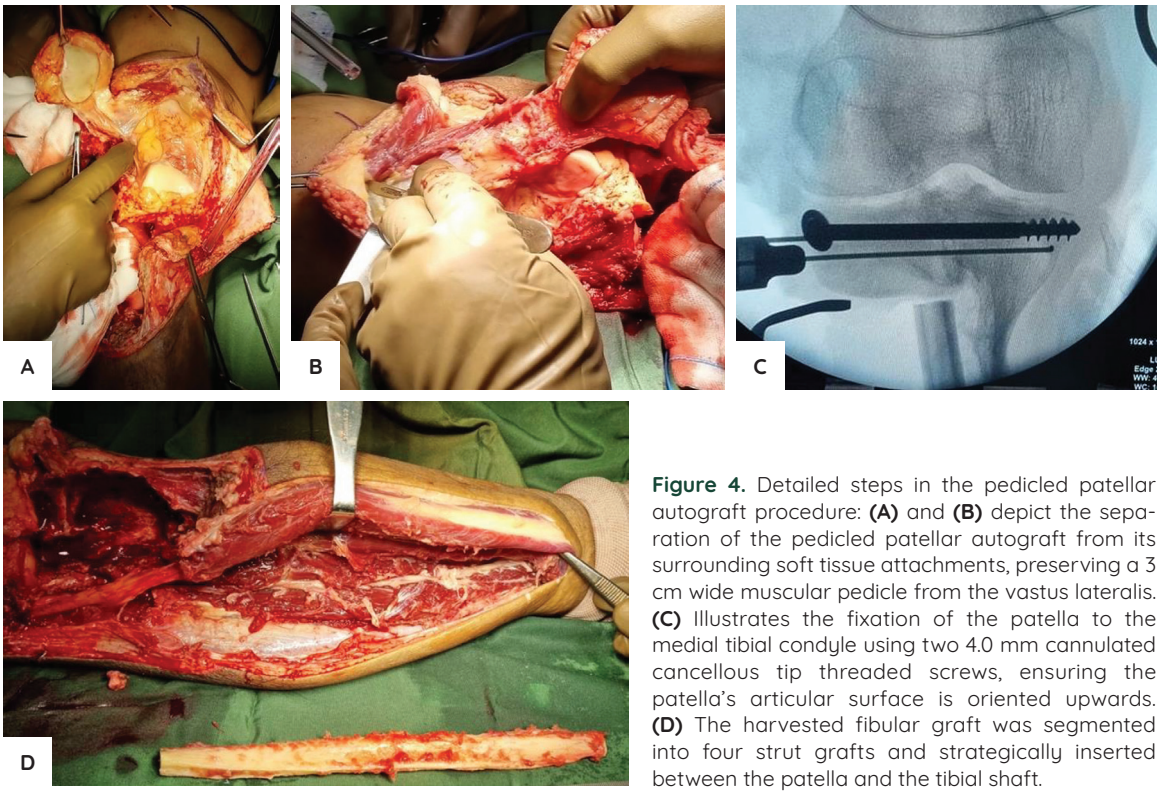

Figure 4. Detailed steps in the pedicled patellar autograft procedure: **(A)** and **(B)** depict the separation of the pedicled patellar autograft from its surrounding soft tissue attachments, preserving a 3 cm wide muscular pedicle from the vastus lateralis. **(C)** Illustrates the fixation of the patella to the medial tibial condyle using two 4.0 mm cannulated cancellous tip threaded screws, ensuring the patella's articular surface is oriented upwards. **(D)** The harvested fibular graft was segmented into four strut grafts and strategically inserted between the patella and the tibial shaft.

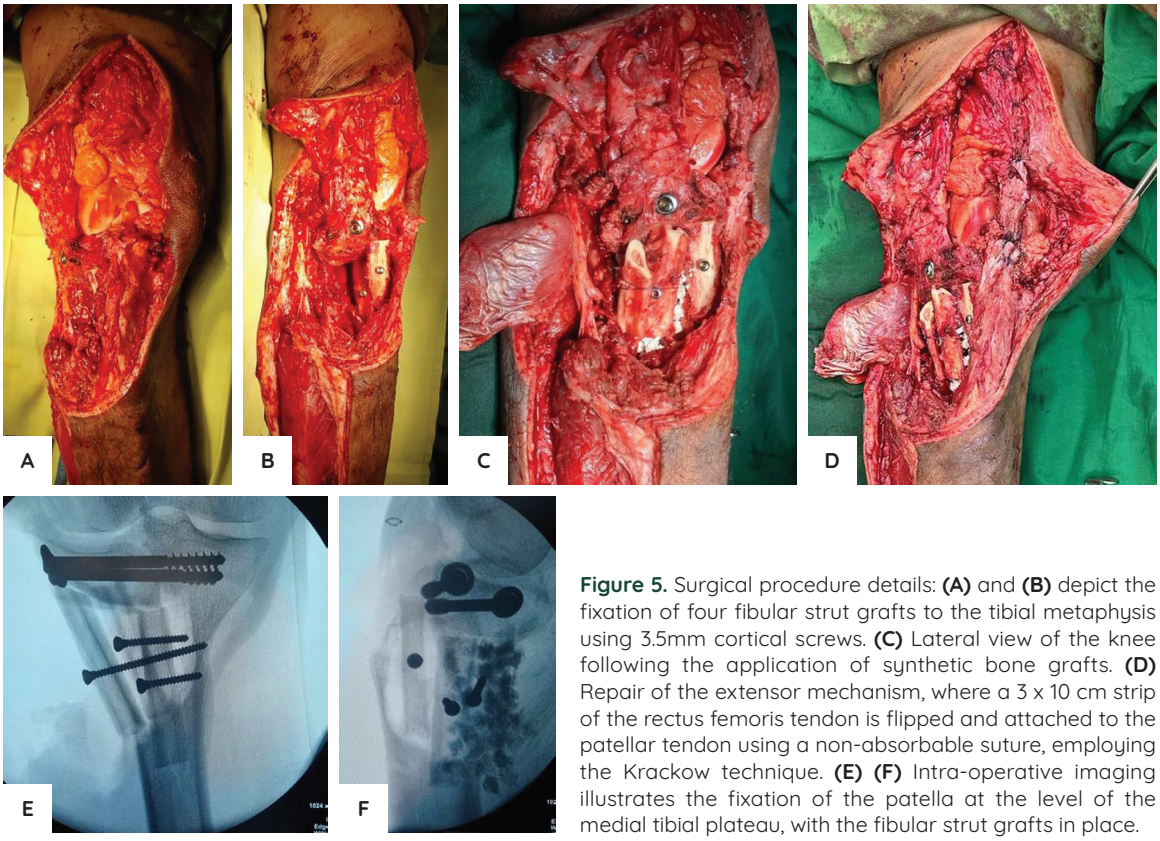

Figure 5. Surgical procedure details: **(A)** and **(B)** depict the fixation of four fibular strut grafts to the tibial metaphysis using 3.5mm cortical screws. **(C)** Lateral view of the knee following the application of synthetic bone grafts. **(D)** Repair of the extensor mechanism, where a 3 x 10 cm strip of the rectus femoris tendon is flipped and attached to the patellar tendon using a non-absorbable suture, employing the Krackow technique. **(E) (F)** Intra-operative imaging illustrates the fixation of the patella at the level of the medial tibial plateau, with the fibular strut grafts in place.

Figure 6. Surgical and post-operative details: **(A)** Attachment of the quadriceps tendon to the patellar tendon, reinforced using the Krackow technique and further augmented with a suture anchor on the tibia diaphysis. **(B)** Placement of the gastrocnemius flap. **(C)** Application of the split-thickness skin graft over the gastrocnemius flap. **(D)** Insertion of a drain at the proximal end of the incision. Post-operative radiographs of the right knee and leg in **(E) (G)** anteroposterior and **(F) (H)** lateral views show the patella's articular surface aligned with the medial tibial plateau, secured with two cancellous screws with threaded tips. Additionally, four fibular strut grafts, fixed with 3.5 mm cortical screws and supplemented with synthetic bone grafts, are visible.

Figure 7. Four months post-operatively, the patient demonstrated significant healing at the surgical site **(A) (D)**. He regained the ability to perform toe-touch weight-bearing with the aid of crutches. Functionally, he exhibited a knee extension-flexion arc ranging from 15 degrees to 95 degrees **(B) (C)**, indicating a substantial recovery of joint mobility. There were no sensory or motor deficits noted. Follow-up radiographs of the right knee and leg, taken in anteroposterior **(E) (G)** and lateral views **(F) (H)**, revealed a well-maintained reduction of the patella and strut grafts. There were no indications of tumor recurrence in these images.

Table 2. Post-operative Musculoskeletal Tumor Society Score of the patient, 16 out of 30, denoting improved function

	Pain	Function	Emotional	Support	Walking	Gait
5	No Pain	No restriction	**Enthused**	None	Unlimited	Normal
4	**Intermediate**	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
3	Modest/Non-disabling	Recreational restriction	Satisfied	Brace	**Limited**	Minor cosmetic
2	Intermediate	**Intermediate**	Intermediate	Intermediate	Intermediate	**Intermediate**
1	Moderate/Disabling	Total restriction	Accepts	One cane or crush	Inside only	Major cosmetic
0	Severe disabling	Total restriction	Dislikes	**Two canes of crutches**	Not independently	Major handicap

the resected mass revealed a giant cell tumor. After six weeks of immobilization, the patient was encouraged to do active-assisted range of motion exercises of the knee, focusing on isometric strengthening of the quadriceps and hamstrings. Exercises were slowly progressed to regain his knee range of motion. Four months post-operatively, the patient had a fully healed surgical site, a knee extension-flexion arc of 15 to 90 degrees, no pain, and no noted sensory or motor deficits. He was able to do toe-touch weight-bearing (Figure 7). Follow-up radiographs showed that the patellar and fibular grafts were in place and that there was no tumor recurrence. His follow-up musculoskeletal tumor society score was 16, denoting improved function (Table 2).

At 11 months post-operatively, his active knee extension-flexion arc was from 15 degrees to 95 degrees (Figure 8). Follow-up radiographs of the right knee and leg showed a stable reduction, further strut graft incorporation, and no tumor recurrence. The patient was able to ambulate without any assistance, without any pain or discomfort (Figure 9). There were no sensory or motor deficits. He was able to return to his previous work as a construction worker.

At 1.5 years post-operatively, his knee extension-flexion arc was 15 degrees to 95 degrees (Figure 10). He was able to do pain-free ambulation without assistance. There was no recurrence of the fungating knee mass. He was able to resume his role as his family's breadwinner.

Figure 8. Eleven months post-operatively, the incision was fully healed **(A)**. The active knee extension-flexion arc was 15 degrees to 95 degrees **(B) (C) (D)**. Follow-up radiographs of the right knee and leg, taken in anteroposterior **(E) (G)** and lateral views **(F) (H)**, showed maintenance of reduction and further incorporation of the strut graft. Tumor recurrence was not noted on the images.

Figure 9. Patient was able to ambulate without any assistance, without any pain or discomfort. There were no sensory or motor deficits noted. He was able to return to his previous work as a manual labourer.

Figure 10. 1.5 years post-operatively, the post-op site was fully healed **(A) (C)**. Active knee extension-flexion arc ranged from 15 degrees to 95 degrees **(B)**. He was able to do pain-free ambulation without assistance, and no recurrence of the fungating knee mass was noted.

DISCUSSION

Giant cell tumors (GCT) of the bone, particularly in weight-bearing areas like the distal femur or proximal tibia, present unique challenges in orthopaedic oncology, one of which is the need to preserve joint functionality in young, active individuals. Our case demonstrated a successful pedicled patellar transplant with suture anchor augmentation for articular reconstruction, augmented with suture anchors, following the resection of a GCT in the lateral proximal tibia, highlighting a novel surgical approach.

This case is particularly significant considering local findings from the Philippine Orthopedic Center by Carolino and Tud.[4] Thirty cases of histologically-confirmed GCT were reported over eight years, with a higher incidence in females (67%), and a predilection for the distal femur (47%) and proximal tibia (40%). Our case stands out as a male patient with a proximal tibia tumor, which was initially excised, recurred with a fungating mass, and was successfully treated with the D'Aubigne procedure.

Traditional joint reconstruction options, such as allografts, arthrodesis, or megaprostheses, each have their drawbacks. Allografts may cause immunogenic responses or infections,[5] arthrodesis can lead to ambulatory difficulties and accelerated degenerative changes in adjacent joints, and megaprostheses, though effective, are often cost-prohibitive, especially in resource-limited settings.[6]

In contrast, the D'Aubigne procedure, as applied to a 35-year-old male construction worker, demonstrated remarkable clinical benefits. The pedicled patellar transplant being an autograft precluded the risks of immunologic reactions and fibrosis. Additionally, the vascular pedicle facilitated rapid graft consolidation, enhancing recovery and joint stability. The patient's recovery trajectory of significant functional improvement in knee extension-flexion arc (from 15 to 95 degrees) and pain-free weight-bearing underlines the effectiveness of this approach in functional preservation.

Supporting this, D'Aubigne's original work[7] resulted in excellent long-term outcomes. Similarly, Claudio et al.[8] reported successful outcomes in patients with benign GCT of the distal femur treated with this technique, further validating its potential.

CONCLUSION

Our case, therefore, adds to the growing body of evidence supporting the use of pedicled patellar transplants in GCT treatment. The procedure's relatively lower cost, clinical effectiveness and reduced immunologic response make it a viable option in joint reconstruction surgeries, particularly in settings with limited healthcare resources.

However, it is critical to recognize the limitations of this study since long-term follow-up is important to establish the success of the procedure. Extensive studies and prolonged follow-up periods are essential to establish success rates, durability, and overall cost-effectiveness of the surgical technique.

ETHICAL CONSIDERATION

Patient consent forms were obtained before manuscript submission.

STATEMENT OF AUTHORSHIP

All authors certified fulfillment of ICMJE authorship criteria.

CREDIT AUTHOR STATEMENT

FGSSY: Conceptualization, Methodology, Validation, Investigation, Resources, Writing - original draft preparation, Writing – review and editing, Visualization; **VLB:** Conceptualization, Methodology, Validation, Investigation, Resources, Writing – original draft preparation, Writing – review and editing, Visualization; **MAPR:** Conceptualization, Methodology, Validation, Investigation, Resources, Writing – review and editing, Visualization, Supervision, Project administration.

DATA AVAILABILITY STATEMENT

No datasets were generated or analyzed for this research.

AUTHOR DISCLOSURE

The authors declared no conflict of interest.

FUNDING SOURCE

None.

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Submissions shall include: (1) the manuscript, (2) cover letter, (3) author form, and other relevant forms (informed consent form). These shall be screened for completeness and correctness prior to review by the editors.

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The corresponding author with complete contact information (institutional mailing address, work telephone and work e-mail address) should be clearly indicated.

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Complete names of the authors (first name, middle initial, last name), with title indicating the highest educational/professional attainment (e.g., MD, MSc, PhD), and name and location of not more than one (1) institutional affiliation, should be indicated.

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The title page should include:

Complete title of the article which should be informative, concise, meaningful, and as brief as possible (no more than 20 words).

Name of each author with highest academic degree(s) and complete address of one (1) institutional affiliation.

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Original Articles, Review Articles require a structured abstract of not more than 500 words, with the following four headings:

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Methodology: State the study design (e.g., randomized clinical trial, case-control study, cross-sectional study, systematic review), setting (multi-center, institutional, et cetera), study population. Additional modifiers can be stated (consecutive, retrospective, prospective, observational, interventional, non-consecutive, etc.)

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Case Reports or Case Series do NOT require a structured abstract, with a maximum of 300 words.

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The manuscript should be written in IMRAD format (Introduction, Methodology, Results and Discussion, Conclusion).

Organize and prepare the manuscript to include the following sections:

INTRODUCTION. The Introduction should refer only to the most pertinent past publications and should not be an extensive review of the literature. Include a brief background, the research question and/or rationale, objectives/purposes of the study, and major hypothesis to be tested if any.

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RESULTS. Results must be concise. Provide demographic data of the study population. Describe outcomes and measurements in an objective sequence with minimum discussion. Data should be accompanied by confidence intervals (usually at the 95% interval) and exact *p*-values or other indications of statistical significance.

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Funding Sources

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Acknowledgments

Contributors to the work who do not fulfill the authorship criteria should be acknowledged.

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UPDATE

PJO requires authors to include a statement on data availability described in the manuscript submission, to ensure transparency and uphold scientific integrity.

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__ No datasets were generated or analyzed for this research.
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COVER LETTER

(Date)

TO: **The Editor-in-Chief**
Philippine Journal of Orthopaedics

Subject: **SUBMISSION OF MANUSCRIPT FOR PUBLICATION**

We intend to publish the manuscript/, entitled "_____
_____
_____
_____," under the Section *[Original article, Review Article, Feature Article, Brief Report, Case Report, Images in Orthopaedics, Letter-to-the-Editor]* in the Philippine Journal of Orthopaedics.

On behalf of all the authors, I shall act as the corresponding author with the journal from this point onward.

Attached herewith is the completely accomplished Author Form.

Furthermore, we respectfully suggest the following **reviewer**(s) for our manuscript.

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Sincerely,

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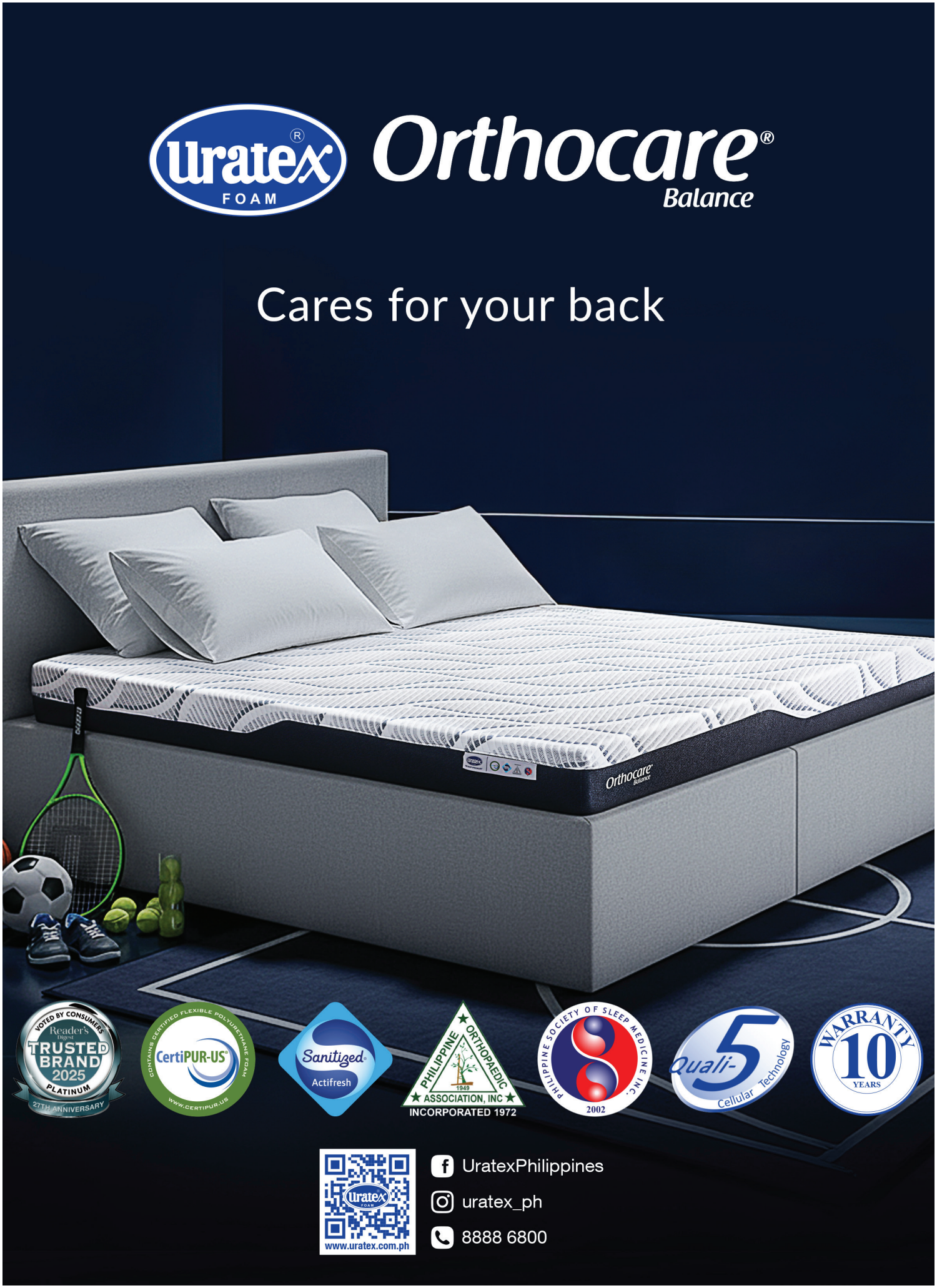

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