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Journal of Arthroscopy and Joint Surgery

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Reject
Accept

Patellar Clunk Post-Total Knee Replacement: The Impact of Resurfacing – A Systematic Review

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Abstract

Background: Patellar clunk syndrome (PCS) is a recognized complication following total knee replacement (TKR), particularly in posterior-stabilized (PS) knee designs. Although patellar resurfacing has been proposed to reduce PCS incidence, conflicting evidence exists regarding its protective role. This meta-analysis aimed to evaluate whether patellar resurfacing significantly reduces the incidence of PCS in primary TKR. **Methods:** A systematic review and meta-analysis were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 guidelines. A comprehensive literature search was performed across PubMed (MEDLINE), Cochrane Library, and Google Scholar up to September 2024. We included randomized controlled trials, systematic reviews, and meta-analyses comparing PCS incidence between patellar resurfacing and non-resurfacing in primary TKR. Meta-analysis was conducted using a random-effects model, with pooled odds ratios (ORs) and 95% confidence intervals (CIs) calculated. Heterogeneity was assessed using the I^2 statistic. **Results:** A total of 32 studies, encompassing 13,720 knees, were included in this analysis. The pooled OR for PCS incidence between resurfaced and non-resurfaced patellae was 0.82 (95% CI: 0.59–1.15; $P = 0.22$), indicating no statistically significant difference. The I^2 value for heterogeneity was 36%, suggesting low-to-moderate variability among studies. Contributory factors for PCS included smaller patellar components, reduced patellar height, increased patellar offset, higher tibial polyethylene thickness, and anterior tibial tray placement. PS designs showed a higher PCS incidence than cruciate-retaining designs due to femoral box impingement. **Conclusion:** This meta-analysis found no statistically significant reduction in PCS incidence with patellar resurfacing in TKR. Instead, prosthesis design, patellar height, tibial tray positioning, and flexion angle appear to have a greater impact on PCS development.

Keywords: Crepitation, patella catch, patella clunk syndrome, posterior-stabilized design, prosthesis design, total knee replacement

Introduction

Total knee replacement (TKR) is a procedure performed to treat patients with severe osteoarthritis, and it typically has a good outcome.[1] TKR offers patients significant long-term benefits in terms of quality of life, pain reduction, and function, resulting in a high level of patient satisfaction.

According to various studies, TKR has a long-term survival rate that is >90% after a minimum follow-up of 10 years. However, there is still controversy about whether to resurface the patella or not. In up to 5%–47% of instances following primary TKR, anterior knee pain (AKP) has been documented to be the cause of patient dissatisfaction.[2-6] The patella was retained in earlier TKR designs. The fact that AKP is a common complaint led numerous surgeons to resurface the patella. Patellar resurfacing can occasionally be worsened by a post-operative pathology known as patellar clunk syndrome (PCS), in addition to its problems such as subluxation, dislocation, loosening, patellar fractures, and quadriceps or patellar tendon rupture.[7]

PCS is a known complication following TKR that is almost exclusively found in association with posterior stabilized designs.[8,9] Its incidence ranges from 0% to 20%, depending on the design, in all primary TKR.[10-13] Patellar clunk can

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result in symptoms ranging from slight catching to significant locking, which can lead to patient dissatisfaction with TKR.[8]

Symptoms of patella clunk are characterized by AKP coupled with painful locking of the knee during full flexion to extension,[9,10,13,14] which results in a painful clunk as the knee extends. The quadriceps tendon's under surface, close to the patella's superior pole and patellar button, is where scar tissue builds up and causes patella clunk.[8] As the knee is flexed, the patella contacts the implant's trochlea. The knee may then lock in mid-flexion because of the scar tissue knot becoming trapped in the femoral box when the knee extends. In addition, the intercondylar notch may be impacted by the scar tissue nodule, resulting in pain with extension. Forceful knee extension causes the scar tissue to painfully separate itself from the box and then snap, which is generally seen at 30°–50° from full extension of the knee.[15]

Under the Patient, Intervention, Comparison, Outcome, Study algorithm, we conducted a meta-analysis of articles published on PCS after TKR associated with or without patella resurfacing to (1) understand if there is any difference in the incidence of PCS in patients who underwent TKR with and without patellar resurfacing and (2) clarify weakness and strengths of the current evidence.

Methods

Search strategy and information sources

We conducted this study following the Cochrane Handbook for Systematic Reviews of Interventions and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines.[16] We searched PubMed (MEDLINE), Cochrane Library, and Google Scholar from inception until September 2024. The search used the following Medical Subject Headings terms: "patellar OR patella" AND "catch OR clunk OR crepitus" AND "total knee replacement." In addition, the "relevant articles" feature in PubMed and Google Scholar was used to capture any associated studies. The following search terms were specifically utilized: "Total knee replacement," "Complications following TKR," "Patellar clunk syndrome," "Patellar resurfacing versus non-resurfacing."

Inclusion criteria

- Randomized controlled trials (RCTs), systematic reviews, and meta-analyses assessing PCS in patients undergoing TKR with or without patellar resurfacing
- Studies reporting incidence rates of PCS with a minimum follow-up period of 6 months
- Studies evaluating prosthesis design, patellar height, thickness, tilt, and component positioning in relation to PCS
- Full-text, peer-reviewed publications in English.

Exclusion criteria

- Cadaver studies, conference abstracts, and letters to the editor
- Studies not specifying PCS as a postoperative complication
- Studies that did not compare resurfacing versus nonresurfacing
- Studies with fewer than 20 participants.

Study selection

Two authors independently screened the titles and abstracts of articles retrieved from the search to assess their relevance. Subsequently, full-text articles were reviewed to confirm their eligibility. Discrepancies in study selection were resolved by consensus. The AMSTAR score was used to rate the quality of the meta-analyses.

Collected information included the lead author, year of publication, sample size, resurfacing versus nonresurfacing, PCS absent or present, follow-up period, patellar height, patellar tilt, patellar thickness, post-operative knee flexion, and femoral component status.

Risk of bias assessment

We used the Risk of Bias in Systematic Reviews (ROBIS) tool to assess the risk of bias in the included studies. The assessment covered the following domains: study eligibility criteria, identification and selection of studies, data collection and study appraisal, synthesis of findings, and risk of bias in the review.

Quantitative analysis and meta-analysis

We performed a meta-analysis to quantify the effect of patellar resurfacing on the incidence of PCS. Statistical analysis was conducted using Review Manager (RevMan 5.4). We used the DerSimonian and Laird random-effects model to calculate pooled odds ratios (ORs) and 95% confidence intervals (CIs). Statistical heterogeneity was assessed using the I^2 statistic, where $I^2 > 50\%$ indicated substantial heterogeneity.

Results

Study selection

Eight hundred and sixty-one citations were found in the search for research on the variables that affect PCS incidence post-TKA; 503 citations were included after screening for duplicates. 397 articles were eliminated from the review when abstracts were applied with inclusion and exclusion criteria. Following the application of exclusion and inclusion criteria to 106 full-length manuscripts, 32 articles were left for review [Figure 1]. The relevant findings from these 32 publications can be seen in Tables 1 and 2.

Risk of bias assessment

Using the ROBIS tool, the risk of bias was assessed. A complete risk of bias table was created, highlighting studies with low or high risk of bias across each domain. Studies exhibiting a high risk of bias in any domain were noted and interpreted with caution during data synthesis. The overall bias across studies remained low, ensuring the reliability of the pooled outcomes [Tables 3 and 4].

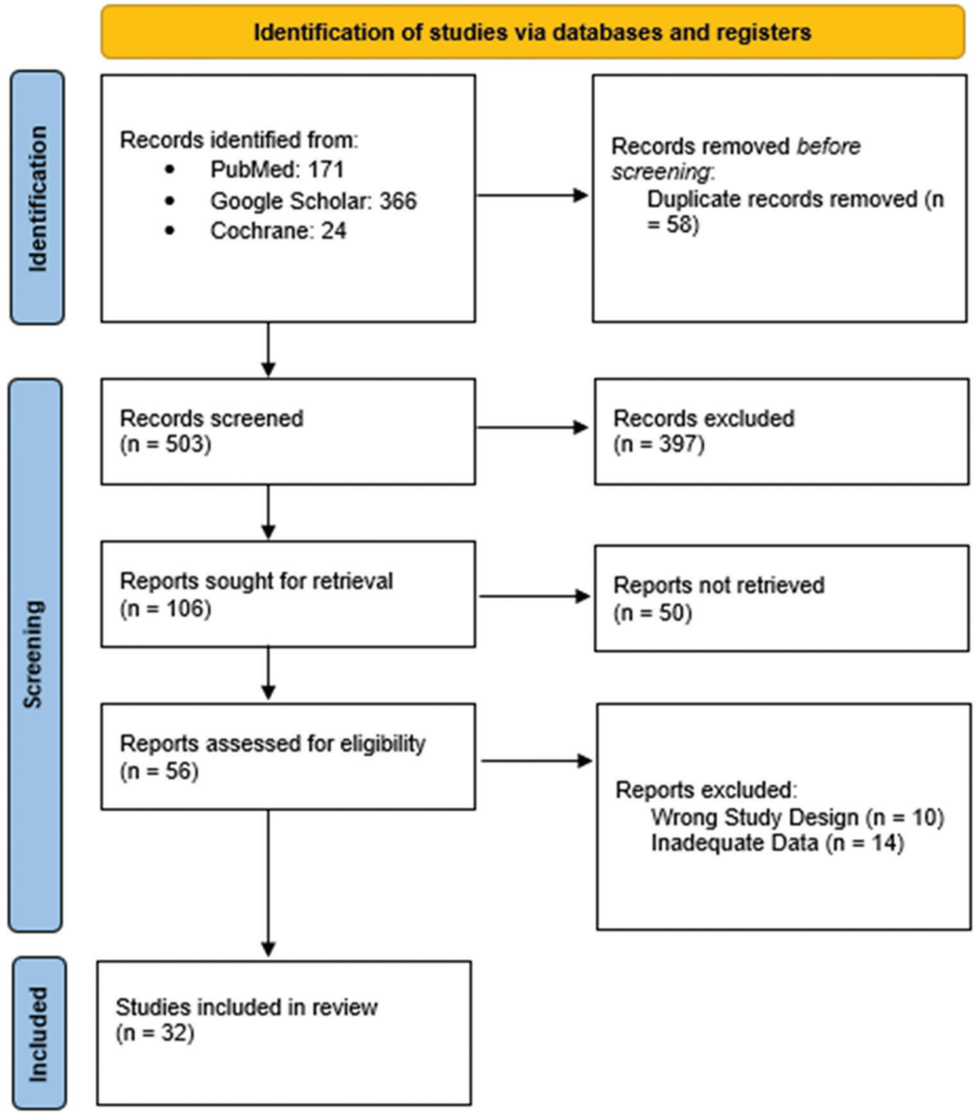

Figure 1: Preferred reporting items for systematic reviews and meta-analyses flowchart of the systematic review

Pathophysiology and contributory factors for patellar clunk syndrome

We reviewed studies with a cumulative sample size of 13,720 knees in our meta-analysis and identified several significant factors contributing to PCS development. Scar tissue formation beneath the quadriceps tendon, particularly at the superior pole of the patella, was a consistent finding.[1,2] This scar tissue could potentially become entrapped in the femoral box during knee extension, causing the characteristic clunk.

Several mechanical factors were linked to increased PCS risk.[5,6,8,11] These included smaller patellar components, shorter patellar length, higher patellar offset, thick tibia polyethylene inserts, decreased patellar composite thickness, and flexed or small femoral components.[11] The intercondylar notch contact area was found to increase significantly when the patellar ligament length was reduced by 2 standard deviations (12 mm) from the mean, predisposing the knee to PCS.[12] This condition, commonly known as patella baja, increases the risk of postoperative PCS, especially when distal femoral resection leads to higher tibial polyethylene thickness and lower joint line levels.[9,13]

Our analysis also showed that tibial tray positioning played a significant role. Studies revealed that anterior placement of the tibia tray in relation to the central line of the tibia increased PCS risk.[4,10] Conversely, positioning the tibial tray neutrally or posteriorly resulted in reduced PCS incidence. Similarly, reduced Insall-Salvati ratios and decreased patellar height were consistently associated with higher PCS incidence.[13,14] Prosthesis design also contributed significantly to PCS occurrence. Posterior-stabilized (PS) designs were more commonly associated with PCS due to the presence of a femoral box and cam mechanism, which could entrap scar tissue.[17,18] In contrast, cruciate-retaining (CR) designs showed a lower incidence of PCS as they lack the intercondylar notch box mechanism.[19-23]

Notably, while patellar resurfacing showed some reduction in PCS incidence in a few studies, our pooled meta-analysis

Table 1: Characteristic features of the included studies

Reference	Year	Number of knees	Prosthesis design	Patellar resurfacing	Patella nonresurfacing	PCS	Patellar height	Patellar tilt	Patellar thickness	Postoperative knee flexion	Posterior femoral condylar status	Component size
Choi *et al*.[14]	2013	647	Significant	Significant	NS	Significant	NS	NS	NS	NS	NS	NA
Ip *et al*.[17]	2004	246	Significant	NA	Significant	Significant	NA	NA	NA	NA	NA	NA
Maloney *et al*.[18]	2003	389	Significant	NA	Significant	Significant	NA	NA	NA	NA	NA	NA
Yau *et al*.[19]	2003	236	NA	NA	Significant	Significant	NA	Significant	NA	NA	NA	NA
Lonner *et al*.[20]	2007	300	Significant	NA	Significant	Significant	NA	NA	NA	NA	NA	NA
Clarke *et al*.[21]	2006	238	Significant	NA	NS	Significant	NA	NA	NA	NA	NA	NA
Fukunaga *et al*.[22]	2009	113	Significant	NA	Significant	Significant	NA	NA	NA	Significant	NA	NA
Ranawat *et al*.[23]	2006	297	Significant	N	Significant	Significant	NA	NA	NA	NA	NA	NA
Pollock *et al*.[24]	2002	459	Significant	NA	Significant	Significant	NA	NA	NA	NA	NA	NA
Shoji and Shimozaki[25]	1996	647	NA	NS	Significant	Significant	NA	NA	NA	NA	NA	NA
Ogawa *et al*.[26]	2016	84	NA	Significant	Significant	Significant	NA	NA	NA	NA	NA	NA
Aglietti *et al*.[27]	2001	NA	Significant	Significant	NS	Significant	NA	NS	NA	NS	NA	NA
Agarwala *et al*.[28]	2018	120	Significant	NS	NS	Significant	NA	NA	NA	NA	NA	NA
Noh *et al*.[29]	2022	500	Significant	NS	NS	Significant	NA	NA	NA	NA	NA	NA
Agarwala *et al*.[8]	2013	208	Significant	NS	NS	Significant	NA	NA	NA	NA	NA	NA
Breeman *et al*.[30]	2011	1715	Significant	NS	NS	Significant	NA	NA	NA	NA	NA	NA
Ha *et al*.[31]	2019	120	Significant	Significant	Significant	Significant	NA	NA	NA	NA	NA	NA
Bateman *et al*.[32]	2020	219	Significant	NS	NS	NS	NA	NA	NA	NA	NA	NA
Li *et al*.[33]	2012	130	Significant	NA	NS	NS	NA	NA	NA	NA	NA	NA
Khan and Pradhan[34]	2012	765	Significant	NS	NS	NS	NA	NA	NA	NA	NA	NA
Rajshekhar *et al*.[35]	2014	130	Significant	NA	NS	NS	NA	NA	NA	NA	NA	NA
Snir *et al*.[36]	2014	411	Significant	NA	NS	Significant	NA	NA	NA	NA	NA	NA
Beight *et al*.[37]	1994	111	NA	NS	NS	NS	NA	NS	NA	NS	NA	NA
Schroer *et al*.[38]	2009	747	Significant	NS	NS	Significant	NA	NA	NA	NA	NA	NA
Niikura *et al*.[39]	2008	NA	Significant	NS	NS	Significant	NA	NA	NA	NA	NA	NA
Tang *et al*.[40]	2014	44	Significant	NS	NS	Significant	NA	NA	NA	NA	NA	NA
Lonner *et al*.[20]	2007	300	Significant	NS	NS	Significant	NA	NA	NA	NA	NA	NA
Hozack *et al*.[41]	1989	NA	Significant	NS	NS	Significant	NA	NA	NA	NA	NA	NA
Frye *et al*.[10]	2012	244	Significant	NS	NS	Significant	N	Significant	NA	Significant	NA	NA
Costanzo *et al*.[7]	2014	75	NA	NS	NS	NS	NA	NA	Significant	NA	Significant	NA
Peralta-Molero *et al*.[42]	2014	570	NA	NS	NS	NS	NA	NA	NA	Significant	NA	NA
Hamilton *et al*.[43]	2017	3655	NA	NS	NS	NS	NA	NA	Significant	NA	NA	NA

P=0.05 for significance. NA: Not applicable, NS: Not significant, PCS: Patellar clunk syndrome data did not demonstrate any statistically significant difference between resurfaced and nonresurfaced patellae in terms of PCS occurrence. This finding further supports the hypothesis that PCS is more closely linked to component design and knee flexion mechanics rather than patellar resurfacing.

Table 2: Table 1 metrics defined

Metrics	Definition
Postoperative knee flexion	After surgery, the degree to which the knee can flex
Prosthesis design	Several prosthesis designs can be implanted in a total knee arthroplasty
Patellar height	Measured as the perpendicular distance from the inferior pole of the patellar implant to the joint line of the prosthesis
Patellar tilt	Angle subtended by the equatorial line of the patella and the line connecting the anterior limits of the femoral condyles
Patella thickness	The width of the patella (medial to lateral)
Femoral condyle offset	Distance between the lateral condyle and the vertical line parallel to the lateral edge of the femur

Meta-analysis results

A meta-analysis was conducted to compare the incidence of PCS between patients who underwent TKR with patellar resurfacing versus those without resurfacing.

The pooled OR and 95% CIs for each included study are illustrated in the forest plot [Figure 2]. An OR >1 favors an increased incidence of PCS in the resurfacing group, while OR <1 favors a lower PCS incidence in the resurfacing group.

The pooled effect size across the 32 studies showed a statistically nonsignificant difference between the resurfacing and non-resurfacing groups (OR: 0.82; 95% CI: 0.59–1.15; $P = 0.22$). Although some individual studies suggested a higher incidence of PCS in the non-resurfacing group, overall results remained inconclusive.

The I^2 statistic for heterogeneity was calculated at 36%, indicating low-to-moderate heterogeneity across studies. This suggests that differences in study design, prosthesis type, or surgical technique may contribute to variance in outcomes.

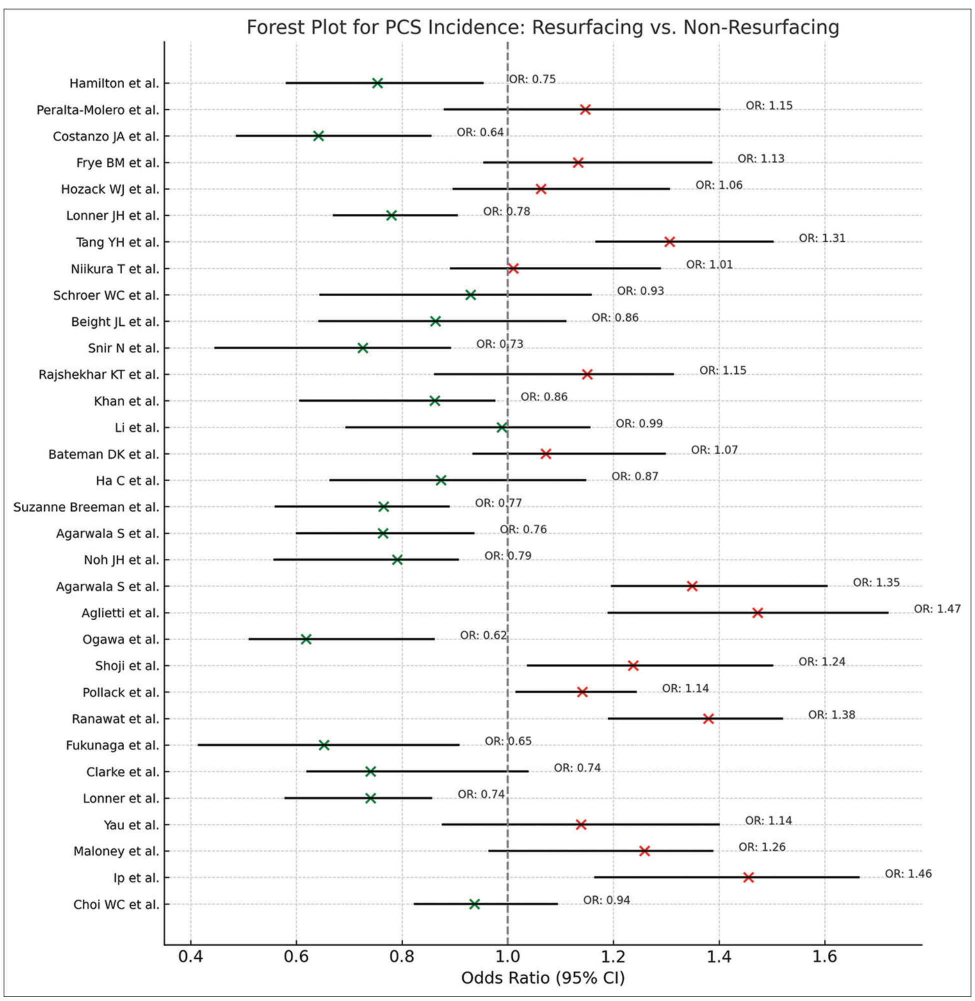

Figure 2: Forest plot for patellar clunk syndrome incidence

Table 3: Risk of bias assessment of included studies

Study	Prosthesis design	Patella resurfacing	PCS	Eligibility criteria	Identification and selection	Data collection and appraisal	Synthesis findings	Overall bias
Choi WC *et al*. (2013)[14]	PS	Yes	No	Low	High	High	Low	Low
Ip *et al*. (2004)[17]	CR	Yes	Yes	Low	High	High	High	Low
Maloney *et al*. (2003)[18]	PS	No	No	High	High	Low	Low	Low
Yau *et al*. (2003)[19]	PS	Yes	No	Low	Low	High	High	Low
Lonner *et al*. (2007)[20]	PS	Yes	Yes	Low	High	Low	High	Low
Clarke *et al*. (2006)[21]	PS	No	Yes	Low	Low	Low	High	High
Fukunaga *et al*. (2009)[22]	CR	No	No	Low	High	Low	High	Low
Ranawat *et al*. (2006)[23]	PS	Yes	Yes	Low	Low	High	Low	Low
Pollack *et al*. (2002)[24]	PS	Yes	Yes	High	High	High	Low	Low
Shoji *et al*. (1996)[25]	CR	No	Yes	Low	High	High	High	High
Ogawa *et al*. (2016)[26]	PS	Yes	Yes	Low	Low	Low	High	Low
Aglietti *et al*. (2001)[27]	CR	No	Yes	Low	Low	Low	Low	High
Agarwala S *et al*. (2018)[28]	PS	No	Yes	Low	Low	High	High	High
Noh JH *et al*. (2022)[29]	PS	Yes	No	Low	Low	Low	High	Low
Agarwala S *et al*. (2013)[8]	PS	Yes	No	Low	High	High	Low	Low
Suzanne Breeman *et al*. (2011)[30]	PS	Yes	No	Low	Low	High	High	High
Ha C *et al*. (2019)[31]	PS	No	Yes	High	Low	High	Low	High
Bateman DK *et al*. (2020)[32]	CR	No	No	Low	Low	Low	High	High
Li *et al*. (2012)[33]	PS	No	Yes	High	High	High	Low	High
Khan *et al*. (2012)[34]	PS	No	Yes	High	High	Low	Low	High
Rajshekhar KT *et al*. (2014)[35]	PS	No	No	Low	High	Low	High	Low
Snir N *et al*. (2014)[36]	PS	Yes	Yes	Low	High	High	Low	Low
Beight JL *et al*. (1994)[37]	PS	Yes	No	High	Low	High	Low	Low
Schroer WC *et al*. (2009)[38]	PS	Yes	No	High	High	High	High	Low
Niikura T *et al*. (2008)[39]	CR	No	No	High	High	High	Low	High
Tang YH *et al*. (2014)[40]	PS	No	No	Low	Low	Low	Low	Low
Lonner JH *et al*. (2007)[2]	PS	Yes	No	Low	High	Low	High	Low
Hozack WJ *et al*. (1989)[41]	CR	Yes	No	High	Low	High	High	Low
Frye BM *et al*. (2012)[10]	PS	Yes	Yes	Low	Low	Low	Low	Low
Costanzo JA *et al*. (2014)[7]	PS	Yes	Yes	Low	Low	Low	Low	Low
Peralta-Molero *et al*. (2014)[42]	PS	No	No	High	Low	Low	High	Low
Hamilton *et al*. (2017)[43]	PS	Yes	Yes	Low	High	Low	High	Low

PS: Poststabilized, CR: Cruciate retaining, PCS: Patellar clunk syndrome

Table 4: Risk of bias - summary

	Study eligibility criteria	Identification and selection of studies	Data collection and study appraisal	Synthesis findings	Risk of bias in the review
PCS etiology	Yes	Yes	Yes	Yes	Yes
Systematic review				Yes	No
					Overall bias: Low

PCS: Patellar clunk syndrome

Discussion

Our meta-analysis, which included 32 studies with a cumulative sample size of 13,720 knees, provided comprehensive insights into the pathophysiology and contributory factors of PCS after TKR. Our findings revealed that patellar resurfacing did not significantly reduce the incidence of PCS (pooled OR: 0.82; 95% CI: 0.59–1.15; $P = 0.22$). However, multiple mechanical and prosthetic design factors were identified as major contributors to PCS development, underscoring the complexity of the condition.

Pathophysiology and mechanical contributing factors

Scar tissue formation beneath the quadriceps tendon, particularly at the superior pole of the patella, emerged as a predominant mechanism for PCS. This scar tissue may become entrapped within the femoral box of PS knee designs during extension, resulting in a characteristic painful clunk.[19-24] This condition is further exacerbated when the scar tissue nodule impinges upon the intercondylar box, causing a locking or clunking sensation during flexion-extension cycles.

Several mechanical risk factors were identified across the included studies. Reduced patellar height, decreased patellar tendon length, and increased patellar offset significantly correlated with higher PCS incidence.[21,24,25] In addition, decreased patellar composite thickness and thick tibial polyethylene inserts were associated with increased postoperative scar tissue impingement, resulting in higher PCS occurrence.[18,26]

Patella baja, a condition characterized by an abnormally low patellar height, was noted in several studies as a strong contributor to PCS.[17] It was found that a reduction in patellar ligament length by two standard deviations (12 mm) from the mean significantly increased the contact area between the intercondylar notch and quadriceps tendon, predisposing the knee to PCS.[27-29] Surgeons can minimize the risk of patella baja by reducing distal femoral resection and minimizing tibial polyethylene thickness, ultimately reducing joint line depression (Fukunaga *et al*.[22]).

Prosthesis design also played a pivotal role in PCS occurrence.[30,31] PS knee designs demonstrated a higher PCS incidence due to the presence of a femoral box and cam mechanism that could trap scar tissue.[21] In contrast, CR designs had significantly lower PCS incidence as they lacked the intercondylar box that facilitated scar tissue entrapment.[25] Furthermore, higher posterior condyle offset and shallower trochlear grooves in PS designs also contributed to higher PCS rates.[32-34]

Impact of patellar resurfacing

While some individual studies reported reduced PCS incidence with patellar resurfacing,[26] our meta-analysis revealed no statistically significant difference between resurfaced and non-resurfaced groups (OR: 0.82; 95% CI: 0.59–1.15; $P = 0.22$). This finding is consistent with previous large-scale reviews indicating that patellar resurfacing does not provide a consistent protective effect against PCS.[28,34]

The underlying rationale for resurfacing's minimal impact may stem from the predominant influence of component design, tibial tray positioning, and patellar height, which collectively outweigh any protective effect offered by resurfacing.[35-38] In addition, resurfacing may reduce AKP but does not address the primary pathology contributing to PCS – the interaction between scar tissue and the intercondylar box.[39,40,42]

Surgical implications

Given the findings of this meta-analysis, we propose that reducing PCS incidence may require a shift in surgical technique rather than solely focusing on patellar resurfacing.[42,44] Optimizing tibial tray positioning, minimizing patellar height reduction, and selecting implants with reduced intercondylar box height could significantly lower PCS incidence (Costanzo *et al*.;[7] Ranawat *et al*.[23]). Surgeons should also focus on minimizing flexion gap mismatches and avoiding excessive distal femoral resection to prevent patella baja.

Furthermore, choosing CR designs over PS designs may reduce PCS incidence, particularly in high-flexion knee designs.[20,25] Standardized intraoperative techniques, such as limiting scar tissue formation through aggressive synovium excision, may further contribute to reduced PCS rates.

Strengths

This study comprehensively reviewed 32 RCTs/meta-analyses/systematic reviews with a cumulative sample size of 13,720 knees, making it one of the largest meta-analyses on PCS incidence. We provided mechanistic insight into the role of prosthesis design, patellar height, and tibial tray positioning, helping clarify PCS pathogenesis. The study followed the PRISMA 2020 guidelines and used ROBIS for bias assessment, ensuring high methodological rigor.

Weaknesses

Significant heterogeneity ($I^2 = 36\%$) among included studies, largely due to differences in implant design and surgical technique, which may have impacted pooled results. Absence of standardized definitions of PCS across studies, creating variability in reported incidence rates. Several studies had limited follow-up duration, potentially underestimating the long-term incidence of PCS.

Opportunities

Future RCTs with standardized surgical techniques, consistent implant designs, and clear diagnostic criteria could provide more definitive conclusions. Investigating the role of soft-tissue balancing and scar tissue excision during surgery may significantly reduce PCS occurrence. The development of modified prosthesis designs with reduced intercondylar box height could potentially eliminate PCS in high-flexion knees.

Threats

Lack of long-term follow-up in several studies may underestimate late-onset PCS incidence. The limited global standardization of surgical techniques and implant designs may hinder the reproducibility of findings.

Conclusion

Our systematic review and meta-analysis demonstrate no statistically significant difference in the incidence of PCS between resurfaced and nonresurfaced patellae in total knee arthroplasty. However, factors such as prosthesis design, patellar component size, and postoperative knee flexion significantly influence PCS occurrence. Future studies should aim to isolate these variables for a clearer understanding of PCS etiology.

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Conflicts of interest

There are no conflicts of interest.

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Original Article

Assessment of Using Patellar Resurfacing versus Patelloplasty for Treatment of Patellofemoral Joint Osteoarthritis in Total Knee Replacement: A Comparative Short-term Study

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Abstract

Background: One of the controversial topics among arthroplasty surgeons is whether to resurface the patella or not. Three basic strategies have evolved in response to this debate: always resurfacing the patella, never resurfacing the patella, and selectively resurfacing the patella based on specific patient factors. **Aim:** The aim of this study was to compare patellar resurfacing versus patelloplasty for the treatment of patellofemoral joint osteoarthritis (OA) in total knee replacement. **Materials and Methods:** This randomized study involved 30 patients with tibiofemoral OA or rheumatoid arthritis (RA) who were candidates for primary knee arthroplasty, exhibited symptoms of patellofemoral arthritis, and had a Bartlett patellofemoral score below 21, along with moderate-to-severe radiographic changes indicating patellofemoral arthrosis. The patients were assigned randomly into two equal groups, Group I underwent patellar resurfacing and Group II underwent patellar nonresurfacing and patelloplasty. Patients were followed up at 3 months, 6 months, and 1 year assessed. **Results:** A significant difference was observed between both groups in terms of pain, alignment, and mediolateral instability ($P < 0.05$). Range of motion (ROM) was significantly higher in Group I compared to Group II ($P = 0.046$), with no significant difference between the groups regarding flexion contracture and extension lag. The Knee Society Clinical Rating System showed a significantly lower total score in Group I compared to Group II ($P = 0.039$), whereas the total functional knee score was significantly better in Group I ($P = 0.011$). **Conclusions:** In total knee prosthesis, patellar resurfacing is a better choice contrasted with patelloplasty for patellofemoral OA or RA treatment. Patellar resurfacing resulted in improved functional outcomes, including better ROM, stair-climbing ability, and reduced pain. While patellar resurfacing showed significant improvements in pain relief and knee function, both groups demonstrated similar results regarding quadriceps strength and patellar tracking.

Keywords: Arthroplasty, patellar resurfacing, patellofemoral joint osteoarthritis, patelloplasty

Introduction

Patellar resurfacing does not have any absolute indications; however, there are numerous relative indications, for example, anterior knee pain (AKP), inflammatory arthritis, history of patellar subluxation, intraoperative patellofemoral wear, intraoperative patellar maltracking, and nonanatomic trochlear groove on the femoral implant.[1-3]

In comparison to conventional resurfacing, certain surgeons argue that the nonresurfacing procedure is more efficient and cost-effective.[4] They perform selective patellar resurfacing in preoperative obesity, rheumatoid arthritis (RA), advanced chondromalacia, anterior knee discomfort, patellar bone stock, and patellar shape.[5]

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We aimed to compare patellar resurfacing versus patelloplasty to treat patellofemoral joint osteoarthritis (OA) or RA in total knee replacement.

Materials and Methods

This randomized study involved 30 patients of both sexes diagnosed with tibiofemoral osteoarthritis (OA) or rheumatoid arthritis (RA), all presenting with symptoms indicative of patellofemoral arthritis—such as anterior knee pain (AKP), difficulty rising from chairs, and challenges with stair climbing. Eligible participants were candidates for primary knee arthroplasty, had a Bartlett patellofemoral score below 21, and demonstrated moderate to severe patellofemoral arthritis on radiographs. Radiographic findings included joint space narrowing, increased bone density at the patellofemoral margins, osteophyte formation on the lateral patellar facet, and/or lateral patellar tilt. The study was conducted in accordance with the Declaration of Helsinki. The patient or their relatives provided written consent that was informed.

The exclusion criteria included patients with tibiofemoral arthritis who had either no or only mild patellofemoral arthritis, individuals who had undergone patellar realignment procedures or high tibial osteotomy, those with prior patellar surgeries such as patellectomy, cases involving revision knee arthroplasty, patients with a history of patellar dislocation, and those with a preoperative patellar thickness of less than 15 mm as seen on the skyline radiographic view.

Randomization and blinding

To maintain the integrity of the study, a random allocation process was utilized, employing computer-generated numbers (https://www.randomizer.org/). Each participant's code was placed in an opaque, sealed envelope to preserve blinding. The patients were randomly assigned into two groups (1:1 ratio) to receive either patellar resurfacing performed using cemented with three pegs, all polyethylene dome-shaped patellar components in Group I or patellar nonresurfacing in Group II. To maintain the blinding, both patients and outcome assessors were blind to the group allocation.

All patients underwent complete history taking, clinical examination, and laboratory (blood grouping and complete blood picture, kidney and liver function tests, blood sugar, and bleeding profile) and radiological investigations. Further, based on the patient's condition, additional investigations were conducted, including electrocardiogram, echocardiography for cardiac patients, Doppler ultrasound for those with vascular disease, and urine analysis when indicated.

The preoperative knee examination focused on local assessment of the affected knee joint. This included evaluating the alignment and any deformities, specifically assessing the degree of deformity and whether it was correctable. Knee instability was tested in both the mediolateral and anteroposterior directions to identify any abnormal movement or potential instability. Range of motion (ROM) was carefully measured, including both active and passive ROM, to assess the knee's flexibility and limitations. In addition, a neurovascular examination was performed to assess the affected limb, including sensory function, motor strength, and the presence of any extension lag.

Operative technique

Epidural anesthesia was used in all patients. In all cases, a pneumatic tourniquet was applied as high as possible over the thigh. Then, the limb was exsanguinated using an Esmarch bandage. The inflation pressure was 100–150 mmHg above systolic pressure. The medial parapatellar approach was utilized in all cases of this study. All femoral cuts were made utilizing an intramedullary alignment guide. The femoral point of entry was located at the intercondylar notch top and closer to the medial femoral condyle. The hole was parallel to the femur shaft in both the lateral and anteroposterior projections (assessed using an image intensifier (C-arm) intraoperatively. The distal femoral valgus angle was between 5° and 7° valgus angle. Distal femoral cut thickness was done using the measured resection technique. The posterior condyles were utilized as a reference for proper femoral component rotation and sizing. The size was checked before the completion of the final cuts by a special stylus to avoid either femoral notching or faulty sizing. The last femoral cut was the notch cut. A saw is employed to cut the sides of the notch, with the anterior tab resting in the trochlear recess, after the notch chamfer guide was affixed to the cut distal femur surface.

Optimal exposure of the whole tibial plateau surface was the first step in tibial preparation. Combined intra- and extramedullary alignment guides were used in all cases to avoid varus or valgus tibial cut. The intramedullary point of entry was determined by the anteroposterior axis of the tibia (Akagi's line). The entry point was at the junction of posterior 2/3 and anterior 1/3 of this line. The tibial cut level was identified as either 2 mm below the worn tibial plateau side or 10 mm below the healthy side and double checked using a specific stylus. Using electrocautery, the AP axis of the tibia was drawn. After choosing the proper size and rotation, the final preparation of the tibia was done using the proper size tibial broach. The tibial broach impactor was impacted to the appropriate depth showed by the marked groove on the impactor handle and then removed to create a space for the keel of the tibial tray.

Patellar preparation

In Group I, patellar resurfacing was done, where the knee was placed in extension. The patella thickness was measured using a special caliber. The universal patellar saw guide was positioned parallel to the anterior patella cortex, its serrated jaws were positioned at the patellar articular surface distal and proximal margins, and then the thumbscrew of the guide was tightened so that the jaws were firmly holding the patella. This patellar guide had a calibrating 10 mm gauge which ensures that only 10 mm thickness is resected from the patella. Resection was done with an oscillating saw, maintaining the saw blade flush with the cutting guide surface. The superior–inferior dimension sized the remaining patellar surface using a series of templates. The proper sized template was positioned so that its medial border is flush with the medial border of the patellar surface without overhang. This was medializing the patellar component and improving patellar tracking. Then, the three holes for the fixation pegs were drilled using a special drill bit.

In Group II, the knee is located in extension as in Group I. The patellofemoral ligament was liberated. Then, bone-holding forceps with a pointed tip were utilized to firmly hold the patella, and all peripheral osteophytes were removed utilizing a rongeur bone nibbler or oscillating saw to regain more or less the normal patellar shape. Patellar edges were denervated using electrocautery. Eburnated articular surface drilling was also done to decompress the patellar bone and decrease postoperative pain.

Trial components were inserted for size assessment, fitting of the prosthesis, position, rotation, ligamentous balance, and bone gap equality. Furthermore, patellar tracking and stability were assessed using no thumb technique. Intraoperative imaging of the knee was a routine step in all cases. Soft tissue adjustment through medial or lateral release as required for each specific case. Copious irrigation lavage and suction were done in all cases either by suction irrigation machine or by 50 cc syringe. The femoral component was cemented first then the tibial component with trial insert applied, and the joint was reduced. The knee was extended, and gentle pressure was applied to pressurize the cement. At the same time in Group I, only the patellar prosthesis was positioned and pressurized. Once the cement had hardened, ligament balance and both anteroposterior and mediolateral tibiofemoral stability were re-evaluated. The tourniquet was deflated, and hemostasis was done. Again, patellar tracking and stability were rechecked using the "no-thumb technique." If maltracking presented, lateral retinacular liberation was done from inside to outside starting from approximately the superior patella pole down to a variable distance but mostly not reaching down to the inferior pole. At last, the definitive polyethylene insert was applied, and the knee was reduced.

Closure of the arthrotomy with continuous absorbable (polyglactin 910) suture no. 2 was done with the use of suction drainage system. Then, the subcutaneous tissue was closed by absorbable (polyglactin 910) suture no. 0, and the skin was locked by staples. The wound was covered, and the whole lower limb was wrapped by crepe bandage starting from the tourniquet site till the foot.

Postoperative management

The vital data such as blood pressure, pulse, and oxygen saturation were checked. Postoperative pain management involved the continued use of epidural analgesia in the ward, delivered through a continuous syringe pump system to provide sustained relief for 48 hours after surgery. The antibiotic regimen was continued. Anticoagulant treatment was continued. Administered intravenous fluids for two days along with a daily intravenous dose of 40 mg pantoprazole sodium. The postoperative hemoglobin level was checked. Physical therapy included the use of an arteriovenous pump on both lower limbs to prevent deep vein thrombosis. Ice was applied to decrease postoperative pain and hematoma.

Postoperative assessment

The cases were monitored at 3 months, 6 months, and 1 year postoperatively and evaluated through clinical assessment using the Knee Society Clinical Rating System, which includes knee and functional scores assessing pain, range of motion (ROM), flexion contracture, alignment, anteroposterior instability, extension lag, and mediolateral (ML) instability. Additionally, the Bartlett Patellofemoral Scoring System was used to evaluate quadriceps strength, anterior knee pain (AKP), and the ability to climb stairs and rise from a chair. Radiological evaluation of limb alignment, change in component alignment, patellar subluxation or dislocation, and skyline view measured data [patellar tilt angle (α angle), lateral patellar placement (d), and patellar thickness (T)].

Sample size calculation

The sample size was calculated using G*Power software version 3.1.9.4. (StatSoft Inc., Tulsa, OK, USA). Using *t*-test at power 70%, 0.05 alpha error, and 0.9 effect size d for comparing patellar resurfacing versus patelloplasty for patellofemoral joint OA treatment in total knee replacement, the total number of patients to be enrolled in the study was 30 patients (15 patients in each group).

Statistical analysis

The statistical analysis was performed using SPSS v28 (IBM Inc., Armonk, NY, USA). To compare the mean and standard deviation of quantitative variables between the two groups, an unpaired Student's-*t*-test was employed. For qualitative variables, the Chi-square test or Fisher's exact test was utilized, depending on the distribution of the data, and the results are presented as frequency and percentage where appropriate. The mean difference and 95% confidence intervals were also reported to provide a more comprehensive understanding of the differences between the groups. A two-tailed $P < 0.05$ was considered statistically significant.

Results

The study initially assessed 39 patients for eligibility. Of these, 30 were included, while 3 were excluded for not meeting the inclusion criteria, 4 were omitted due to missing data, and 2 declined participation. These 30 patients were then randomly assigned to two groups and continued with follow-up and analysis [Figure 1].

No significant difference was indicated between the two studied groups regarding basic demographic and clinical data [Table 1].

In terms of postoperative Knee Society Score (KSS), a significant difference was observed between the two groups in pain, alignment, and mediolateral (ML) instability (P <

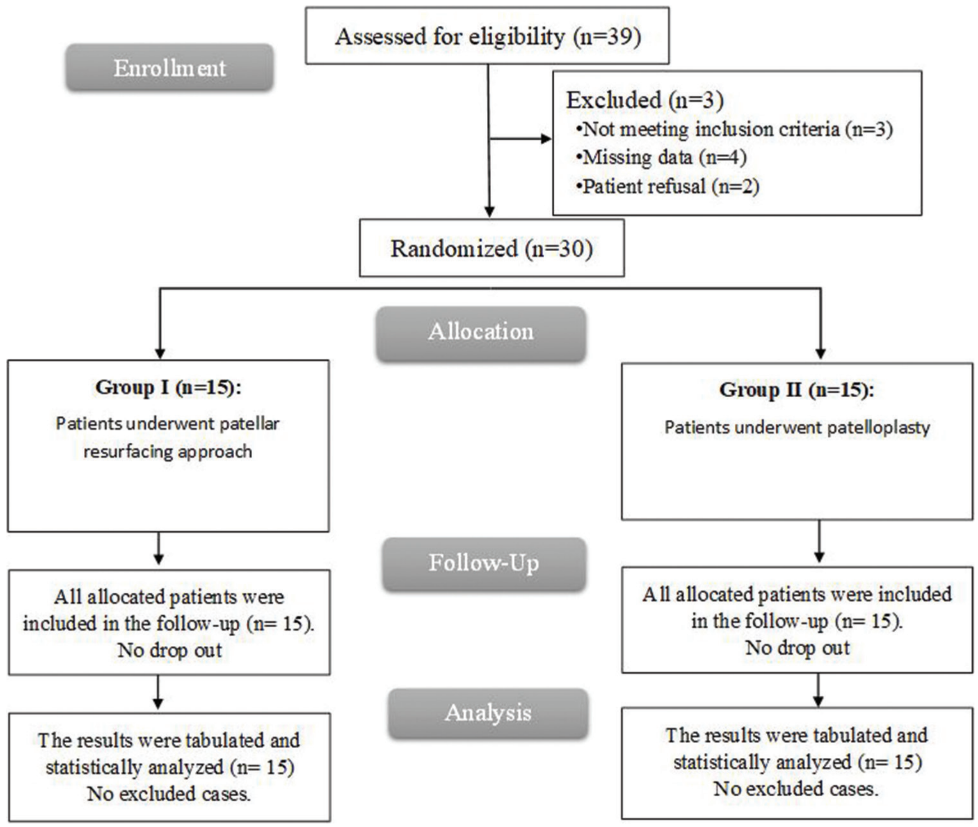

Figure 1: CONSORT flowchart of the studied groups

Table 1: Comparison of basic demographic and clinical data of the studied groups

	Group I (patellar resurfacing) (*n*=15), *n* (%)	Group II (patelloplasty) (*n*=15), *n* (%)	*P*
Age (years)	56.20±11.42	57.73±9.18	0.298
Sex			
Male	5 (33.3)	4 (26.7)	0.581
Female	10 (66.7)	11 (73.3)	
Side operated			
Right	9 (60.0)	9 (60.0)	1.0
Left	6 (40.0)	6 (40.0)	
Diagnosis			
OA	13 (86.67)	12 (80.0)	0.652
RA	2 (13.33)	3 (20.0)	

Data presented as mean±SD or frequency (%). OA: Osteoarthritis, RA: Rheumatoid arthritis, SD: Standard deviation

0.05). Range of motion (ROM) was notably higher in Group I compared to Group II ($P = 0.046$). However, no significant differences were found between the groups in flexion contracture and extension lag.

The postoperative functional knee score indicated that a walking distance score of 30 was more prevalent in Group I, while a score of 20 was more common in Group II. Similarly, a stair climbing score of 30 was higher in Group I, whereas a score of 15 was more frequent in Group II. Additionally, more patients in Group I required no walking aids (score 0), while a score of −5 for walking aid usage was more common in Group II. Regarding the Knee Society Clinical Rating System, the total score was significantly dropped in Group I contrasted to Group II ($P = 0.039$), and the total functional knee score was significantly improved in Group I more than Group II ($P = 0.011$) [Table 2].

A significant difference was observed between the two groups in terms of stair climbing, anterior knee pain (AKP), ability to rise from a chair, and the total score ($P < 0.05$), while the difference in quadriceps strength was not statistically significant [Table 3].

There was a significant difference between both groups regarding lateral patellar placement and patellar thickness ($P < 0.05$), with no significant difference regarding patellar tilt angle (β) and patellar tilt angle (α) [Table 4].

Case 1

A male patient, 58 years old, right side, OA, underwent patellar resurfacing and followed up 12 months. There were no postoperative complications [Figure 2].

Case 2

A female patient, 58 years old, right side, OA, underwent patellar nonresurfacing and was followed up 20 months. The reported postoperative complication was AKP, where the patient had severe pain while doing skyline view postoperative, so we delayed it until the pain improved [Figure 3].

Table 2: Postoperative Knee Society Score, functional knee score, and Knee Society Clinical Rating System of the studied groups

	Group I (patellar resurfacing) (*n*=15), *n* (%)	Group II (patelloplasty) (*n*=15), *n* (%)	*P*
Knee Society Score			
Pain			
40	2 (13.3)	7 (46.7)	
45	8 (53.3)	2 (13.3)	
50	4 (26.7)	1 (6.7)	
ROM	21.33±2.19	20.99±1.32	0.046*
Alignment			
−3	3 (20.0)	1 (6.67)	0.021*
0	12 (80.0)	14 (93.33)	
Flexion contracture			
−5	1 (6.7)	0	0.421
−2	14 (93.3)	15 (100)	
Extension lag			
−10	1 (6.7)	1 (6.7)	1.0
−5	14 (93.3)	14 (93.3)	
AP instability			
10	15 (100.0)	15 (100)	-
ML instability			
10	2 (13.3)	0	0.036*
15	13 (86.7)	15 (100)	
Functional knee score			
Walking distance			
10	2 (13.3)	5 (33.3)	0.029*
20	4 (26.7)	8 (53.4)	
30	9 (60.0)	2 (13.3)	
Stair climbing			
0	0	2 (13.3)	0.011*
15	5 (33.3)	8 (53.4)	
30	10 (66.7)	5 (33.3)	
Walking aids used			
−20	0	2 (13.3)	0.013*
−10	0	1 (6.7)	
−5	4 (26.7)	7 (46.7)	
0	11 (73.3)	5 (33.3)	
Knee Society Clinical Rating System			
Total knee score	78.80±9.37	88.93±8.49	0.039*
Total functional knee score	44.00±12.67	30.60±15.80	0.011*

*Statistically significant as $P<0.05$. Data are presented as mean±SD or frequency (%). ROM: Range of motion, AP: Anteroposterior, ML: Mediolateral, SD: Standard deviation

Discussion

TKA is the preferred treatment for OA of the knee joint, as it corrects deformity, alleviates discomfort, and reestablishes normal biomechanics.[6,7] According to reports, AKP is a prevalent cause of patient dissatisfaction in about 50%,[8] occurring in up to 5%–47% of cases.[9] The patella was frequently resurfaced by surgeons due to the fact that AKP was a prevalent symptom. Complications associated with patellar resurfacing involve subluxation, dislocation, laxity, patellar fracture, patellar tendon or quadriceps tendon rupture, and patellar clunk.[10]

AKP is multifactorial, and patellar resurfacing or patelloplasty is not the sole determinant of post-TKA pain.[8] Component malalignment or malrotation, particularly internal rotation of the femoral or tibial components, can disrupt patellar tracking and lead to AKP. Similarly, patellar tracking abnormalities caused by soft-tissue imbalance or extensor mechanism malalignment increase mechanical stress on the patellofemoral joint, contributing to pain.[11] In addition, implant design and material can influence patellar kinematics and joint mechanics, with some prosthesis designs offering better conformity and potentially reducing pain.[12]

Other factors, such as soft-tissue issues such as Hoffa's fat pad impingement, synovial irritation, or tightness in the extensor mechanism, can also play a significant role in AKP. Patient-specific variables, including preexisting patellar cartilage damage, patellofemoral arthritis, obesity, or pain sensitivity, further complicate the assessment.[13]

The results of our study presented that the basic clinical and demographic data which including age, sex, side operated, and diagnosis showed no significance between both studied groups. This outcome was crucial in suppressing the influence of demographic and clinical data on the final outcomes. The postoperative knee score demonstrated a significantly greater improvement in the patellar resurfacing group compared to the patelloplasty group in terms of pain relief and range of motion (ROM). Additionally, the functional score was notably higher in the resurfacing group, particularly in walking distance, stair climbing, and use of walking aids. The Bartlett patellofemoral score also showed significantly better outcomes in the resurfacing group for anterior knee pain (AKP), stair climbing ability, and rising from a chair, with no significant difference in quadriceps strength. Overall, the total Bartlett patellofemoral score was significantly higher in the patellar resurfacing group than in the patelloplasty group. A significant difference was indicated between both groups regarding lateral patellar placement and patellar thickness ($P < 0.05$), with no significant difference regarding patellar tilt angle.

Table 3: Bartlett patellofemoral scoring system of the studied groups

	Group I (patellar resurfacing) (*n*=15), *n* (%)	Group II (patelloplasty) (*n*=15), *n* (%)	*P*
AKP			
15	11 (73.3)	9 (60.0)	0.002*
10	4 (26.7)	6 (40.0)	
5	0	0	
0	0	0	
Quadriceps strength			
5	12 (80.0)	14 (93.33)	0.107
3	3 (20.0)	1 (6.67)	
1	0	0	
Ability to rise from chair			
5	11 (73.3)	5 (33.33)	0.002*
3	4 (26.7)	9 (60.00)	
1	0	1 (6.67)	
0	0	0	
Stair climbing			
5	0	3 (20.00)	0.001*
4	0	6 (40.00)	
3	11 (73.3)	1 (6.7)	
2	1 (6.7)	4 (26.6)	
0	3 (20.00)	1 (6.7)	
Total score	28.90±3.62	23.87±4.41	0.027*

*Statistically significant as $P<0.05$. Data are presented as mean±SD or frequency (%). AKP: Anterior knee pain, SD: Standard deviation

Consistent with our findings, Gogia *et al*.[14] revealed that the patellar resurfacing group outperformed the nonresurfacing group on the KSS functional and clinical ratings and the pain score.

Similarly, Chaudhary *et al*.[15] stated that the patellar resurfacing group showed statistically significant superiority over the nonresurfacing group in mean pain and KSS scores.

In addition, Thilak and Mohan[16] discovered that the patellar resurfacing group exhibited substantially higher functional scores (70.90 vs. 66.44, $P = 0.02$) and Feller's (23.36 vs. 21.98, $P = 0.001$) at the final follow-up, which occurred after a minimum of 10 years.

Moreover, a meta-analysis by Migliorini *et al*.[17] concluded that patellar resurfacing in TKA showed superior overall outcomes, including higher KSS scores, lower rates of AKP, and fewer reoperations.

In contrast with our results, Gupta[18] reported that both resurfacing and nonresurfacing groups were comparable in clinical, functional KSS, and pain scores. The study's design may be the cause of the discrepancy. Our randomized controlled trial provides more robust evidence by reducing bias and confounding variables. Conversely, observational studies, such as Gupta's, are particularly susceptible to confounding and variability, which can obscure substantial disparities between groups.

Ha *et al*.[19] came in line with our findings and reported that the resurfacing group exhibited significantly improved KSS and Feller scores postoperatively compared to the non-resurfacing group. The resurfaced side exhibited lower AKP and patellar dislocation rates than the nonresurfaced side.

In contrast, Mishra *et al*.[20] found no statistically significant difference in pain, modified HSS, or KSS ratings between the groups that had and did not undergo resurfacing. Their study's more extended follow-up period of 2 years might explain this difference.

Nonpatellar resurfacing was not associated with better clinical results than patellar resurfacing, according to Barot *et al*.[21] The KSS found no statistically significant differences in clinical results when comparing patellar resurfacing with nonpatellar resurfacing. The difference in the sample size may explain this difference.

Table 4: Skyline view measured parameters of the studied groups

	Group I (patellar resurfacing) (*n*=15)	Group II (patelloplasty) (*n*=15)	*P*
Patellar tilt angle (α) (°)	-	21.33±4.29	-
Patellar tilt angle (β) (°)	8.93±2.55	-	-
Lateral patellar placement (d) (mm)	1.80±0.86	2.53±1.19	0.036*
Patellar thickness (T) (mm)	20.40±3.14	23.53±2.92	0.041*

*Statistically significant as $P<0.05$. Data are presented as mean±SD. SD: Standard deviation

AKP is a multifactorial condition, and potential confounding factors may also play a significant role in its development and persistence.[22] Malalignment of the femoral or tibial components can lead to abnormal patellar tracking, which is a primary contributor to AKP.[23] Internal rotation of the femoral or tibial components can disrupt the normal patellofemoral mechanics, leading to increased friction, pain, and potentially joint damage.[24]

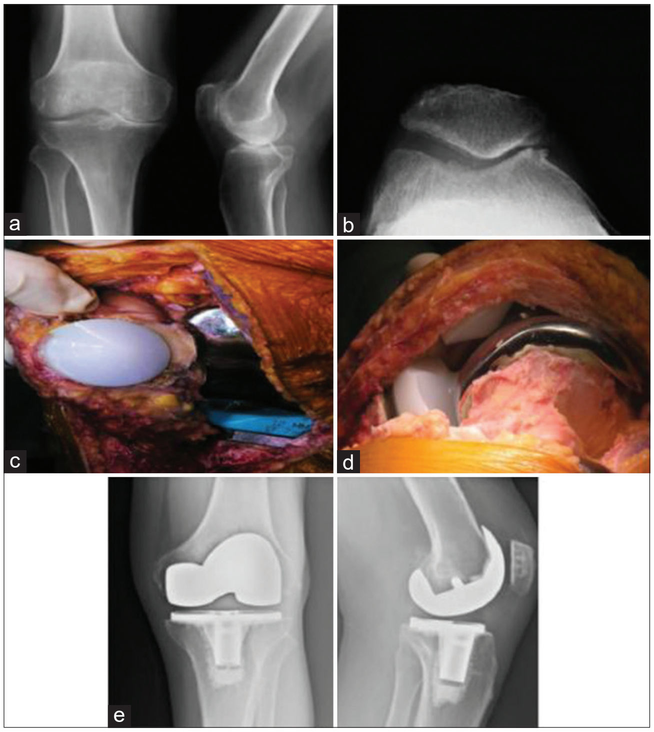

Figure 2: Male patient 58 years old suffered from osteoarthritis on the right side, with follow-up 12 months, (a and b) preoperative imaging, (c) intraoperative pictures, (d) intraoperative patellar tracking, (e) postoperative anteroposterior and lateral view

Soft-tissue imbalance, such as tightness in the extensor mechanism or Hoffa's fat pad impingement, can also contribute to increased pressure and pain in the patellofemoral joint.[25]

Furthermore, implant design and material can significantly impact patellar kinematics and, consequently, AKP outcomes. Modern implants with better conformity and those that reduce mechanical stress on the patellofemoral joint have been shown to reduce pain and improve patient satisfaction. However, implant failure or incompatibility with the patient's anatomy may still contribute to pain even in the absence of patellar resurfacing.[26]

Patient-specific variables are another aspect that complicates the assessment of AKP. Obesity, preexisting patellar cartilage damage, and pain sensitivity can all influence the severity of AKP post-TKA.[27,28]

The current study has several limitations that must be acknowledged. The relatively small sample size of 30 participants is a limitation that affects both the generalizability and statistical power of our findings, as well as the ability to systematically observe and report adverse events across the

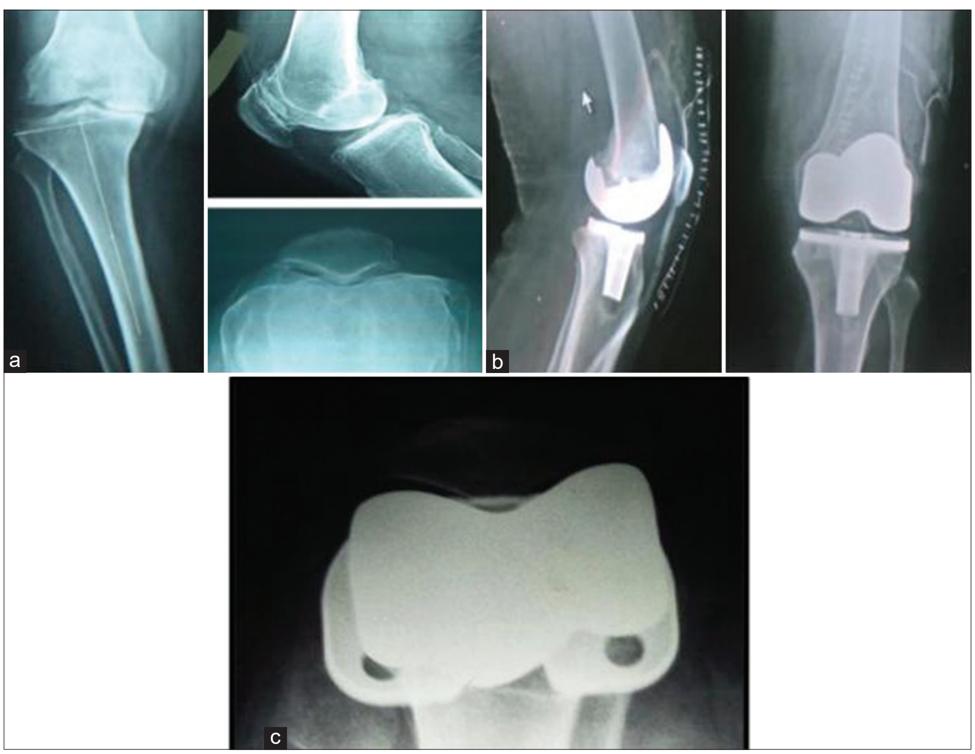

Figure 3: Female patient 58 years old suffered from osteoarthritis on the right side with follow-up 20 months, (a) preoperative imaging, (b) postoperative imaging, and (c) 20 month follow-up skyline view

patient population. The justification for this sample size was based on logistical constraints imposed by the COVID-19 pandemic, which significantly impacted the availability of prosthetic components and the number of surgeries conducted. In addition, the study's follow-up period of 1 year may not be sufficient to evaluate long-term outcomes such as implant durability, progression of patellofemoral arthritis, or late complications. The reliance on subjective scoring systems, such as the KSS and the Bartlett patellofemoral scoring system, can be influenced by patient perception and variability in assessor evaluation.

Conclusions

In total knee prosthesis, patellar resurfacing is a better choice than patelloplasty for patellofemoral OA or RA treatment. Patellar resurfacing resulted in improved functional outcomes, including better ROM, stair-climbing ability, and reduced pain. While patellar resurfacing significantly improved pain relief and knee function, both groups demonstrated similar results regarding quadriceps strength and patellar tracking.

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Conflicts of interest

There are no conflicts of interest.

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Assessment of Blood Loss, Pain Score, and Functional Outcome in Patients Undergoing Bilateral Total Knee Arthroplasty with or without Tourniquet: A Randomized Controlled Study

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Abstract

Background: The most common affliction of the knee joint is osteoarthritis (OA), with a prevalence of 22%–39% in India. Total knee arthroplasty (TKA) is the standard definitive treatment in symptomatic patients of advanced OA. A tourniquet has been traditionally applied in TKA to achieve less intraoperative bleeding and create a bloodless surgical field for ease of surgery and to improve the quality of cementation leading to decreased surgical time. However, it also has certain complications, including but not limited to increased postoperative pain, deep vein thrombosis, pulmonary embolism, nerve palsy, vascular injury, and poor wound healing. This study was conducted to aid in the justification of the use of a tourniquet during TKA by comparing postoperative hematocrit, pain score, and knee function. **Materials and Methods:** This was a prospective, randomized controlled study conducted in the Department of Orthopedics, Fortis Hospital, Shalimar Bagh, New Delhi, on 60 patients undergoing bilateral TKA over 2 years from December 2017 to December 2019 to assess blood loss, pain score, and functional outcome in patients undergoing bilateral TKA with or without a tourniquet. **Results:** The mean age of patients undergoing bilateral TKA without a tourniquet was 64.07 ± 9.12 years, and for bilateral TKA with a tourniquet, it was 61.03 ± 8.07 years. The cumulative blood loss was found to be 795 mL without the use of a tourniquet, and when the tourniquet was used, it was calculated to be 690 mL. At the end of 3 months, there was no significant difference between the Visual Analog Scale scores of the two groups. Functional outcome evaluated using the Oxford Knee Score and Knee Society Score was statistically insignificant at 2 weeks, 6 weeks, and 3 months. **Conclusion:** From our study, we concluded that the use of a tourniquet decreases the intraoperative blood loss but has no role in reducing cumulative blood loss. However, it does not affect operating time, pain, functional outcomes, and quadriceps strength in a span of 3 months of follow-up. Hence, we suggest that rational thinking is required for the routine use of a tourniquet in every case of TKA.

Keywords: Blood loss, total knee arthroplasty, tourniquet

Introduction

The knee is the largest weight-bearing joint of the human body. As it is extremely important for locomotion, any serious affliction of this joint results in severe disability. The most common affliction of this joint is osteoarthritis (OA), primary or secondary. OA is the most frequent joint disease, with a prevalence of 22%–39% in India.[1] OA is more common in women than men. According to the World Health Organization, 9.6% of men and 18% of women aged over 60 years have symptomatic OA worldwide.[1] Almost 45% of women over the age of 65 years experience symptoms of osteoarthritis, while 70% of women in this age group exhibit radiological evidence of the condition.[1] Around 80% of cases with OA have limitations in movement, and 25% of cases cannot perform their major daily activities.

Various symptomatic and conservative treatments such as nonsteroidal anti-inflammatory drugs (NSAIDS) have been used; however, definitive treatment in symptomatic patients of advanced OA remains total knee arthroplasty (TKA). It

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provides significant pain relief, correction of deformity, and improvement in function.[2]

Recommended treatment options for early-stage OA are exercise,[3] cryotherapy,[4] conservative treatments (e.g., NSAIDs and intra-articular steroid injection), arthroscopic debridement, viscosupplementation, or osteotomies. Definitive treatment in symptomatic patients of advanced OA (Grade 4) is TKA.

There are many debatable questions in TKA, though it has been one of the most successful surgeries performed for pain alleviation and to improve quality of life. One of them is reducing blood loss. Various methods have been employed for reducing blood loss, including tourniquet, coagulation cautery, administration of tranexamic acid topically or intravenously.[5] A tourniquet has been traditionally applied in TKA to achieve less intraoperative bleeding and create a bloodless surgical field for ease of surgery and to improve the quality of cementation.[6-9]

By reducing the bleeding during surgery, it decreases the incidence of cardiovascular and hemodynamic complications. Thus, surgery can be performed more easily and in a shorter span of time.[10-12]

The tourniquet controls intraoperative blood loss; however, it cannot control postoperative blood loss. Reactive blood flow reaches its peak within 5 min of releasing the tourniquet.[13] Patients may complain of thigh pain after tourniquet application, possibly due to direct pressure on the nerves and local soft tissues. Reactive hyperperfusion may lead to the limb swelling and an increase in soft tissue tension, which may be contributory to the wound pain. Quadriceps strength may also decrease after application of a tourniquet, possibly due to reperfusion and ischemia. A prolonged surgery may even intensify the loss of muscle strength.[14,15] Another serious postoperative complication is thromboembolism, which may become even more significant when a tourniquet is used during the surgery.[16,17] The incidence of deep vein thrombosis (DVT) is much higher when a tourniquet is used without any DVT prophylaxis.[18,19] The deflation of the tourniquet may lead to hemodynamic changes. This may lead to the dislodgement of emboli, which may travel from the lower limb to the pulmonary artery and cause pulmonary embolism (PE).[20,21]

Other tourniquet-related complications may include nerve palsy,[22] vascular injury,[23] rhabdomyolysis,[24] subcutaneous thigh fat necrosis,[25] intraoperative patellofemoral maltracking,[26-28] and poor wound healing.[8,29] However, the final verdict regarding tourniquet use is not yet out, as there are proponents of both "use" and "do not use." The benefits of a tourniquet must be balanced against the disadvantages and risks. This study was conducted to aid in the justification of the use of a tourniquet during TKA by comparing postoperative hematocrit (HCT), pain score, and knee function.

Objectives

The objectives of the study were to compare the blood loss, functional outcome, and pain score during TKA with and without the application of a tourniquet.

Materials and Methods

This was a prospective, randomized controlled study conducted in the Department of Orthopedics, Fortis Hospital, Shalimar Bagh, New Delhi, on 60 patients undergoing bilateral TKA after obtaining written informed consent from the patient for the study and surgery over 2 years from December 2017 to December 2019, after the clearance from the ethical committee. Adherence to international ethical standards was ensured. The comorbidities, like diabetes mellitus and hypertension, were managed by a multidisciplinary team and fitness for surgery was obtained.

Patients with bleeding diathesis, peripheral vascular diseases, a history of infection in knee joints or infective foci elsewhere in the body, deranged kidney functions, revision TKA, and patients with inflammatory arthritis, e.g., rheumatoid arthritis was excluded from the study.

The sample size was calculated by the following formula:

$$n_1 = \frac{\left(\sigma_1^2 + \sigma_2^2 / \kappa\right).\left(Z_{1-\alpha/2} + Z_{1-\beta}\right)^2}{\Delta^2}$$

$$n_2 = \frac{\left(\kappa \times \sigma_1^2 + \sigma_2^2 / \kappa\right)\left(Z_{1-\alpha/2} + Z_{1-\beta}\right)^2}{\Delta^2}$$

The notation for the formulae are:

n_1 = Sample size of Group 1

n_2 = Sample size of Group 2

σ_1 = Standard deviation (SD) of Group 1

σ_2 = SD of Group 2

Δ_1 = Difference in group means = ratio = n_1/n_2

$Z_{1-\alpha/2}$ = Two-sided Z value

$Z_{1-\beta}$ = Power

Considering the difference in group means to be 20%, power of the study as 80%, and at a 95% confidence interval, the ratio of sample size (Group 1/Group 2) as 1, and with the significance level set at 5%, a sample size of 60 was derived (i.e., 30 in each group).

Inclusion criteria

The study included the patients undergoing simultaneous sequential bilateral primary TKA.

Exclusion criteria

1. Patients with bleeding diathesis and peripheral vascular diseases
2. Patients with history of infection in knee joints
3. Patients with deranged kidney functions
4. Patients undergoing Revision TKA
5. Patients with history of infective foci elsewhere in the body
6. Patients with history of inflammatory arthritis, e.g., rheumatoid arthritis

7. Patients with history of neuromuscular or neurosensory deficit.

Randomization

A person not involved in the study picked the nontransparent sealed envelope containing the slip of both patient groups, and it was decided which patient had to receive the tourniquet and which patient was to be operated on without the tourniquet.

Blinding

Patients and personnel involved in the study were blinded to treatment group until before surgery. The investigator collecting the data remained blind during the procedure, during postoperative data collection, and also during follow-ups.

Procedure

TKA was done using the Zimmer biomet, Warsaw, Indiana, United States. Intraoperatively, patients were administered combined spinal–epidural anesthesia – for spinal 3 mL 0.5% bupivacaine and for epidural 4 mL Xylocaine with adrenaline after a test dose was given. The patient was positioned supine on the operating table. Pneumatic tourniquet was applied over thigh in patients under tourniquet group [Figure 1]. Both the lower limbs were prepared and draped, after which prophylactic antibiotics were administered. For the tourniquet group, the tourniquet was placed as high as possible on the thigh, over cast padding, and the leg was elevated, and limb occlusion pressure (LOP) was measured to calculate the tourniquet inflation pressure.

It was the pressure in the tourniquet at which the distal arterial blood flow, as assessed by a Doppler probe held over a distal artery, was occluded. This value was generally higher than the systolic BP. A safety margin was added to cover intraoperative fluctuations in arterial pressure. If LOP was <130 mmHg, the safety margin was 40 mmHg; if LOP was 131–190 mmHg, the margin was 60 mmHg; and if LOP was >190 mmHg, the margin was 80 mmHg. One gram intravenous tranexamic acid injection was given before tourniquet inflation.

Patients underwent a simultaneous sequential knee arthroplasty. Intraoperative blood loss was assessed by calculating suction drain volume after subtracting the irrigation volume, and each fully soaked sponge was considered equivalent to 80 mL of blood. Operative and tourniquet times were noted. Preoperative and postoperative X-rays of knee (anteroposterior view standing and lateral) along with orthoscanogram of both the lower limbs were obtained [Figure 2].

Figure 1: Thigh high tourniquet application

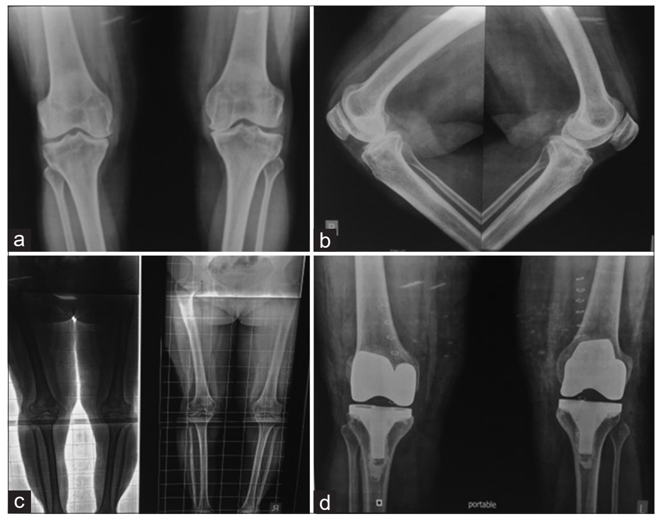


Figure 2: Preoperative and postoperative radiographs of total knee arthroplasty. (a) Preoperative anteroposterior standing view of both knees, (b) preoperative lateral view of both knees, (c) orthoscanogram of both lower limbs, (d) postoperative anteroposterior standing view of both knees

Figure 3: Measuring collection of blood in drain to assess postoperative bleeding

Methods of assessment

Blood loss

Intraoperative blood loss was measured by [(Volume in suction reservoir − Volume of saline wash used) + (Total weight of wet mops used during the surgery − Total weight of so many dry mops)].

Roughly one fully soaked mop is considered 80 mL.

Postoperative blood loss was calculated by measuring the volume of blood collected in the suction drain in mL [Figure 3].

Hemoglobin (Hb) and HCT levels were calculated on day 1, day 3, and on the day of discharge. Packed red blood cells (RBC) were transfused when Hb level was <8.5 g/dL. Cumulative blood loss estimation was done using the Mercuriali formula,[30] expressed in milliliters of RBC:

Table 1: Age and gender distribution of cases undergoing total knee arthroplasty with and without tourniquet

	Without tourniquet	With tourniquet
Age, mean±SD	64.07±9.12	61.13±8.07
Sex, *n* (%)		
Male	23 (76.7)	23 (76.7)
Female	7 (23.3)	7 (23.3)

SD: Standard deviation

Table 2: Comparison of mean values of intraoperative blood loss and blood loss in drain between total knee arthroplasty with and without tourniquet group

	Tourniquet		*P*
	Without tourniquet, mean±SD	With tourniquet, mean±SD	
Blood loss (mL)	550.00±279.78	305.27±143.75	<0.001
Drain (mL)	86.00±35.09	100.26±36.65	0.132

SD: Standard deviation

Table 3: Comparison of mean values of hemoglobin and hematocrit preoperatively, on day 1, day 3, and at the time of discharge between total knee arthroplasty with and without tourniquet group

	Without tourniquet, mean±SD	With tourniquet, mean±SD	*P*
Hb			
Preoperative	12.26±1.42	12.76±1.7	0.221
Day 1	9.88±1.19	10.93±1.52	0.004
Day 3	9.07±1.17	9.85±1.53	0.032
Day 6	9.39±0.92	9.78±1.28	0.184
PCV			
Preoperative	0.37±0.04	0.38±0.05	0.255
Day 1	0.31±0.03	0.33±0.04	0.031
Day 3	0.28±0.04	0.30±0.04	0.056
Day 6	0.28±0.03	0.30±0.04	0.099

PCV: Packed cell volume, Hb: Hemoglobin, SD: Standard deviation

Table 4: The mean difference in actual blood loss between the two groups

	Tourniquet		*P*
	Without tourniquet, mean±SD	With tourniquet, mean±SD	
Cumulative blood loss	795.21±412.03	690.09±387.16	0.313

SD: Standard deviation

Estimated blood loss = Blood volume × (HCT_{preop} − $HCT_{at\ the\ time\ of\ discharge}$) + mL of transfused RBC.

The patient's blood volume was calculated through the Nadler formula[31] (in milliliters of blood) and required the volume of RBC transfused as well. The volume of RBC transfused was based on the number of RBC in one blood unit pack. No patient in our study needed blood transfusion preoperatively.

Pain score

Pain score was recorded once the epidural analgesia and IV analgesics were discontinued and when patients were mobilized and physiotherapy was started. Visual Analog Scale (VAS) score was recorded on day 1, day 3, and on the day of discharge, 2 weeks, 6 weeks, and at 3 months.

Knee Society Score and Oxford Knee Score

The pain intensity, functional outcome, range of motion (ROM), and stability were assessed at 2 weeks, 6 weeks, and at 3 months.

Operating time

Operating time was measured from time of incision to wound closure in both the groups in minutes.

Complications

Wound examination was done regularly in the postoperative period to see for any wound-related complications such as localized swelling, redness, blisters, and discharge from the wound. The postoperative period was carefully monitored to evaluate DVT and PE.

Follow-up visit

Patients were assessed using Knee Society Score (KSS), Oxford Knee Score (OKS), and VAS scales during follow-ups at 2 weeks, 6 weeks, and 3 months postoperatively in outpatient department.

Statistical methods

The obtained data were compiled systematically in Microsoft Excel. A master table was prepared, and the total data were subdivided and distributed meaningfully and presented as individual tables along with graphs [Figure 4].

Data collected were analyzed using the SPSS software, IBM, Armonk, New York, USA. Descriptive and inferential statistical analyses were carried out in the present study. Results on continuous measurements were presented as mean ± SD, and results on categorical measurements were presented in number (%). The level of significance was fixed at $P = 0.05$, and any value ≤0.05 was considered statistically significant.

Chi-square analysis was used to find the significance of study parameters on a categorical scale. A two-tailed, independent Student's *t*-test was used to find the significance of study parameters on a continuous scale between two groups (intergroup analysis) on metric parameters.

If required, any other suitable statistical methods were used at the time of data analysis.

Results

The mean age of patients undergoing bilateral TKA without a tourniquet was 64.07 ± 9.12 years, and bilateral TKA with a tourniquet was 61.03 ± 8.07 years.

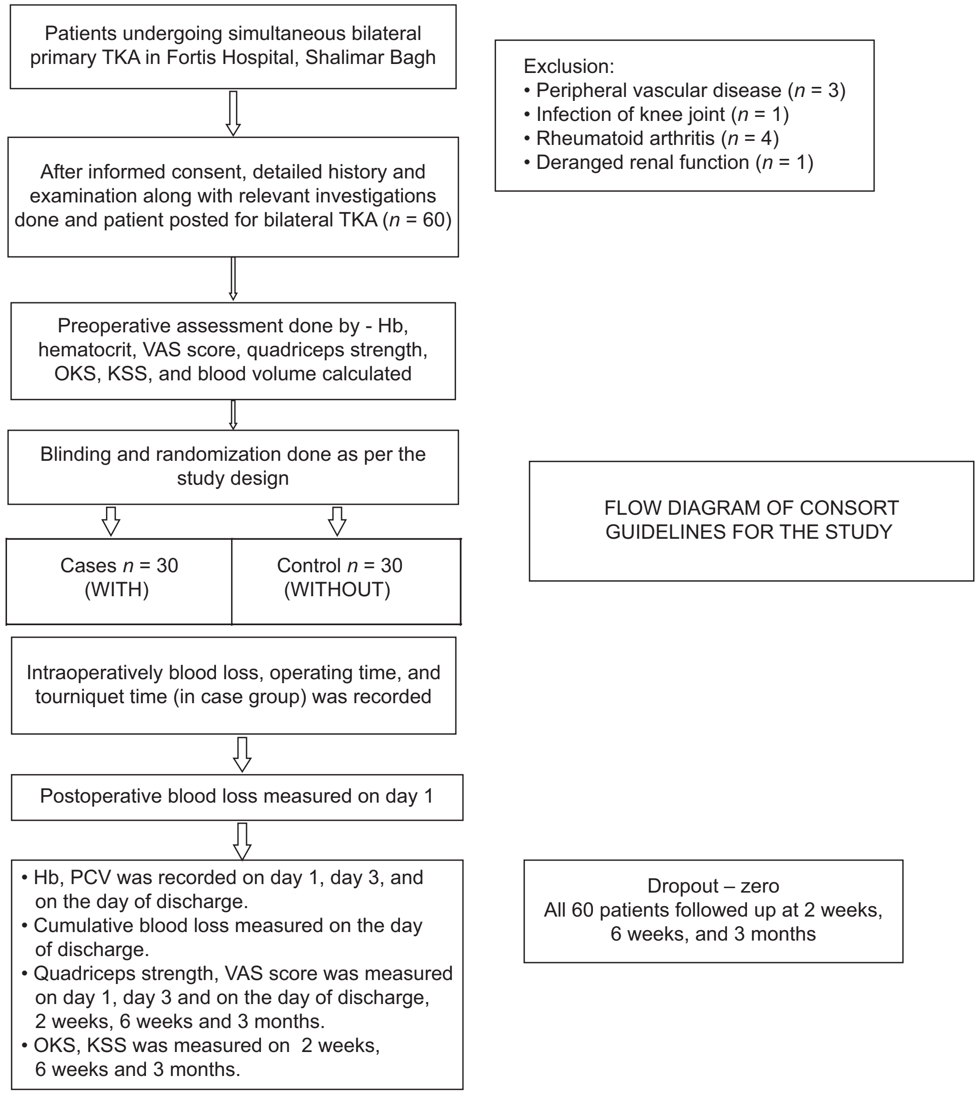


Figure 4: Flow diagram of consort guidelines for the study

Out of a total 60 patients, 46 (76.7%) were female, and 14 (23.3%) were male. There were 23 (76.7%) females and 7 (23.3%) males in each group [Table 1].

Intraoperative blood loss and suction drain blood loss

Intraoperative blood loss was assessed by calculating suction drainage less irrigation volume, and each fully soaked sponge was considered equivalent to 80 mL of blood. The mean difference in blood loss between two groups was statistically significant ($P < 0.001$).

Suction drains were removed in both groups 24 h after surgery. It was emptied in a kidney tray, and volume was measured with the help of a 50 cc syringe. However, the correlation between the two groups was found to be insignificant ($P = 0.132$) [Table 2].

Fall of hemoglobin and hematocrit

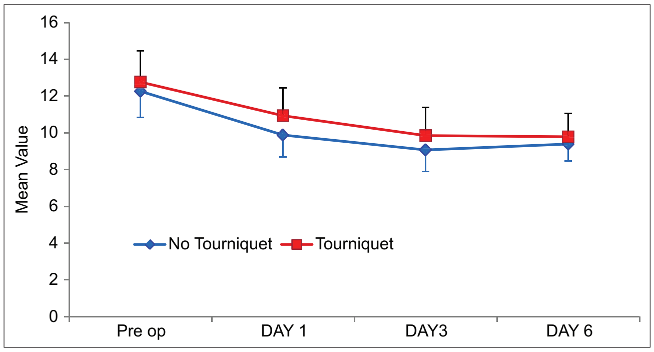
Mean Hb and HCT both were measured preoperatively [Graph 1], on day 1, day 3, and at the time of discharge. Postoperatively, blood transfusion was done when Hb was <8.5 mg/dL or if the patient was symptomatic. The fall of Hb was statistically significant on day 1 ($P = 0.004$) and day 3 ($P = 0.032$), whereas the fall of HCT was statistically significant on day 1 ($P = 0.031$) [Table 3].

Cumulative blood loss

Cumulative blood loss was calculated using the Mercuriali formula in milliliters of RBC. The cumulative blood loss was found to be 795 mL without the use of a tourniquet, and when the tourniquet was used, it was calculated to be 690 mL. However, it was statistically insignificant as the P value was found to be 0.313 [Table 4].

Operating time

The mean operating time on both sides operated using a tourniquet was 62.6 min, whereas without a tourniquet, the operating time was 62.98 min. The time difference between the two groups was statistically insignificant.



Graph 1: Comparison of mean values of hemoglobin preoperatively, on day 1, day 3, and at the time of discharge between total knee arthroplasty with and without tourniquet group

Table 5: Comparison of mean values of Oxford Knee Score and Knee Society Score preoperatively, 2 weeks, 6 weeks, and 3 months, resepectively between total knee arthroplasty with and without tourniquet group

	Tourniquet		*P*
	Without tourniquet, mean±SD	With tourniquet, mean±SD	
OKS			
Preoperative	12.03±4.18	14.83±5.33	0.027
2 weeks	33.23±5.57	34.97±4.37	0.185
6 weeks	37.43±4.59	39.1±3.04	0.104
3 months	40.5±3.31	41.53±2.76	0.194
KSS			
Preoperative	22.73±12.95	28.5±10.67	0.068
2 weeks	77.17±7.01	79.1±5.34	0.239
6 weeks	83.42±6.37	85.1±3.96	0.229
3 months	88.57±4.12	89.36±3.58	0.432

OKS: Oxford Knee Score, KSS: Knee Society Score, SD: Standard deviation

Pain (Visual Analog Scale score)

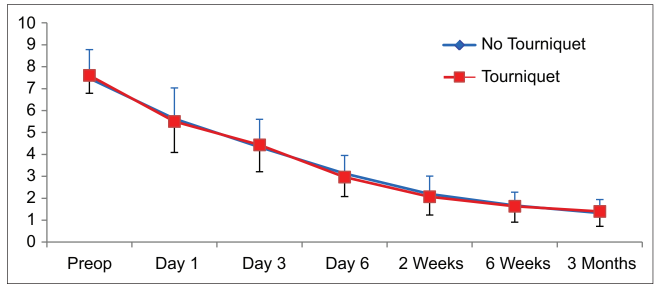
It was measured using a VAS. VAS score was recorded as per pro forma preoperatively, at day 1, day 3, day 6, 2 weeks, 6 weeks, and 3 months. The score was noted on a scale of 0–10 with increasing pain severity. The pain score decreased over a period of time in both the groups and was proportionate. At the end of 3 months, there was no significant difference between both the two groups and VAS score was comparable in both the groups.

Functional outcome

Functional outcome was evaluated using OKS and KSS preoperatively, at 2 weeks, 6 weeks, and 3 months. The mean OKS as well as mean KSS was statistically insignificant at 2 weeks, 6 weeks, and 3 months [Table 5].

Discussion

In our study, we had 60 patients undergoing bilateral TKA under evaluation. Out of these, 30 patients were allocated in the case group, i.e., the tourniquet group, and 30 remaining were in the control group, i.e., without a tourniquet. The mean age of patients undergoing bilateral TKA without a tourniquet was 64.07 ± 9.12 years, and for bilateral TKA with a tourniquet, it was 61.03 ± 8.07 years. Out of a total 60 patients, 46 (76.7%) were female, and 14 (23.3%) were male. There were 23 (76.7%) females and 7 (23.3%) males in each group. Various parameters were assessed as per the study design, and the findings are as follows.



Graph 2: Comparison of mean values of Visual Analog Scale score preoperatively, day 1, day 3, day 6, 2 weeks, 6 weeks, and 3 months between total knee arthroplasty with and without tourniquet group

Blood loss

In our study, we observed that tourniquet application during the whole surgery provided a bloodless operative field, superior cementation, and reduced intraoperative blood loss. The intraoperative blood loss in our study was reported as 310 mL when TKA was performed with tourniquet application and 550 mL when the tourniquet was not applied. The mean difference of intraoperative blood loss between the two groups had a $P < 0.001$, which was statistically significant. In our study, the suction drain volume, i.e., postoperative blood loss, was higher in patients who underwent TKA with a tourniquet. But the difference was insignificant ($P = 0.132$).

The cumulative blood loss in the group without a tourniquet was found to be 795 mL in our study. It was higher than the tourniquet group, which was 690 mL. "*P* value" was found to be 0.313, and this correlation was statistically insignificant.

Dennis *et al*.,[32] Zhang *et al*.,[33] and Tetro and Rudan[34] stated similar findings in their study that use of a tourniquet during surgery improves visibility and reduces intraoperative blood loss. However, there was no statistically significant difference in overall blood loss.

Visual Analog Score

In our study population, the pain control was assessed by VAS score on day 1, day 3, and on the day of discharge, 2 weeks, 6 weeks, and 3 months. The VAS score gradually improved in patients who underwent TKA either with or without a tourniquet over 3 months, and there was no significant difference. Barker *et al*.[35] stated similar results in their study that pain was not significantly different between the two groups. Teitsma *et al*.[36] and Ejaz *et al*.[37] also concluded there was no significant difference between the two groups at the 8-week follow-up [Graph 2].

AORN[38] recommended that the pain score in the knees operated on with a tourniquet can be minimized by using wider cuffs, which provide better transmission of tissue compression, and lower cuff pressure is required to compress the artery.

Oxford Knee Score

In our study, we assessed the OKS preoperatively, at 2 weeks, 6 weeks, and 3 months. The questionnaire consisted of 12 questions that cover the function and pain of the knee. In our study, the preoperative OKS score was found better in the tourniquet group and was 14.8; whereas, in the group without a tourniquet, it was 12.03, but it was statistically significant ($P = 0.027$).

Postoperative OKS scores improved in both groups when assessed at 2 weeks, 6 weeks, and 3 months and were statistically insignificant. Liu *et al*.[39] also had similar results in their study. They found that there was no significant difference in OKS between the tourniquet and no tourniquet groups at 6 weeks and 3 months. Mittal *et al*.,[40] Vandenbussche *et al*.,[41] and Harsten *et al*.[42] also had similar findings in their study.

Knee Society Score

In our randomized controlled study, we compared the KSS among patients who underwent TKA with and without a tourniquet over 3 months. The reported influence of the use of a tourniquet on the functional outcomes after TKA was found to be variable. In our study, the KSS among the two groups was comparable, and the difference was statistically insignificant. There was not much difference between the two groups in KSS scoring. Dennis *et al*.,[32] Teitsma *et al*.,[36] and Liu *et al*.[39] found similar results in their study that there was no significant difference in KSS among the two groups.

Operating time

The same surgeon performed all the surgeries using the same surgical technique in our study to eliminate this confounding factor. In our study, the mean operative time was similar in both groups and was 62.98 and 62.60 min in the with and without tourniquet groups, respectively. It was statistically insignificant as the $P = 0.902$.

Similar to our study, several studies were done by Ledin *et al*.,[43] Kageyama *et al*.,[44] Matziolis *et al*.,[45] and Vandenbussche *et al*.[41] All of them reported no significant difference in the operating time between the two groups. Whereas, Li *et al*.[46] and Tai *et al*.[29] stated that the operating time was significantly less in the tourniquet group.

Limitations

It was a single-center study; hence, it does not represent the actual geographical distribution of patients suffering from OA knee in India.

The sample size of the study was small. A larger sample size will be required to improve the statistical significance of the study.

More extensive and multicentric studies are required to validate our recommendations and to find further strategies to optimize better functional outcomes after TKA.

Although various studies have been conducted in various part of the world, there is paucity of data from India regarding usage of tourniquet in Indian populace. The data collected from western literature might not be very helpful as there is difference in thigh fat, male–female ratio undergoing TKA, age group, pathology, etc.

Conclusion

From our randomized comparative study on 60 patients divided into two groups of 30 patients with 60 knees in each group (total 120 knees), we found that

- tourniquet application during TKA decreases intraoperative blood loss significantly and provides a bloodless field
- There is more blood loss during the immediate postoperative period when a tourniquet was applied during TKA, as reflected in the suction drain
- There was no statistically significant difference in the cumulative total blood loss
- Not using a tourniquet during TKA does not significantly improve functional outcome
- Use of a tourniquet does not significantly increase the postoperative pain (VAS score)
- Use of a tourniquet does not significantly decrease the operating time
- Blood transfusion rate was higher when the tourniquet was not applied; however, it was insignificant
- Use of a tourniquet during TKA does not significantly hinder the OKS
- The use of a tourniquet is not associated with any significantly increased pain, decrease in ROM, or decreased functional scores as compared to the no tourniquet group in the early postoperative period.

Hence, we suggest that rational thinking is required for the routine use of tourniquets in every case of TKA.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Single-center Midterm Outcomes of Primary Cemented Modular Bipolar Hemiarthroplasty in Unstable Intertrochanteric Fractures in the Indian Population

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Abstract

Introduction: Intertrochanteric (IT) fractures account for approximately 45% of all hip fractures in elderly individuals. Over the last century, sliding hip screws and proximal femoral nailing have emerged as reliable methods for the fixation of these fractures. However, comminution and osteoporosis, especially in unstable fractures, present challenges in the osteosynthesis of IT fractures. Varus collapse, screw cutout and non-union are frequently associated problems. The existing comorbidities and high mortality and morbidity associated with these fractures complicate the situation further. This has led to the rising trend of primary hemiarthroplasty as an alternative to osteosynthesis in unstable IT fractures. We aimed to study the outcomes of primary cemented modular bipolar hemiarthroplasty in unstable IT femoral fractures in the Indian population. **Materials and Methods:** Fifty-four patients admitted to a tertiary care hospital with a diagnosis of unstable IT fractures (AO/OTA 31-A2) underwent cemented modular bipolar hemiarthroplasty with/without stainless steel wire augmentation as a primary procedure from January 2020 to June 2022. All patients were followed up for a minimum period of 1-year postsurgery. Clinical, functional, and radiological outcomes were assessed at 3, 6, and 12 months postoperatively and every 6 months thereafter. **Results:** The mean age of the population was 71.84 ± 3.17 years. A total of 40.75% were males and 59.25% were females. The mean surgical time was 76 ± 10.7 min, and the mean blood loss volume was 350 ± 63.8 ml. The mean duration of hospitalization was 5.16 ± 2.67 days. One patient died in the immediate postoperative period, and two patients were lost to follow-up after 3 months. The mean follow-up duration was 17.84 ± 4.09 months. At the end of 1 year, the mean Harris hip score (HHS) was 84.35 ± 8.3 for 54 patients, of whom excellent functional outcomes were observed in 17 hips (30.9%), good HHSs were reported in 28 hips (50.9%), and fair HHSs were reported in 9 hips (16.4%). Poor outcomes were observed in one patient who had two episodes of dislocation and required revision surgery at 3 months. **Conclusion:** “Cemented modular bipolar hemiarthroplasty, when performed as a primary procedure for elderly patients (over 60 years) with unstable IT fractures in the context of osteoporosis, comminution, and multiplanar splits, has proven to be an excellent treatment option. The procedure offers significant benefits, including earlier weight-bearing, reduced risk of reoperation, and excellent functional outcomes, enabling patients to return to their preinjury activity level more quickly.”

Keywords: Functional outcome, hemiarthroplasty, intertrochanteric fractures, modular bipolar, unstable

Introduction

Intertrochanteric (IT) fractures are the most commonly encountered fragility fractures of the lower limb with the highest mortality rate, close to 20%.[1,2] Owing to the sedentary lifestyle, deficient diets, and increasing geriatric population, we have witnessed a surge in the number of IT fractures in osteoporotic bones. It is estimated that by 2050, the number of annual hip fractures will be approximately 6.26 million per year worldwide.[3] As of July 2022, there are approximately 149 million people (10.5%) above the age of 60 years in India, and this number is expected to increase to 347 million (20.8%) by 2050.[4] Despite being a tropical country, a deficient diet and a shift to a sedentary lifestyle have contributed to a significant increase in osteoporosis in the Indian population. A large-scale study revealed that the mean Indian bone mineral

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density (BMD) was 2 standard deviations (SDs) less than that in the Western countries.[5]

Osteoporosis causes bone strength to decline, the trabeculae to become sparser and thinner, and the bone cortex to shrink. Fractures can occur easily with minor stress.[6] A typical fracture occurs when someone falls over the lateral surface. The level of protection of adipose and muscle tissue that covers the fracture site correlates with response times and energy absorption and dissipation.[7] Low BMD, muscle wasting around the hip, and direct fall over the trochanter in elderly individuals are known to lead to unstable fractures associated with posteromedial comminution, lesser trochanter fracture or multiplanar fracture, and lateral wall blowout.[8-10] These factors lead to difficulty in obtaining or maintaining the reduction intraoperatively. They are also not helpful in preventing excessive collapse or screw backouts in the postoperative period necessitating the need for secondary surgery. Hence, they are called unstable IT fractures.[7-11]

Conservative treatment is reserved for morbid patients or those who are unfit for surgery. These patients have a relatively high rate of mortality due to problems related to prolonged immobilization such as bed sores, infections, lung atelectasis, and deep vein thrombosis.[1,12,13] While most IT fractures yield excellent results with sliding hip screw systems and intramedullary nailing, the results have not been promising in cases of unstable IT fractures.[8-10,13-16] Despite the advances in implants for IT fractures over the past 100 years, the search for ideal surgery in unstable fractures is still ongoing.[7] While lateral wall comminution and reverse obliquity are contraindications for sliding hip screws, loss of medial support with lesser trochanteric fragment, uncontrolled collapse, and prolonged nonweight-bearing lead to higher rates of failure in this system.[10]

Stable fixation, prompt full weight-bearing, and early mobility are the main objectives of therapy.[17] Nevertheless, intramedullary fixation is propagated as the procedure of choice for osteosynthesis in unstable fractures.[18] It is a minimally invasive procedure offering better biomechanical stability (achieved by a reduced lever arm of distracting forces and medializing the lateral wall by bypassing the lateral wall blowout). There are helical blades and screw modifications to reduce the rate of cutouts in osteoporotic bones. Still, this type of fixation faces many issues such as screw migration, and uncontrolled collapse leading to shortening/coxa vara/fibrous nonunions.[8-10,13,16,19,20] Moreover, nonweight-bearing mobilization or even delayed mobilization along with supplemental parathyroid hormone therapy is the usual protocol for the osteosynthesis of these fractures.[1,21] Despite all these measures, the rates of failure in unstable fractures are as high as 7.1%–12.5%, and the dreaded complications of immobilization are an additional burden.[9,13,20-22]

Over the past decade, hemiarthroplasty has emerged as a reliable treatment method in these patients as it not only offers stability but also allows early postoperative weight-bearing.[7,8,12,16] Several studies have reported better patient satisfaction and functional scores with bipolar hemiarthroplasty than with proximal femoral nails in unstable IT fractures.[1,8-10,13,16] Patients not only attained preinjury activity levels earlier but also had a lower Koval score and a lesser chance of requiring a secondary surgery in comparison with the nailing group. However, guidelines are yet to recommend arthroplasty as a primary option in the management of these fractures. Keeping in mind the expected rise of the elderly population in our country, the burden of these fractures on their lives, and their sociocultural demands in our population, we aim to study the clinical, functional, and radiological outcomes of primary cemented modular bipolar hemiarthroplasty in unstable IT femoral fractures in the elderly Indian population.

Objective

To assess the clinical, functional, and radiological outcomes of primary cemented modular bipolar hemiarthroplasty in elderly Indian patients with unstable IT femoral fractures, with a focus on its effectiveness and impact on recovery.

Materials and Methods

Study design

This was a prospective study carried out at a tertiary care government hospital in Karnataka from January 2020 to June 2022. A total of 57 patients admitted with AO type 31A2 IT fractures fulfilling the inclusion criteria were enrolled in this study.

Inclusion criteria

- Patients above 65 years of age
- Closed fractures
- Singh's osteoporosis index of <3 assessed via pelvis with both hip radiographs
- Sagittal split
- Patients with no mobilization difficulties before fracture.

Exclusion criteria

- Bilateral fractures
- Pathological fractures other than osteoporosis
- Revision or nonprimary fracture
- Patients with progressive neurological diseases
- Active Foci of infection
- Terminally ill patients.

Ethical consideration

The study was approved by the institutional ethics committee before its initiation. Patients who met the inclusion criteria were enrolled into the study. Informed consent was taken for their participation and willingness to receive required treatment and examination.

Data collection

Data were collected in the form of inpatient case sheets and outpatient follow-up sheets. The preoperative data obtained included name, age, sex, laterality of fracture, comorbidities, time to surgery, and preoperative radiographs. Intraoperative data included operative time and blood loss. Postoperative data included time to weight-bearing and duration of hospital stay. The follow-up data included severity of pain on the visual analog scale (VAS) by the patient, Harris hip scores (HHSs), and radiographs (pelvis with both hips anterior–posterior view and hip with thigh lateral view).

Surgical technique

- All patients were operated on by the same team led by a senior experienced orthopedic surgeon
- The standard posterolateral approach was used, subcutaneous tissue was dissected, and the gluteus maximus muscle was split along the line of the fibers. The trochanteric bursa was excised. The greater trochanter, if grossly displaced, was provisionally fixed to the shaft with 1.8-mm K-wires
- Short external rotators were identified and tagged. The limb was externally rotated while the tendinous portion of the short external rotator was cut together with the posterior capsule. The fracture site was exposed, and a provisional neck cut was taken at a higher level with the femoral head *in situ* to minimize displacement. Head extracted by corkscrew
- The lesser trochanter fragment was provisionally fixed with a 1.5 mm K-wire to the shaft and was cerclage with 18-mm stainless steel (SS) wire at the level of the lesser trochanter to recreate the calcar. The neck cut was revised. A box cut was taken, standard femoral canal preparation was done, broaching was done, and an appropriately sized stem was chosen
- Trial reductions were done. Limb length, offset, and abductor tensioning were assessed on the table, and an appropriately sized head was chosen. A thorough wash of the femoral canal was given, ribbon gauze was placed in the acetabulum, cementing of the femoral canal was performed with a cement gun in a retrograde fashion, and the final stem was inserted. Extravasated cement was removed via clearance
- If the greater trochanteric fragment was large, additional tension band wiring was performed. After the setting of the cement, the appropriately sized head was inserted and reduction was done after the removal of the ribbon gauze, thorough washing, and final inspection of the acetabulum. The capsule was repaired, and external rotators were fixed by Ranawat technique. The drain was placed, and the wound was closed in layers.

Postoperative protocol

- Postoperatively, the limb was maintained at 15° of abduction with a pillow positioned between the 2 lower limbs
- Physiotherapy and full weight-bearing mobilization with a walker started on day 1
- The dressing was done on day 2, the drain was removed, and the tip was sent for culture and sensitivity. IV antibiotics were continued until day 3. After this, the patient was switched to oral antibiotics upon discharge after dressing on day 5. The staples were removed on day 14
- Patients were advised not to adduct and internally rotate their limbs, not to squat, and to use one or two pillows between the thighs while lying on the nonoperated site
- To prevent disuse syndrome, all patients were sent to the rehabilitation department. They were then permitted to resume full weight-bearing as tolerated starting the day after surgery along with side sitting, quadriceps strengthening, and ankle mobility exercises
- Immediate postoperative (within 24 h) radiographs were obtained to ensure correct implant placement and any immediate complications such as fractures and dislocations were checked
- Patients were followed up at 3 months, 6 months, and 1 year postoperatively and every 6 months thereafter, and radiographs, VAS scores, HHS, and complications were recorded
- Six-week postoperative radiographs were obtained to assess early healing, alignment, and any signs of complications
- Further radiographs were obtained at 3, 6, and 12 months, and annual follow-ups for the assessment of the implant position, bone healing, and any signs of long-term complications such as cement failure or loosening, osteolysis, or the development of fractures and early signs of degeneration of the contralateral hip joint were performed.

Data analysis

- The data were entered into Microsoft Excel and analyzed using IBM Statistical Package for Social Sciences (SPSS) version 26.0 (IBM Corp., Armonk, NY) with descriptive analysis
- Numerical data were analyzed with descriptive statistics
- The normality of the continuous data was tested by the Kolmogorov–Smirnov test and the Shapiro–Wilk test
- Categorical data were presented as frequencies and proportions
- Continuous data were presented as mean and SD.

Results

Fifty-seven patients underwent cemented modular bipolar hemiarthroplasty. One of the patients died in the immediate postoperative period due to pneumonia and 2 patients were lost to follow-up after 3 months. The causes for majority of fractures (59.25%) were fall from standing height, followed by road traffic accidents (31.5%). The mean age of the population in our study was 71.84 ± 3.17 years. The youngest patient was a 60-year-old male with a history of bull gore injury. There were 59.25% females and 40.75% males. Thirty-two fractures were Singh's Grade III, 21 fractures were Grade II, and one fracture in a 74-year-old female had a Singh's index of Grade I [Table 1]. The mean duration of surgery was 76 ± 10.7 min, and the mean blood loss volume was 350 ± 63.8 ml. The mean duration from admission to surgery was 3.25 days (range 1–6 days) and the mean duration of hospital stay was 5.16 ± 2.67 days. In our study, 34 required SS wire augmentation, 12 patients required tension band wiring/K wire, and 8 patients did not require any augmentation [Figure 1].

In our study, even though we encountered transient intraoperative hypotension, we have not observed immediate complications such as persistent hypotension following cementation, deep vein thrombosis (DVT), and embolism.

Post-surgery limb length discrepancy was observed in 17.5% (9 patients), of which 5 patients had shortening of <1 cm and 1 patient had 1.75 cm shortening. Lengthening was noted in 3 patients. The mean preoperative HHS was 86 ± 5.41 which reduced to 57 ± 10.81 at the time of discharge.

The mean follow-up duration was 17.84 ± 4.09 months. At the end of 1 year, the mean HHS was 85.89 ± 7.51 for 54 patients, of which excellent functional outcomes were observed in 17 hips (30.5%), good HHSs were reported in 27 hips (50.0%), and fair HHSs were reported in 9 hips (16.7%) [Table 2 and Figure 2]. A poor outcome was observed in one patient who had two episodes of dislocation requiring revision with long-stem bipolar at 3 months. The mean VAS score at discharge was 4.31 ± 1.74 which improved to 3.06 ± 1.06 at the end of 6 months. The majority of patients (56%) were mobilized without any aid at the end of the day one.

Radiographic evaluation at the 6-month follow-up showed no evidence of loosening or stem subsidence. However, at the 1-year follow-up, 4 hips (7.01%) showed stem subsidence and one patient had aseptic loosening of stem appreciated at the 18-month follow-up X-ray. However, the mean HHS in these cases was 77.75 ± 6.25 at the last follow-up. Trochanteric nonunion was noted in 3 patients, of which two were asymptomatic and had good abduction; however, one patient was noticed to have a Trendelenburg gait at the 6-month follow-up.

Table 1: Distribution of demographic data

	Male	Female	Total
Sample	22	32	54
Mode of injury			
Fall from standing height	6	25	32
Road traffic accident	12	5	17
Others (assault, skid, and fall)	4	2	6
Singh's index			
Grade III	12	20	32
Grade II	10	11	21
Grade I	0	1	1

Discussion

Most IT fractures can be treated with internal fixation to yield excellent outcomes. However, there is a subset of fractures that have posteromedial comminution, coronal split, lesser trochanteric fractures, and lateral wall blowouts rightly called unstable IT fractures. The loss of calcar and severe comminution lead to inherent instability and uncontrolled collapse. Fixation in these fractures is further complicated by osteoporosis in elderly individuals which leads to loss of fixation, screw backouts, varus collapse, and stress fractures. Failure rates as high as 56% are reported for unstable IT fractures, and screw cutouts are relatively common (4%–16.5%).[8,16] The poor quality of bone, reduction of bony trabeculae in the cancellous metaphysis, and associated comorbidities make osteosynthesis unreliable. In addition, patients are often advocated delayed mobilization or weight-bearing postsurgery which increases the incidence of complications such as pneumonia, delayed wound healing, DVT, and thromboembolism. Moreover, adherence to nonweight-bearing mobilization in the frail elderly is questionable.

Replacement rather than osteosynthesis is emerging as a promising option for unstable IT fractures in elderly patients as it encourages early mobilization and rapid recovery. Stern and Goldstein studied 29 patients with IT fractures treated with the Leinbach prosthesis with excellent results in 88% of the patients.[23,24] Similar results were obtained by Angerman and Stern in the 1970s.[25] Since then, orthopedic surgeons have considered arthroplasty as a solution for these fractures. However, proponents of intramedullary fixation often argue that the proximal femoral nailing (PFN) system offers better results even in unstable IT fractures in osteoporotic bones. Yoo *et al*.,[26] Andriollo *et al*.,[27] Jayaram *et al*.,[28] and Tajima *et al*.[29] reported that the arthroplasty group experienced partial weight-bearing earlier than the fracture fixation group, but there was no discernible difference between the two groups in terms of overall mortality, reoperation rate, and comorbidities. Another study by Kumar *et al*.[30] showed that compared to the Hemiarthroplasty group, PFN had a lower overall mortality rate and superior functional outcomes. Our present study was carried out to evaluate the outcomes of cemented modular bipolar hemiarthroplasty for unstable IT fractures in the elderly Indian population.

Table 2: Harris hip score distribution

Functional outcome	HHS score range	Number of hips (n=54) (%)	HHS scores
Excellent	90–100	17 (30.5)	90, 92, 94, 96, 98, 100, 95, 91, 93, 97, 99, 94, 90, 92, 96, 100, 95
Good	80–89	27 (50.0)	80, 82, 83, 84, 85, 86, 87, 88, 89, 84, 82, 86, 85, 83, 84, 88, 87, 89, 81, 82, 83, 84, 85, 86, 87, 89, 80, 84, 83
Fair	70–79	9 (16.7)	70, 72, 74, 76, 78, 75, 71, 77, 79
Poor	<70	1 (1.8)	65

HHS: Harris hip score

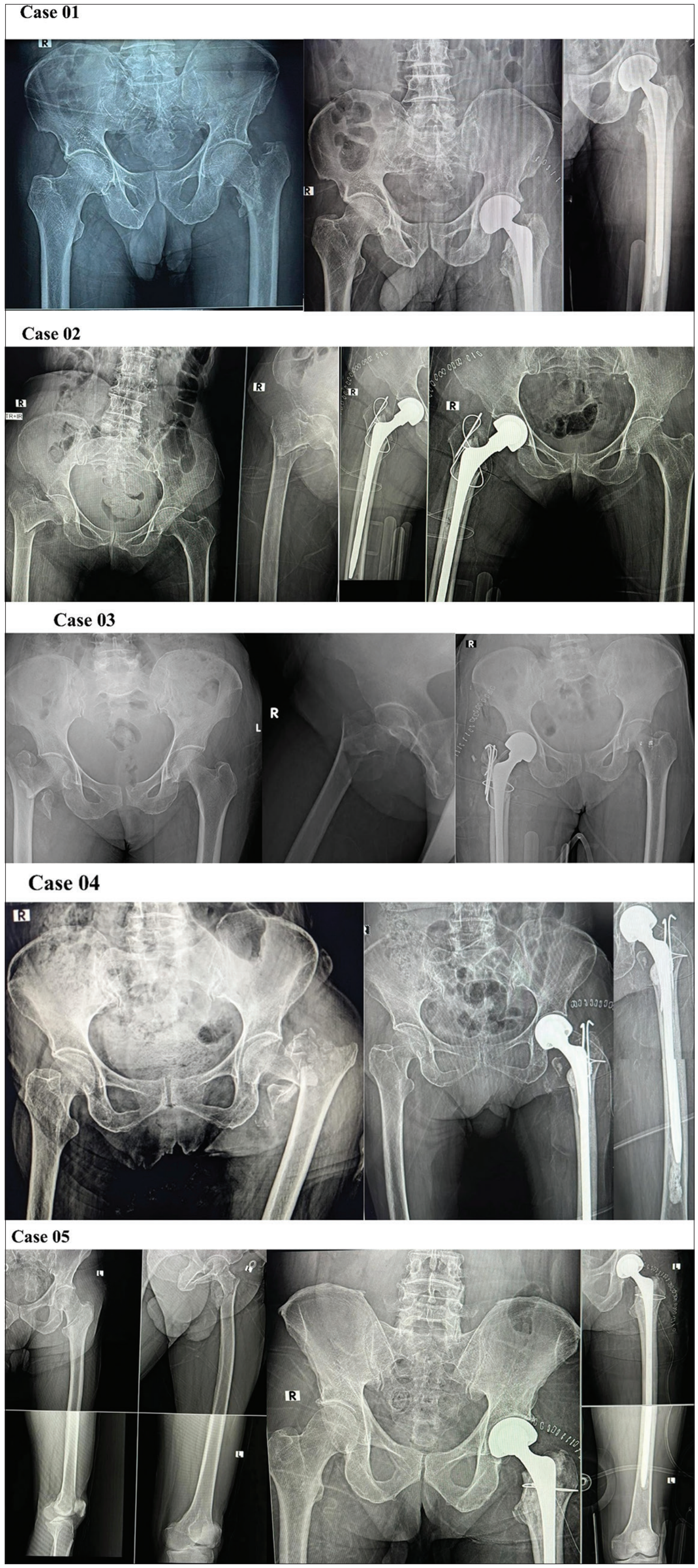

Figure 1: Radiographs of representing clinical cases – Case 1 to 5

In our study, the mean age of the population was 70.34 ± 4.87 years; among them, 59.65% were females and 40.35% were males. Thirty-two patients were Singh's Grade III, 24 patients were Grade II, and one 74-year-old female had a

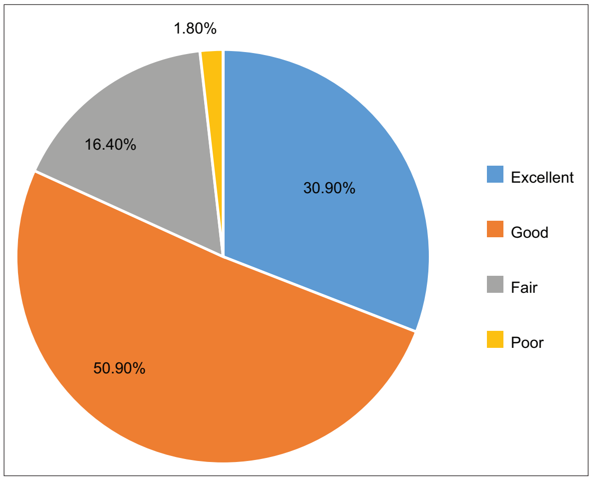

Figure 2: Harris hip score distribution at the 1-year follow-up

Singh's index of Grade I. This finding was comparable to the study by Voleti *et al*.[31] who reported that 54% of women in the series had unstable IT fractures compared with only 35% of men, possibly reiterating the fact that osteoporosis is more rampant in females than in males.

The mean duration of surgery in our study was 77 ± 11.3 min, and the mean blood loss was 190 ± 75.0 ml; only 2 patients required transfusions during the postoperative period. Patel *et al*.[32] reported a mean duration of surgery of 84 min (55–105) and a mean blood loss of 272 ml (200–400).

The postoperative period was uneventful indicating the relative safety of this procedure. No patients had weight-bearing restrictions postsurgery and were mobilized the next day with a walker. All patients mobilized independently at the time of suture removal.

Andriollo *et al*.,[27] Jayaram *et al*.,[28] and Rodop *et al*.[33] reported that unipolar or bipolar hemiarthroplasty offered better outcomes than did open reduction internal fixation in unstable IT fractures in terms of mortality and morbidity rates and comorbidities. They also had rapid rehabilitation and faster return to activities of daily living. The mean preoperative Koval category was 1.07 ± 0.14, and the mean Koval category at the end of 1 year of follow-up was 1.53 ± 0.65. This difference denotes that most patients were able to attain preinjury levels by the end of 1 year.

The associated comorbidities in older patients (87% in our study) further complicate unstable IT fractures treated by osteosynthesis requiring prolonged immobilization and delayed rehabilitation. Primary hemiarthroplasty bypasses the phases of fracture healing in these osteoporotic bones and offers "a stable, mobile, and painless hip." Tronzo[34] was the first to use a long-stemmed prosthesis and achieved good results in unstable IT fractures by "coxa femoral bypass." In his recent article, Andreoli *et al*.[27] advocated for uncemented long-stemmed prosthesis. The functional outcomes obtained in our patients were similar to those reported by others.

Despite limb length discrepancies being noted in 9 patients, only 3 of them reported discomfort and required intervention. One patient with 1.75 cm shortening was managed with a heel raise of half an inch. Two patients with lengthening of 1.3 cm and 1.8 cm, respectively, were managed with opposite heel raises. Similar results were reported by Jayaram *et al*.,[28] who reported that the mean LLD was 0.75 cm ± 0.69 cm. Harwin *et al*.[35] operated on 58 elderly osteoporotic patients with comminuted IT femoral fractures with a bipolar Bateman-Leinbach prosthesis and followed them for an average of 28 months; he noted trochanteric nonunion in 2 patients. This finding is comparable with our study where we noted trochanteric nonunion in 3 of 55 patients; however, two patients still had good abductor muscle function and no gait abnormalities. In contrast, Andriollo *et al*.[27] and Jayaram *et al*.[28] did not report any cases of nonunion.

This study was performed at a single institution using consecutive patients and regular follow-up which minimizes the variability in patient care practices that is inherent in a retrospective study design. To the best of our knowledge, this has not been done at this scale in a single center in our country.

Limitations

The small sample size and short follow-up period are limitations of our study. Another limitation of this study is the variation in stem design, which may affect consistency in analysis. Differences in stem functionality could impact the comparability and generalizability of findings.

Conclusion

"Cemented modular bipolar hemiarthroplasty, when performed as a primary procedure for elderly patients (over 60 years) with unstable IT fractures in the context of osteoporosis, comminution, and multiplanar splits, has proven to be an excellent treatment option. The procedure offers significant benefits, including earlier weight-bearing, reduced risk of reoperation, and excellent functional outcomes, enabling patients to return to their preinjury activity level more quickly. However, one limitation of this study is the relatively short follow-up period, which may not fully capture long-term complications such as implant loosening, periprosthetic fractures, or other delayed outcomes. Further studies with extended follow-up are needed to assess the long-term efficacy and safety of this surgical approach."

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Conflicts of interest

There are no conflicts of interest.

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Comparison between Results of Open Reduction Internal Fixation and Conservative Treatment in Comminuted Proximal Humerus Fractures in Elderly

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Abstract

Introduction: Proximal humerus fractures (PHFs) are common injuries in the elderly population. The literature on the management of PHFs is vast and controversy remains regarding the optimal care of displaced fractures with potential treatment options of nonoperative management, open reduction internal fixation (ORIF), and arthroplasty. **Aim of the Work:** The study aims to compare the radiological and functional outcome between ORIF and nonoperative treatment of displaced three/four-part PHFs in the elderly. **Methods:** This study included 40 patients with PHFs admitted between February 2020 and March 2023. The study included two groups. Group I ($n = 20$) underwent ORIF, while group II ($n = 20$) was treated conservatively. The mean age was 66.50 ± 4.95. All cases were assessed retrospectively after at least 12 months as regards the radiological outcome using plain X-ray, the functional outcome using the Constant-Murley score, the quality of life using the disabilities of arm, shoulder, and hand score, and the extent of pain using the Visual Analog Scale. **Results:** There was no statistically significant difference between the two groups as regards the functional outcome ($P = 0.820$), the satisfaction rates ($P = 0.678$), and extent of pain ($P = 0.678$). Radiological assessment showed no statistically significant difference as regards the union rates or avascular necrosis. Valgus malunion was significantly higher in the conservative group compared to the fixation group ($P = 0.02$). **Conclusion:** Fixation of comminuted proximal humerus fractures in the elderly does not provide a better functional outcome when compared to the conservative treatment.However, malunion rates are higher in the conservative treatment.

Keywords: Conservative treatment, constant score, elderly, neer classification, open reduction internal fixation, proximal humerus fractures

Introduction

Proximal humerus fractures (PHFs) account for 5%–6% of all adult fractures. It is the third most common fracture pattern seen in the elderly.[1] PHFs typically occur in a bimodal distribution pattern. A domestic low-energy fall from standing height is the most frequent cause in elderly patients with osteoporosis, while younger patients sustain these fractures following high-energy trauma such as road traffic accidents (RTA).[2] Females are more commonly affected than males, with a ratio of 2:1.[3]

Seventy percent of PHFs occur in the elderly, and this can be explained by low bone mineral density and higher incidence of falls in this population.[4]

The literature is vast, and controversy remains regarding the optimal care of displaced fractures with potential treatment options of nonoperative management, open reduction internal fixation (ORIF) by locked plates, and arthroplasty. The decision-making should be tailored according to patient age, medical comorbidities, functional demands, and expectations.[5]

The study aimed to compare the radiological and functional outcome between ORIF and nonoperative treatment of displaced three- and four-part PHFs in the elderly.

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Methods

Patients

This retrospective study was conducted on 49 patients with PHFs, and patients were admitted to Alexandria Main University Hospital between February 2020 and March 2023. Nine patients were lost to follow-up. Forty patients were available for the final assessment. Inclusion criteria included patients aged above 60 years with isolated three/four-part PHFs according to Neer classification as evidenced using both plain X-ray and computed tomography scan. Patients with concomitant fractures, neurovascular injuries as well as shoulder fracture-dislocations were excluded from the study. The patients were divided into 2 groups. Each group included twenty patients. Group I was treated by ORIF by locked plate while group II was treated conservatively by sling immobilization for 3 weeks followed by early passive range of motion and physiotherapy.

The mean age of the patients was 66.50 ± 4.95. Nine patients were male (22.5%), while 31 patients were female (77.5%). Twenty-seven patients had dominant side affection (67.5%), while 13 patients had nondominant side affection (32.5%). The mechanism of injury was domestic fall in 35 patients (87.5%) and RTA in five patients (12.5%). The local research ethics committee approved this study. Serial number: 0107077, IRB No: 00012098.

Technique

Patients were treated surgically by ORIF by the same trauma team. They were positioned in a beach chair position and operated through a deltopectoral approach. Reduction was achieved and fixation was done using Proximal Humerus Internal Locking System "PHILOS" plate. Postoperatively, patients were immobilized in a sling for 3 weeks followed by physiotherapy.

Patients treated conservatively were immobilized in a sling for 3 weeks followed by early passive range of motion and physiotherapy initiated after 4 weeks.

Evaluation

Clinical and radiological assessment was performed by 2 authors separately, and then the average was obtained. All patients were assessed retrospectively after at least 12 months (range 12–29 months) as regards the radiological outcome, functional outcome, satisfaction rate and the extent of pain. Radiological evaluation was done using plain X-ray for assessment of radiological union, measurement of the head shaft angle [Figure 1],[6] radiographic signs of avascular necrosis (AVN), and malunion. Functional assessment was done using the Constant Murley score (CS). The disabilities of arm, shoulder, and hand (DASH) score and the visual analog scale (VAS) were used for the assessment of satisfaction rates and the extent of pain, respectively.

Statistical analysis of the data

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY, USA: IBM Corp). Qualitative data were described using number and percentage. The Shapiro–Wilk test was used to verify the normality of distribution. Quantitative data were described using range (minimum and maximum), mean, standard deviation, median, and interquartile range. The significance of the obtained results was judged at the 5% level.

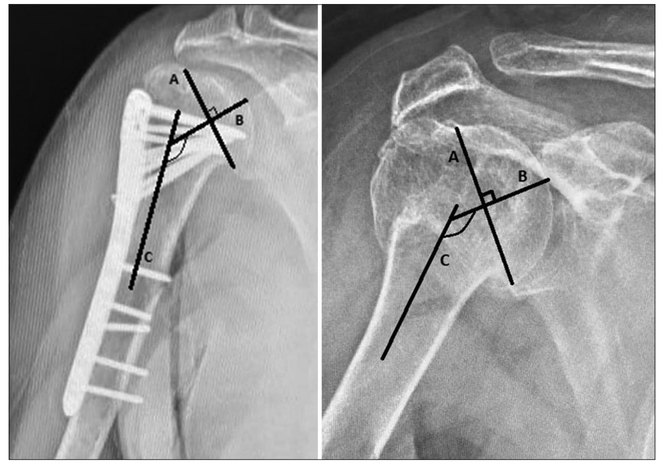

Figure 1: The measurement of the head shaft angle using the plain X-ray anteroposterior view. The angle between line B and line C represents the head shaft angle. A line: from the superior to the inferior border of the articular surface of the humerus. B line: perpendicular to the A line through the center of the humeral head. C line: line bisecting the humeral diaphysis

Results

Functional outcome using the Constant score [Table 1]

The mean CS was 63.15 and 60.75 in group I and group II, respectively. This difference reflects no statistical significance in the functional outcome between the two groups ($P = 0.820$).

Analysis of the range of motion as scored by the Constant score

Compared to the conservative group, the fixation group scored higher results for forward flexion, external rotation, and internal rotation ($P = 0.86$, $P = 0.737$, $P = 0.688$, respectively). Abduction scores were higher in a conservative group compared to the fixation group ($P = 0.825$). These differences reflect no statistical significance.

Radiological assessment using plain X-ray [Table 2]

Radiological union evidenced by bone trabecula obliterating the fracture site in plain X-rays (standard AP and lateral views) was detected in 85% of cases in both groups. The nonunion rate was equal in both groups (15%). The incidence of malunion was significantly higher in the conservative group compared to the fixation group. Valgus malunion was encountered in 30% of cases in the conservative group but was not detected in any case in the fixation group. This difference reflects a statistical significance ($P = 0.02$). Varus malunion was encountered in 20% of cases in the conservative group compared to 10% of cases in the fixation group. Tuberosity malunion was encountered in 25% of cases in the conservative group compared to 10% of cases in the fixation group. AVN of

Table 1: Comparison between the two studied groups according to functional outcome using the Constant score

Constant score	Fixation group (*n*=20), *n* (%)	Conservative group (*n*=20), *n* (%)	Test of significant	*P*
Poor	6 (30.0)	8 (40.0)	χ^2=1.254	0.846 (MC)
Fair	3 (15.0)	3 (15.0)		
Good	8 (40.0)	5 (25.0)		
Excellent	3 (15.0)	4 (20.0)		
Minimum–maximum	15.0–95.0	15.0–93.0	*U*=191.50	0.820
Mean±SD	63.15±24.39	60.75±25.90		
Median (IQR)	71.50 (43.0–80.0)	69.0 (41.0–79.0)		

P: *P* value for comparing between the two studied groups. χ^2: Chi-square test, *U*: Mann–Whitney test, MC: Monte Carlo, SD: Standard deviation, IQR: Interquartile range

Table 2: Comparison between the two groups according to the radiological outcome using plain X-ray

Radiological assessment	Fixation group (*n*=20), *n* (%)	Conservative group (*n*=20), *n* (%)	χ^2	*P* (FE)
NU	3 (15.0)	3 (15.0)	0.000	1.000
AVN	3 (15.0)	2 (10.0)	0.229	1.000
Valgus malunion	0	6 (30.0)	7.059*	0.020*
Varus malunion	2 (10.0)	4 (20.0)	0.784	0.661
Tuberosity malunion	2 (10.0)	5 (25.0)	1.558	0.407

**P* value is statistically significant. *P*: *P* value for comparing between the two studied groups. χ^2: Chi-square test, FE: Fisher's exact test, AVN: Avascular necrosis, NU: Nonunion

the head of the humerus was evident in plain X-ray in 15% of cases in the fixation group compared to 10% in the conservative group. This difference reflects no statistical significance.

Quality of life: using the disabilities of arm, shoulder, and hand score

The fixation group achieved better satisfaction rates compared to the conservative group. The mean DASH score was 37.41 and 44.15 in fixation and conservative groups, respectively. This difference reflects no statistical significance as regards the quality of life between the two groups (*P* = 0.678).

Extent of pain using Visual Analog Scale

Conservative group experienced less pain as compared to fixation group. The difference reflects no statistical significance between the two groups (*P* = 0.678).

Complications

Excluding malunion as a complication, the fixation group showed a higher overall complication rate compared to the conservative group due to surgery-related complications. Complications were encountered in 30% of patients in the fixation group compared to 25% in the nonsurgical group. This difference reflects no statistical significance (*P* = 0.723).

Patients complicated with nonunion after conservative treatment were dated for reverse shoulder arthroplasty while those in the fixation group declined further management. As regards cases of AVN, two patients were planned for reverse shoulder arthroplasty, and the others lost follow-up.

Distribution of the complications in the fixation group [Table 3]

In the fixation group, screw cutout was the most common complication (encountered in 25% of cases), followed by nonunion and osteonecrosis of the head of the humerus (encountered in 15% of cases). Malreduction resulting in varus malalignment and tuberosity malunion was encountered in 10% of cases. Loss of reduction (varus collapse), screw back-out, postoperative infection, and glenohumeral OA were encountered in 5% of the cases.

Case presentation

Case 1

A 63-year-old female sustained a 3-part PHF in November 2021. ORIF was done using locked plate. Follow-up 13 months postsurgery was done [Figures 2 and 3].

Case 2

A 66-year-old female sustained a 3-part PHF in December 2021 after falling down. Conservative management was done by immobilization in an arm sling. Follow up after 16 months [Figures 4 and 5].

Case 3

A 69-year-old female sustained a 4-part PHF in October 2021. The mechanism of injury was RTA. ORIF by PHILOS plate was done. Follow-up after 15 months [Figures 6 and 7].

Discussion

According to this current study, there is no statistically significant difference between ORIF and the conservative method in treating 3- and 4-part fractures of proximal humerus in the elderly patients above 60 years of age as regards the functional outcome using modified CS (*P* = 0.820), the satisfaction rate (*P* = 0.678), the extent of pain using VAS (*P* = 0.678), and the complication rate (*P* = 0.723). This is comparable with other papers in the literature.

Orman *et al.*,[7] performed a meta-analysis that included eight randomized controlled trials (RCTs) to compare between surgical and nonsurgical treatment of 3- and 4-part fractures of the proximal humerus. The meta-analysis included eight RCTs, a total of 364 patients with a mean age of 73.4. Clinical outcomes using CS and DASH scores, rate of complications and

Figure 2: Case 1: Three-part proximal humerus fracture managed by open reduction and internal fixation

Table 3: Distribution of the complications in fixation group (n=20)

Complications	n (%)
Intra-articular screw penetration	5 (25.0)
NU	3 (15.0)
AVN	3 (15.0)
Malreduction	2 (10.0)
Loss of reduction (varus collapse)	1 (5.0)
Screw backout	1 (5.0)
Infection	1 (5.0)
Glenohumeral OA	1 (5.0)
Nerve injury	0
Implant failure	0

AVN: Avascular necrosis, OA: Osteoarthritis, NU: Nonunion

rate of reintervention were compared between the nonsurgical and surgical groups. Results demonstrated no statistically significant difference between nonsurgical treatment and ORIF as regards clinical outcome scores (CS/DASH). Nonsurgical treatment was associated with significantly lower complication and reintervention rates when compared to ORIF (P < 0.01).

Hohmann *et al*.,[8] conducted a systematic review and meta-analysis of observational and randomized controlled studies from 2000 to 2022 comparing ORIF to nonsurgical treatment of displaced PHFs regarding the function outcome, range of motion as well as the rate of complications. The minimum mean age of the included studies was 50 years, and the minimum follow-up period was 6 months. The systematic review demonstrated no statistically significant difference between the fixation and conservative treatment for either clinical outcome or range of motion (abduction (P = 0.275), forward flexion (P = 0.447), and external rotation (P = 0.696). The overall complication rate was significantly higher in the fixation groups (P = 0.00001).

Figure 3: Case 1: Assessment of the range of motion using the Constant score: (a) Forward flexion more than 151°. (b) Lateral elevation more than 151°. (c) External rotation: Hands on top of the head with elbows held back. (d) Internal rotation: Thumb points up to T12 vertebrae (twelfth rib)

Beks *et al*.[9] included 22 studies comprising 7 randomized controlled clinical trials and 15 observational trials resulting in a total of 1743 patients. 910 patients were treated operatively, and 833 patients were treated nonoperatively. The mean age of the study was 68.3 and 75 percent of the patients were females. The study revealed no statistically significant difference between operative and nonoperative management regarding the functional outcome using the CS score (P = 0.69).

Rangan *et al*.,[10] conducted a randomized clinical trial called the Proximal Fracture of the Humerus Evaluation by Randomization trial. The study included 250 patients who sustained a displaced PHF with a mean age of 66 years and 77% female predominance. The patients were recruited between September 2008 and April 2011 and were followed up for 2 years (up to April 2013). The study compared between the operative treatment and conservative treatment by sling immobilization. The Oxford Shoulder Score (OSS) was used for comparative functional assessment. There was no

Figure 4: Case 2: Three-part proximal humerus fracture managed conservatively by immobilization and early physiotherapy

Figure 5: Case 2**:** Assessment of the range of motion using the modified Constant score: (a) Forward flexion 91–120° (6 Points). (b) Lateral elevation 91°–120° (6 points). (c) External rotation: Hands behind the head with elbows held back (4 points). (d) Internal rotation: Sacroiliac joint (4 point)

statistically significant difference between the two groups as regards the function using the OSS.

Sun *et al*.,[11] conducted a systematic review based on three RCTs and three comparative studies. This included 113 cases treated by internal fixation and 109 cases treated nonoperatively. The mean age of the included studies was 66.5 years. The primary outcome was to compare the functional outcome using constant score, and the secondary outcome was to compare the complications, including nonunion, AVN, and glenohumeral osteoarthritis. No statistically significant differences in functional outcome or the complication rate, including nonunion, AVN or glenohumeral osteoarthritis were identified.

This study demonstrated no statistically significant difference between the two groups as regard the rate of complications ($P = 0.723$). In the fixation group, screw cut out was the most common complication (encountered in 25% of cases), followed by nonunion and osteonecrosis of the head of humerus (encountered in 15% of cases). Malreduction resulting in varus malalignment and tuberosity malunion was encountered in 10% of cases. Loss of reduction (varus collapse), screw back-out, postoperative infection, and glenohumeral OA were encountered in 5% of the cases.

Correlating the complication rate to the type of the fracture, patients sustaining 4-part fractures had the highest rate of complications. In the fixation group, 50% of the complications were encountered in patients with 4-part fractures compared to 33.3% in those with 3-part nonimpacted fractures. This is comparable with other papers in the literature.

Barlow *et al*.,[12] conducted a retrospective study that included 173 patients aged above 60 years who sustained displaced PHFs. The average age of the study was 73 years. All cases were managed surgically by ORIF using locked plates. After a minimum follow-up period of 2 years, all cases were assessed regarding the complication and failure rates. The overall complication rate was 44%, and a failure rate of 34%. Intra-articular screw penetration was the main complication encountered in 26% of cases, AVN in 13% of cases and implant failure in 11% of patients, and nonunion in 5% of patients. Correlating the failure rate to the type of the fracture, 39% of failures occurred in 3-part fractures compared to 45% in 4-part fractures.

Oldrini *et al*.[13] conducted a systematic review and meta-analysis aiming to quantify the rate of complications and the reintervention rates following fixation of PHFs by PHILOS plate. The systematic review included a total of 4200 patients. The mean age was 60.3, and 65% of patients were females. The mean follow-up period was 19.9 months. The complication rate was 29.1%. Screw cutout was the most common complication, with a rate of 7.5% followed by AVN in 5.1%. Implant impingement was the third most common

Figure 6: Case 3: Comminuted proximal humerus fractured managed surgically by ORIF and complicated later on by head collapse and screw cut-out

complication and was encountered in 2.9% of patients, followed by nonunion (1.9%) and varus collapse (1.1%). Correlating the complication rate to the type of fracture, the complication rate was the highest in 4-part fracture (38.8%) compared to 3- and 2-part fractures (5.8% and 8.9%, respectively).

Limitations of the study

In this study, AVN of the head of humerus was encountered in 15% of the cases in the fixation group compared to 10% of the cases in the nonsurgical group. Possible cases of AVN might have been missed because only plain radiographs were used and because of the short follow-up period of the study that may not be enough for the signs of the AVN to be apparent on plain radiographs, although it may be visible on Magnetic Resonance Imaging.

Another limitation of this study, being retrospective, is that a single follow-up regimen as regards early mobilization and adequate physiotherapy could not be followed in all cases. Some patients might have received a better follow up regimen compared to the others and this might have affected the results regarding the functional outcome after fixation. Some authors prefer internal fixation of displaced PHFs as it allows early postoperative mobilization of the affected shoulder, which cannot be easily achieved in patients managed conservatively.

The presence of concomitant rotator cuff tears in elderly patients sustaining PHFs is common and was not addressed in this study which might have affected the functional outcomes in both groups and is considered a confounding factor.

Figure 7: Case 3: Assessment of the range of motion using the Constant score: (a) Forward flexion 61–90° (4 Points). (b) Lateral elevation 61°–90° (4 points). (c) External rotation: Hands behind the head with elbows held forward (2 points). (d) Internal rotation: buttocks (2 point)

Other limitations of this study are single center, short follow-up period, and small sample size. A larger sample size would have provided a stronger statistical value.

Conclusion

- There is no statistically significant difference between ORIF and conservative treatment of 3- and 4-part PHFs in the elderly as regards the functional outcome, the quality of life, the extent of pain, or the rate of complications, including nonunion, AVN, and glenohumeral OA
- Malunion rate is significantly higher after conservative treatment compared to ORIF of 3- and 4-part PHFs
- Patients sustaining 4-part fractures and older patients (>70 years), whether treated operatively by ORIF or conservatively, have worse functional outcome and higher risk of complications. However, this was not found to be statistically significant because of small sample size of the study.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Anterior Knee Pain Resulting from Giant Cell Tumor of the Patellar Tendon: A Case Report of a 27-year-old Female

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Abstract

This case report outlines an unusual instance of giant cell tumor of the tendon sheath (GCT-TS) occurring within the patellar tendon of a 27-year-old female who experienced persistent anterior knee pain. Overcoming diagnostic challenges was crucial, given the nonspecific symptoms and initially inconclusive radiographic findings. Magnetic resonance imaging eventually revealed a well-localized mass encompassing the patellar tendon, extending into the infrapatellar fat pad and tibia. Surgical intervention involved arthroscopic excision, emphasizing the necessity of a precise and minimally invasive approach. This case underscores the distinctive presentation of nodular-type GCT-TS in a large joint, with involvement in the knee joint and proximal tibia. It contributes valuable insights into the clinical, radiographic, and pathological characteristics of GCT-TS affecting the patellar tendon. Additionally, it offers guidance for arthroscopic treatment, highlighting the importance of total excision to reduce the risk of recurrence.

Keywords: Anterior knee pain, giant cell tumor, intra-articular lesion, nodular-type giant cell tumor of the tendon sheath, patellar tendon

Introduction

Giant cell tumor of the tendon sheath (GCT-TS) is recognized as a benign soft-tissue tumor affecting the synovium and tendon sheath, with its origins traced back to the seminal work of Jaffe in 1941.[1] While histologically identical, GCT-TS presents in two distinct forms based on its pattern of involvement and biological behavior. The localized form is confined to specific regions of the synovium or tendon sheath, while the diffuse form, also known as pigmented villonodular synovitis, involves extensive engagement of the entire synovial membrane and capsule.[2]

Although GCT-TS predominantly occurs in the fingers and toes, where it stands as the second most common tumor of the hand after ganglion cysts, infrequent instances have been documented in the knee, characterized by a nodular growth pattern. Typically, individuals between the ages of 30 and 50 years, with a notable predilection for females, fall within the demographic affected by GCT-TS, emphasizing the importance of understanding its diverse clinical presentations.[3] Giant cell tumors of the tendon sheath are typically benign growths characterized by slow growth rates and commonly manifest as painless soft-tissue masses.[4,5]

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Despite its benign nature, GCT-TS poses challenges in management, particularly in achieving complete excision due to its frequent association with the tendon sheath or synovial joint. Marginal excision is the established standard treatment, yet reports indicate a local recurrence rate ranging between 10% and 20%. This heightened recurrence risk underscores the intricacies involved in ensuring the thorough removal of the tumor.

This report sheds light on an atypical case of GCT-TS originating from the patellar tendon sheath, a rare scenario extending into the knee joint and involving the tibia. The unique features of this presentation add to the existing body of knowledge, offering clinicians valuable insights for improved diagnostic precision and informed treatment decisions. The case underscores the necessity for a nuanced understanding of

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GCT-TS, particularly when confronted with unconventional manifestations, in order to enhance clinical management strategies and mitigate the challenges associated with recurrence. Written informed consent has been duly obtained from the patient, facilitating the ethical dissemination of this clinical encounter.

Case Report

A 27-year-old female presented with persistent 3-month history of left knee pain of sudden onset and progressive in nature.Pain is aggravated by activity and relieved by rest. There was no diurnal variation or swelling. These symptoms did not alleviate despite conservative measures such as anti-inflammatory medication, and physiotherapy. Notably, there was no reported history of prior knee trauma, and her medical background was unremarkable.

Upon clinical examination, the left knee exhibited mild swelling without an associated increase in skin temperature. Palpation of the anteromedial aspect of the knee elicited tenderness, with no observed signs of ligamentous instability. Neurovascular assessment demonstrated normal sensation, and palpable dorsalis pedis and posterior tibial pulses were found to be robust.

Radiographic evaluation revealed normal bone architecture, and laboratory analyses yielded results within the normal range. Subsequent magnetic resonance imaging of the left knee [Figure 1] disclosed a homogenous and discrete mass with low-intensity signals in both T1 and T2 sequences. The mass was identified in the infrapatellar fat pad region, accompanied by hemosiderin deposition and knee joint effusion.

Considering the advantage of arthroscopy in visualizing specific knee joint locations, particularly the area anterior to the tibial plateau and beneath the patellar tendon, an arthroscopic procedure was chosen over an open surgical approach [Figure 2]. This decision aimed to mitigate potential complications associated with splitting the patellar tendon for complete removal.

Guided by arthroscopy, a soft-tissue globular mass measuring 2.5 cm × 2.5 cm × 1 cm was excised, and biopsies were obtained from multiple sites. The excised mass displayed a slight yellow coloration, exhibited a soft consistency, and lacked apparent vascularity. Upon cut section, a homogeneous nature with a cheesy consistency was observed.

The excised specimen underwent a comprehensive histopathological examination, revealing a well-defined tissue composition characterized by mononuclear cells arranged in sheets, scattered osteoclastic giant cells, areas containing foamy histiocytes, and brisk mitotic activity within the collagenous stroma. These histological features were consistent with a diagnosis of a GCT-TS. Following surgery, she was under regular follow-up with supervised rehabilitation. At 1-year follow-up, she had complete range of motion (ROM) with painless gait [Figure 3].

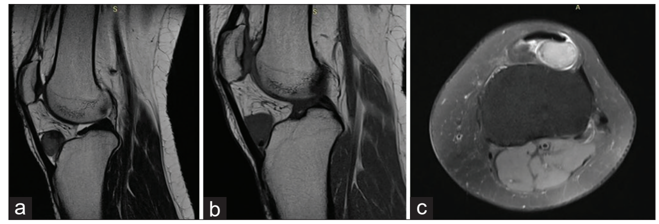

Figure 1: (a) Sagittal T1: well-circumscribed isointense ovoid lesion in the Hoffa's fat pad abutting the patellar tendon, (b) Sagittal T2-weighted (T2W): Lesion is dark on T2W sequence, (c) Axial proton density fat supressed (PDFS): Ovoid lobulated lesion intimately related to the posterior aspect of putting the patellar tendon

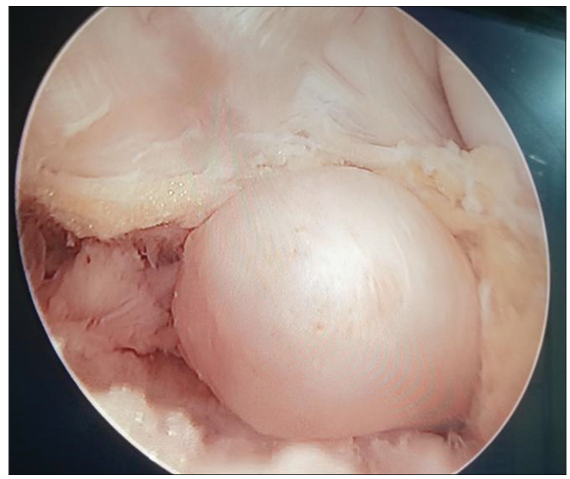
Figure 2: Arthroscopic image of globular mass beneath patellar tendon

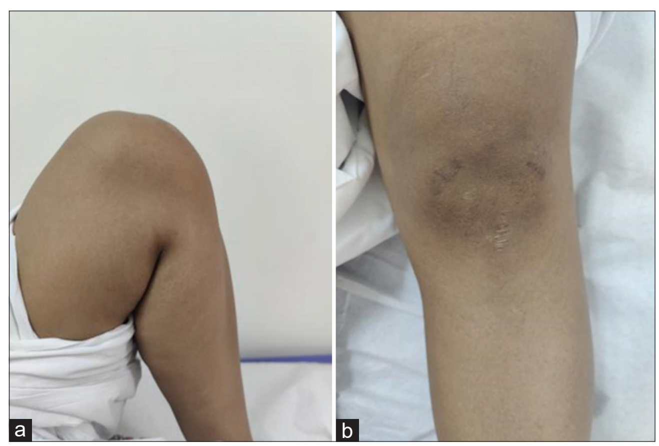

Figure 3: (a) One year follow up clinical image of affected knee with full ROM flexion (b) in extension

Discussion

Surgical resection is the primary treatment for GCT-TS, with both open and arthroscopic approaches being viable options. Currently, there is no consensus on the superiority of either technique. The popularity of arthroscopic approaches has increased due to their minimally invasive nature, reducing the risk of complications. A study comparing open and arthroscopic resection of tumors found no significant difference in recurrence rates. Thus, the choice between open and arthroscopic surgery depends on individual factors, and both methods have proven efficacy in addressing GCT-TS.[6] The choice of the arthroscopic procedure in this case was based on its advantage in visualizing the knee joint topography and the tumor's location, which is anterior to the tibial plateau and beneath the patellar tendon. An open surgical approach might necessitate splitting the patellar tendon for complete removal. A soft-tissue globular mass [Figure 4], measuring 2.5 cm × 2.5 cm × 1 cm, displaying a slight yellow coloration, was excised, and biopsies were obtained from multiple sites utilizing the arthroscopic biopsy technique.[7] Macroscopic evaluation revealed a soft consistency with no apparent vascularity. The cut section exhibited a homogeneous nature with a cheesy consistency. The specimen, subsequently submitted for a thorough histopathological examination [Figure 5], disclosed a well-defined tissue composition characterized by mononuclear cells arranged in sheets, interspersed with scattered osteoclastic giant cells. Additionally, areas containing foamy histiocytes were observed, and brisk mitotic activity was noted within the collagenous stroma. These findings were consistent with giant cell tumor of tendon sheath. The primary approach for treating GCT-TS involves completely removing the tumor. Following surgery, the most frequent complication observed is the local recurrence of the lesion. In cases where the tumor is localized, complete excision typically results in a curative outcome with a minimal recurrence rate.[8] Additional treatments, such as intra-articular radioactive isotope (90-yttrium) injection or external beam radiotherapy, may be employed to reduce the likelihood of recurrence.[2] The patient resumed her daily activities within days, highlighting a notable advantage of arthroscopic procedures over open surgery, which are associated with a higher incidence of wound-related complications when compared to arthroscopy.

The patient underwent regular follow-up for 1 year postsurgery and engaged in consistent rehabilitation sessions aimed at strengthening the knee. She resumed running and other sporting activities 6 months postoperatively, with the interim period dedicated to muscle strengthening. Throughout the follow-up period, the patient remained asymptomatic, and there were no clinical or radiological indications of recurrence observed during the 1-year follow-up assessment.

Conclusion

This case showcases successful GCT-TS management via arthroscopic resection, chosen for improved visualization and tumor localization. Histopathological confirmation was obtained. Rapid recovery and absence of recurrence underscore the efficacy of complete tumor excision, emphasizing the need for tailored treatment and careful postoperative monitoring.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given her consent for her images and other clinical information to be

Figure 4: Soft-tissue globular mass measuring 2.5 cm × 2.5 cm × 1 cm, displaying a slight yellow coloration

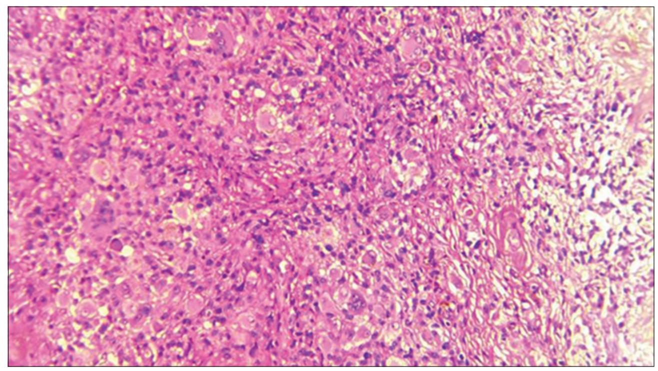

Figure 5: H and E stain of specimen showed well-defined tissue composition characterized by mononuclear cells arranged in sheets, interspersed with scattered osteoclastic giant cells

reported in the journal. The patient understands that her name and initials will not be published and due efforts will be made to conceal her identity, but anonymity cannot be guaranteed.

Authors' contribution

All authors contributed equally to conceptualization, format analysis, investigation, methodology, validation, visualization, and writing-review and editing.

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Conflicts of interest

There are no conflicts of interest.

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Biological Reconstruction of Proximal Tibia after Excision of Giant Cell Tumor

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Abstract

Giant cell tumors (GCTs) of bone are locally aggressive tumors that typically occur in the meta-epiphyseal regions of long bones. This case report presents a 23-year-old female with an expansile large GCT of the proximal tibia, managed using autogenous and equine bone graft around trabecular metal (TM) shell as a scaffold and soft tissue cover using gastrocnemius muscle flap. This approach allowed extensive intralesional curettage after tibial tubercle flip, preservation of articular surface, spanning the void with a strong metallic bone substitute (TM) as a weight transmitting beam, packing with equine bone blocks and paste while achieving vascular soft tissue cover with medial gastrocnemius flap rotation. The integration of various biocompatible materials and the use of a multidisciplinary approach resulted in successful tumor removal, restoration of subarticular bone, and restoration of knee function. This case highlights an innovative biological technique for managing juxtaarticular GCTs while minimizing morbidity.

Keywords: Bone grafting, extended curettage, giant cell tumor, proximal tibia, trabecular metal

Introduction

Giant cell tumors (GCT) of bone account for approximately 5% of all primary bone tumors and 20% of benign bone tumors. They typically affect young adults between 20 and 40 years of age, with a slight female predominance.[1] GCTs most commonly occur in the meta-epiphyseal regions of long bones, with the distal femur, proximal tibia, and distal radius being the most frequent sites.[2] Frequently these lesions are locally aggressive and rapidly destroy the juxtaarticular bone as an expansile lesion leading to cortical breach. Primary GCT is considered benign and on biopsy confirmation, traditional management of these lesions includes intralesional curettage with or without adjuvants preservation of articular surface subarticular autogenous grafting followed by cement augmentation of the lesion with or without plating to provide strength to the construct. If it is an aggressive or recurrent tumor with an articular surface breach or when the lesion has destroyed most of the cortical bone precluding joint salvage we resort to en bloc resection and limb salvage using tumor prosthesis.[3] However, these are nonbiological approaches which do not restore bone they frequently lead to late failures due to cement contraction and loosening. Tumor prosthesis in a young individual also compromises function and risks late failures with aseptic loosening especially in lower limbs. This case report presents a novel surgical reconstructive approach that integrates the use of various biocompatible materials and employs a multidisciplinary approach to manage a GCT of the proximal tibia, adhering to a bone-preserving philosophy.

Case Report

A 23-year-old female student, with no significant medical history or comorbidities, presented to our institution with complaints of pain and swelling in her right knee and proximal leg of 5 month duration. She had painful restriction of right knee movements and limp. Her symptoms rapidly

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deteriorated over 2 months when she consulted an orthopedic surgeon with an inability to bear weight over her right lower limb and swollen right knee. She only received off-and-on analgesics till she reported to us and was admitted for evaluation. Radiological investigations including radiographs and noncontrast computed tomography (NCCT) of the right knee revealed a large, well-defined osteolytic expansile lesion in the proximal tibia. The lesion was eccentrically located, involving the anterior aspect of the tibial metaphysis extending into the epiphyses to the subarticular cortex. It caused cortical thinning and showed evidence of cortical violation anteriorly without periosteal reaction [Figure 1a and b]. She underwent an open biopsy of the right proximal leg over the lesion. The biopsy revealed fragments of neoplasm composed of sheets of mononuclear stromal cells admixed with evenly distributed osteoclast-type giant cells, suggestive of a GCT of her right proximal tibia.

Upon presentation at our institution, her clinical findings included a well-healed biopsy scar over the anteromedial aspect of the right proximal leg, with localized swelling around the scar. No sinus or discharge was observed, but tenderness was localized around the swelling. She had no joint line tenderness. However, she presented with a fixed flexion deformity at her right knee joint of about 10°. Her range of movement at the knee joint was limited, with 10° to 60° of flexion, and movement beyond 60° was painful. Further evaluation for surgical intervention included a contrast-enhanced magnetic resonance imaging of the right knee [Figure 1c and d] with NCCT correlation, which revealed a heterogeneously enhancing, well-defined, irregularly marginated, eccentric expansile lesion at the epiphyseal-metaphyseal regions of the right proximal tibia with intraarticular extension and a soft tissue component. In addition, a CT angiography of the right lower limb was performed to assess vascularity around the lesion, which showed no abutment or encasement of any vessel or vascular structure by the mass.

We used a midline vertical skin incision to include the biopsy scar and medial parapatellar approach [Figure 2]. On the retinacular incision, the well-demarcated soft pale white tumor tissue enclosed in a thin friable capsule was exposed. We removed the large soft-tissue mass after performing a long tibial tuberosity osteotomy to reflect the extensor mechanism [Figure 2]. After the removal of tumor tissue, the large cavity of GCT was extensively curetted using a high-speed burr then the cavity was cauterized using ball tip cautery. This was followed by hydrogen peroxide wash [Figure 3].

To provide structural support and allow weightbearing strut, we fashioned a trabecular metal (TM) augment from a TM acetabular shell using a metal cutting carbide drill. As per preoperative templating, we needed a 50 mm shell to cut into half to allow exact sizing and provide an arch support beam for the articular surface. The remaining void was filled with autogenous iliac crest graft slivers, xenograft cancellous bone block, and injectable bone morphogenic protein (BMP) impregnated xenograft bone paste [Figure 4]. The Xenograft used was processed, freeze-dried xenograft which is available in the market. It does not require any processing or special storage at the user's end.

We also mixed vancomycin powder with the graft and bone paste. To protect the construct and allow immediate weight transmission we used a proximal tibial locking compression plate on the medial side with a few screws locking into the TM cup to stabilize the construct and allow weight transmission to the tibia below the lesion. The extensor apparatus was reattached using a small one-third tubular plate. This was followed by a rotation of the medial head of the gastrocnemius to provide robust soft-tissue cover to the whole construct [Figure 5].

The operated knee was immobilized for 3 weeks allowing the muscle flap cover to heal and operative wound to stabilize. Walker-assisted toe touch ambulation was started in the immediate postoperative period. At 3 weeks knee was mobilized. At 3 months follow up she had 10° to 50° range of movement and was admitted for assisted physiotherapy on a continuous passive motion machine. She regained pain-free 0°–90° at 6 months of follow-up [Figure 6a-c] and shows good graft augmentation and a stable construct

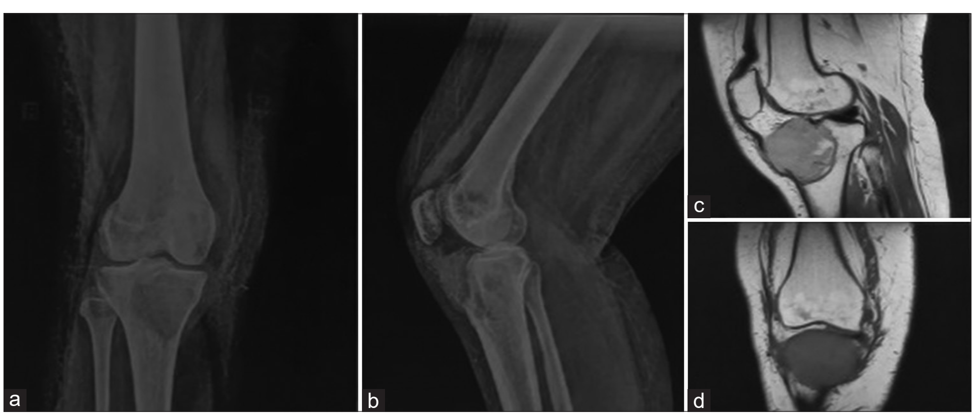

Figure 1: (a-d) Preoperative imaging (plain radiograph, and magnetic resonance imaging) anteroposterior and lateral view showing expansile lytic lesion involving almost 75% of anterior tibia in juxta-articular region destroying the anterior cortex of the tibial condyles

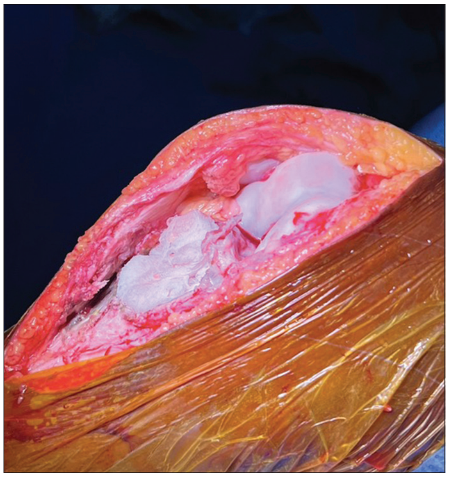

Figure 2: Intraoperative photograph showing exposure of the knee, tibial tubercle osteotomy, and the delineation of the tumor mass

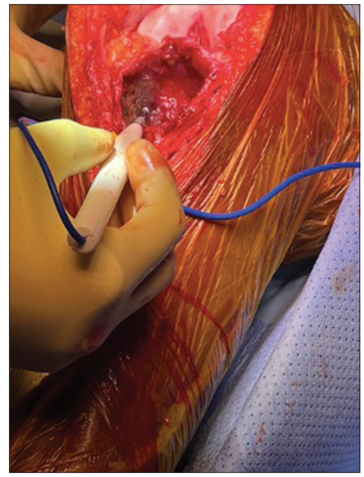

Figure 3: Intraoperative photograph showing cauterization of the cavity after removal of tumor and burring of the walls to ensure extended curettage

Figure 4: Intraoperative photograph showing cavitary filling with trabecular metal (TM) augment fashioned out of TM acetabular cup as a weight-bearing structural arm and remaining cavity filled by xenograft cancellous block, equine bone paste impregnated with Bone Morphogenic Protein and autogenous iliac crest graft

Figure 5: Postoperative plain radiograph of the operated knee

allowing weight-bearing ambulation at the recent follow-up of 18 months [Figure 7].

Discussion

This case demonstrates a novel approach to managing a GCT of the proximal tibia in a young female. We used a combination of osteoconductive and osteoinductive material on a tantalum scaffold to allow cavitary filling. The use of this construct allowed rapid cavitary bone restitution by graft integration while weightbearing was permissible through the tantalum cup graft with a locking plate construct. This construct allowed the preservation of joint surface thus excluding the need for tumor joint prosthesis which has limited function and longevity. By not using bone cement as a nonbiological filler we avoided the incidence of late failures due to contraction and loosening of cement.

The use of TM, known for its excellent osseointegration properties,[4,5] combined with autologous and synthetic bone graft, provides a scaffold for new bone formation while maintaining structural integrity. The addition of BMP to the synthetic graft material may enhance osteoinduction and accelerate bone healing.[6] The uniqueness of this approach lies in its integration of multiple bone grafting techniques and materials. While extended curettage is a well-established method for treating GCTs,[6] the combination of autologous bone graft, TM, and synthetic bone graft with BMP represents a novel approach. This combination aims to provide immediate structural support, promote rapid osseointegration, and stimulate new bone formation.

This approach had several advantages. The use of TM scaffold allowed early loading, the combination of autologous and xenograft bone graft with BMP allowed rapid bone healing and remodeling,[7] the preservation of native bone stock allows easier revision surgery if needed in future, which is particularly important given the young age of the patient.[7] The multidisciplinary

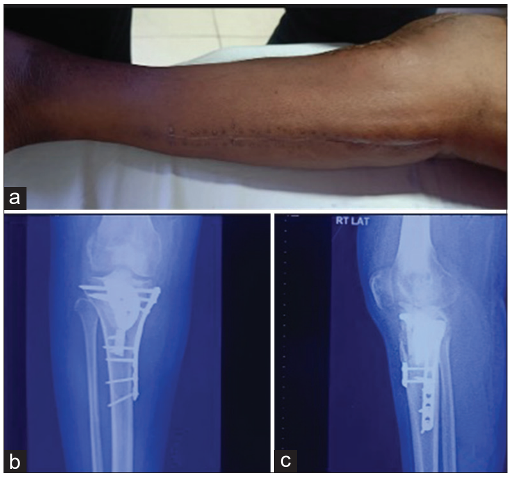

Figure 6: (a-c) Clinical picture and radiograph of 6 months follow-up showing well-healed operative wound and radiograph showing the integration of the graft and bone consolidation

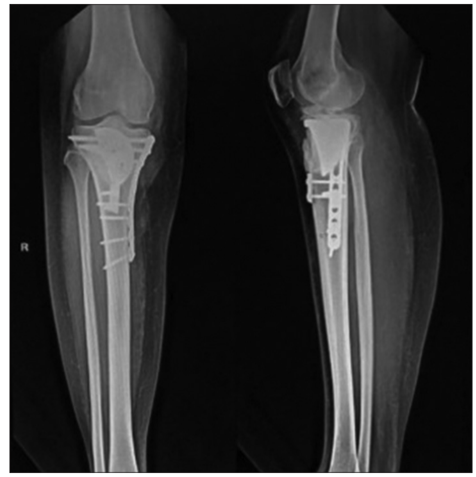

Figure 7: Radiograph of 18 months follow-up with no evidence of reoccurrence

approach involving orthopedic, oncologic, and reconstructive surgery teams allowed for comprehensive management of both the tumor and the resulting soft tissue defect. This collaborative effort ensured optimal oncological clearance while preserving limb function and aesthetics, a crucial consideration in young patients.[8] It avoids the potential complications associated with large endoprostheses, such as aseptic loosening, periprosthetic infection, and mechanical failure.[9]

However, it is important to note that this technique may have limitations. The risk of local recurrence after intralesional procedures is higher compared to wide resection.[10,11] Therefore, close follow-up is crucial to detect and manage any recurrence early. In addition, the long-term outcomes of this specific combination of materials in GCT treatment are not yet known and will require further study.

The lesson we learned

TM scaffold in combination of autologous and xenograft bone graft with BMP can be used as one of the surgical option in patients with GCT which allow early loading, rapid bone healing, and remodeling.

Conclusion

TM scaffold in combination of autologous and xenograft bone graft with BMP can be used as one of the surgical options in patients with GCT.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given her consent for her images and other clinical information to be reported in the journal. The patient understands that name and initials will not be published and due efforts will be made to conceal identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Arthroscopic Treatment for Stieda's Process Fracture Excision with Posterior Ankle Impingement Syndrome Release

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Abstract

Posterior ankle impingement can stem from various sources, encompassing both bony and soft-tissue causes, with origins in either traumatic or nontraumatic events. In this instance, we present an uncommon case involving hindfoot pain resulting from impingement caused by Stieda's process fracture. The patient, a 28-year-old female, underwent hindfoot arthroscopy, during which the Stieda's process fracture fragment was excised along with the decompression of the Flexor hallucis tendon. Subsequently, she was immobilized in a plaster of Paris slab for 1 week, followed by a period of 3 weeks of mobility with a Cam boot walker. Over the course of her follow-up appointments, her pain lessened, and her range of motion improved, allowing her to return to her normal activities.

Keywords: Ankle arthroscopy, posterior ankle impingement, Stieda's process

Introduction

Chronic hindfoot pain due to posterior ankle impingement is generally caused by bony or soft-tissue impingement by structures posterior to the tibiotalar and talocalcaneal articulations during terminal plantar flexion.[1] Discomfort arises from mechanical blockage caused by osteophytes or the entrapment of various soft-tissue elements resulting from the factors such as inflammation, scarring, or excessive joint mobility. This ailment is frequently observed among individuals engaged in sports, particularly soccer players, long-distance runners, and ballet dancers. Pain in the hindfoot can arise from both traumatic and nontraumatic sources.[2] Nontraumatic hindfoot pain can be attributed to the conditions such as tenosynovitis, tarsal tunnel syndrome, Haglund's deformity, a pronounced lateral process (Stieda's process), and the presence of an os trigonum.[2]

Stieda's process, recognized as an elongated lateral extension of the talus, is occasionally regarded as an anatomical variation.[3] This occurrence typically arises from the fusion of a secondary ossification center at the posterior-lateral region of the talus with the rest of the bone. The fused segment often exhibits a longer length than the usual talus, typically manifesting between the ages of 7 and 13 years. First described by L. Stieda in 1869, this phenomenon is often discernible in lateral perspectives of the ankle and in sagittal cross-sections on computed tomography scans and magnetic resonance imaging (MRI) images.[4]

The symptoms can emerge due to Stieda's process in cases of acute fractures or impingement between the tibia and the posterior facet of the calcaneum, particularly during plantar flexion. It is essential to distinguish it from an os trigonum (a distinct bony ossicle located at the lateral tubercle of the talus), especially if partially fused.[5] Fracturing the Stieda process of the talus is an rare, and it is crucial to distinguish it from an os trigonum and ordinary ankle sprains. To effectively differentiate between these conditions, careful examination of the bone's characteristics is essential. An os trigonum typically presents as a rounded structure with well-defined, corticated edges. In contrast, a fracture involving the Stieda's process will exhibit an uneven and irregular surface devoid of distinct cortical edges at the site of the fracture.[6]

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Impingement resulting from a Stieda's process is frequently addressed through excision using either open surgical methods, especially when conservative treatments have proven ineffective.[7]

In this instance, we present a case involving posterior ankle impingement attributed to a Stieda's process fracture. The condition was effectively managed through a successful arthroscopic excision procedure and impingement release.

Case Report

A 28-year-old female visited our outpatient department with a history of persistent pain in her right hindfoot for duration of over 3 months after an ankle sprain. The discomfort had gradually increased after sprain and had been progressively worsening over time. Physical activity seemed to exacerbate the pain, which conversely improved during the periods of rest. Although she used to engage in occasional badminton play, she had to discontinue due to the pain. Her medical history revealed no smoking or alcohol consumption, and she did not experience any other systemic symptoms. She had no symptomatic relief even after 3 months of conservative management.

Upon clinical examination, tenderness was noted in the posterior compartment of the ankle, which intensified when the ankle was moved into a plantarflexed position. There were no indications of inflammation. Assessment of her ankle function revealed a decrease of five degrees in plantar flexion and inversion on the affected side compared to the opposite ankle, while dorsiflexion and eversion were nearly normal. Lateral radiographs of the ankle as shown in Figure 1, as well as MRI images shown in Figures 2 and 3, revealed the fracture of an elongated lateral tubercle of the talus, which corresponds to Stieda's process fracture. Given the significant disability and impact on her daily life, the patient was recommended arthroscopic excision as a treatment approach.

The choice of arthroscopic excision was based on the diagnostic criteria: persistent symptoms despite over 3 months of conservative treatment, clinical signs of posterior ankle impingement confirmed by a positive plantar flexion test, and radiological evidence of impingement and reduced hindfoot space on lateral radiographs and MRI. The decision for surgery was made to address the ongoing symptoms and clear radiographic evidence of impingement.

Under general anesthesia and with tourniquet control, the patient was positioned prone with the ankles placed beyond the edge of the table, a horizontal line linking the tips of the medial and lateral malleoli was marked on the posterior aspect of the ankle. At this demarcated level, a posteromedial portal was established just anterior to the medial edge of the Achilles tendon. The trocar was inserted perpendicular to the skin to prevent harm to neurovascular structures. Similarly, a posterolateral portal was created at the same horizontal level but positioned about one to two centimeters anterior to the lateral border of the Achilles tendon.

Upon visual inspection with the arthroscope, the fractured fragment of posterior process of the talus was found

Figure 1: X-ray showing Stieda's process fracture

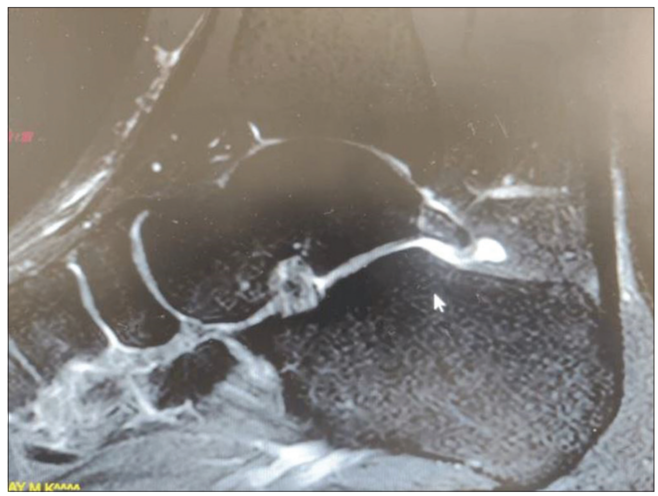

Figure 2: Magnetic resonance imaging image showing Stieda's process fracture

Figure 3: Contrast magnetic resonance imaging image showing Stieda's process fracture

directly in front of the scope. A combination of a shaver and radiofrequency probe was employed to remove the surrounding soft tissue from the talar process. By debriding a portion of the posterior capsule, the tibiotalar joint was discernible above the process. The fragment of Steida's process was excised and ends smoothened using a combination of burrs, chisels, and shavers. Subsequent to the excision, the subtalar joint line became visible. The portals were then switched, and attention was directed toward the flexor hallucis longus tendon. Even though the mobility of the tendon was normal, a decompression procedure was conducted. An erosive irregularity was observed on the superior aspect of the calcaneum due to the impingement from the Stieda process. This area was smoothed using a burr. The main arthroscopic images are shown in Figure 4 with description. The final postoperative radiograph in Figure 5 shows smoothened surface following excision.

In the postoperative phase, the ankle was immobilized in a below-knee plaster of Paris slab for 1 week, followed by the application of a cam walker boot. Ankle mobilization commenced after the 1st week, and partial weight-bearing was permitted for 3 weeks before discontinuing the walker boot. Follow-up radiographs confirmed satisfactory excision of the process without any irregularities. The patient was reviewed regularly, and range-of-motion exercises were initiated at 3 weeks. Over the course of 3 months of follow-up, there was significant relief of symptoms with return to normal pain-free functional activity. The diagnosis and management of patient was done according to the standard management guidelines and current literature.

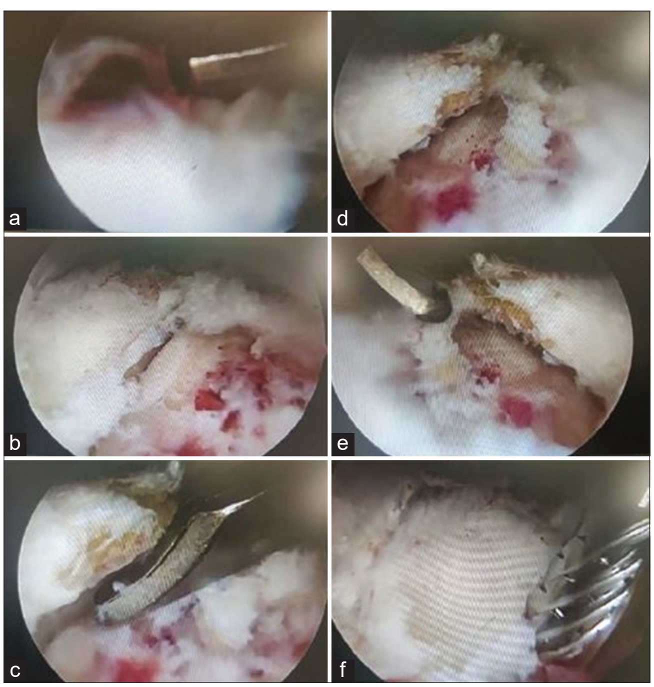

Figure 4: Arthroscopic pictures showing debridement and removal of Stieda's process and release of flexor hallucis longus tendon. (a) Identifying Stieda's process, (b) Debridement of fracture site, (c) Excision of Stieda's process, (d) Clear base after removal, (e) Removing extra tissue near site, (f) Tibio talar posterior space shaved

Discussion

Fractures involving the Stieda's process of the talus are infrequent occurrences and require careful distinction from both os trigonum and simple ankle sprains.[6,8] The os trigonum, an additional bone originating from a secondary ossification center, is positioned directly posterior to the lateral tubercle. Persisting as a distinct ossicle, the os trigonum remains connected to the lateral process through a cartilaginous synchondrosis and can induce pain.[6,8] Owing to their similar appearance and location, numerous fractures of the Stieda process are often mistakenly identified as os trigonum cases. To discern between the two, meticulous examination of the bone's characteristics is crucial. An os trigonum typically displays a rounded shape with well-defined edges, while a Stieda process fracture will exhibit an uneven and irregular surface lacking distinct cortical edges at the fracture site.[6]

Ankle sprains commonly arise due to ankle inversion and plantar flexion, which coincidentally mirror the mechanisms behind Stieda's process fractures.[6,9] Consequently, these fractures are frequently misdiagnosed as sprains, leading to issues in identification. In a particular case series, 17 out of 20 patients with fractures were inaccurately diagnosed with ankle sprains.[6] Given the prevalence of ankle sprains, the Ottawa ankle rules serve as a valuable tool for clinicians to decide on the necessity of radiographs and whether they should be conducted to rule out a fracture. The evaluation involves the patient's ability to take four steps (immediately postinjury or in the emergency department) and assesses localized tenderness at the posterior edge or tip of either malleolus.[6]

Upon confirming the fracture, proper management is critical for favorable outcomes. Fracture fragments with minimal or no displacement can be effectively treated conservatively, involving the application of a short-leg cast and a nonweight-bearing regimen lasting 4–6 weeks. After the immobilization period, weight-bearing can be resumed as tolerated. Instances of misdiagnosis or inadequate fracture

Figure 5: Postoperative radiograph showing smoothened surface after excision

management can lead to complications such as persistent pain, delayed joint degeneration (arthrosis), and restricted ankle range of motion.[3]

Posterior impingement may arise acutely due to fractures or avulsions of the posterior process of the talus, and more subacute or chronic injuries can result from repetitive overuse.[3,10] An elongated lateral tubercule could lead to impingement between the posterior margin of the tibia and the calcaneum, giving rise to discomfort during running and walking on uneven terrain.[3] Some patients might exhibit painful swelling on either side of the Achilles tendon in response to forced plantarflexion.[3] MRI has been a prominent investigative technique in these cases. Administering local anesthetic around the process under image guidance can alleviate pain while also serving as a diagnostic tool and a positive predictive indicator for surgical success, as seen in the presented patient.[3] Cortisone injections can provide temporary pain relief over the short term. Arthroscopy-assisted debridement and excision of the bony irregularity cause less postoperative discomfort compared to open surgery.[3] To avoid injury to the posteromedial neurovascular bundle, careful positioning of the posteromedial portal and prudent use of the burr are crucial.[3,10]

Joseph *et al*. findings showed reduced recovery time, fewer complications, and excellent outcomes in 83% of patients during a 5–8 year' follow-up with arthroscopic management.[3] Similarly, Joseph *et al*. reported promising results after arthroscopic removal of os trigonum in both ankles of a 32-year-old adult. Arthroscopic excision of the Stieda process can lead to substantial clinical improvement, as evidenced in this patient.[3] The procedure is straightforward and replicable, as long as precautions are taken to avoid damaging the neurovascular bundle.[6] Positive patient outcomes in terms of satisfaction are evident in both open and arthroscopic techniques, with arthroscopic methods demonstrating lower complication rates and quicker return to activity and sports.[3] Thus ankle arthroscopy can be used as effective tool in decompression of the posterior ankle impingement arising from chronic fracture of Stieda's process.[3,11]

Conclusions

Fractures involving the Stieda's process of the talus are rare occurrences, demanding careful differentiation from both os trigonum and ordinary ankle sprains. Optimal management plays a pivotal role in achieving favorable outcomes. Arthroscopic excision of the Stieda process has demonstrated substantial clinical improvements, as observed in the present patient. This procedure is not only straightforward and replicable but also necessitates careful attention to prevent harm to the neurovascular bundle.

Good outcome and satisfaction have been observed in both open and arthroscopic techniques. Nevertheless, arthroscopic methods offer distinct advantages, including reduced complication rates and a swifter return to normal activities and sports.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given her consent for her images and other clinical information to be reported in the journal. The patient understand that name and initials will not be published and due efforts will be made to conceal identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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