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Contents

Arthroplasty Articles

Original Articles

Arthroscopy and Sports Articles

Original Articles

Original Article

Correlation between Component Size and Functional Knee Score in Patients Undergoing Bilateral Simultaneous Total Knee Arthroplasty: A Cross-Sectional Study

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Abstract

Background: Simultaneous bilateral total knee arthroplasty (simBTKA) has been a favored surgical solution to reduce costs and patient suffering. We aimed to evaluate the rate of asymmetry of component size in patients undergoing simBTKA and its impact on knee function as we believe that implant asymmetry may affect the functional outcomes in those patients. **Methods:** A cross-sectional study design was done on on 60 patients (120 knees) with simBTKA using patient-specific templating (PST). Patients were included if they had Kellgren–Lawrence Grade III-IV osteoarthritis. Revision surgeries, staged BTKA, or patients with bone defects, valgus deformity, severe varus deformity (defined as above 20°), and extra-articular deformities were excluded from the study. The outcome measures were interlimb component asymmetry, Knee Society Score (KSS), and range of motion (ROM). The comparison between pre- and postoperative findings was done using a dependent *t*-test. **Results:** A total of 29 (48.34%) patients had symmetrical femoral and tibial components, whereas the rest had asymmetry, of them, 11.7% had both femoral and tibial component size asymmetry. There were no statistically significant differences between the changes in KSS and ROM in the smaller implant and larger implant groups ($P = 0.5$ and $P = 0.4$, respectively). The total number of complications was eight and as follows: superficial infection, aseptic loosening, rupture of the patellar tendon after a bathroom fall, anemia requiring blood transfusion, residual varus deformity, deep venous thrombosis, periprosthetic fracture, and malalignment. **Conclusion:** There is no correlation between the interlimb component asymmetry and the knee function. However, there was statistically significant improvement from preoperative to postoperative KSS and ROM in small and large implants.

Keywords: Component size, functional knee score, total knee arthroplasty, patient-specific instrumentation

Introduction

Total knee arthroplasty (TKA) is the ultimate solution to knee osteoarthritis to increase quality of life.[1-3] With the advances in surgical technology, some surgeons have opted for a simultaneous bilateral TKA (simBTKA) rather than staged operations staged BTKA (staBTKA) due to the similar clinical outcomes and the reduced cost of simBTKA.[4]

Proper sizing of the femoral and tibial components has been associated with better long-term outcomes and survivorship, especially in simBTKA, which offers less chance of implant size asymmetry.[5,6] A mismatched flexion–extension gap can result from a femoral component of the wrong size. For instance, a femoral component of a small size may cause flexion instability, whereas a component of a large size may reduce the flexion space, causing postoperative loss of flexion and overstuffing of the patellofemoral joint, which causes pain in the knee.[7-9]

Still, there is little evidence about the benefit of simBTKA on implant size asymmetry between the two sides. We hypothesize that simBTKA can lead to more symmetric placement of implants between the two sides, which may decrease the rate of complications of BTKA. Subsequently, our aim in this study is

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to examine the effects of simBTKA on implant size asymmetry and the consequent complications of those surgeries.

Methods

Study design

After local ethical approval from the Institutional Review Board of the October 6 University (IRB-no. PCM-Me-2209024), we conducted this cross-sectional study at a single tertiary academic medical center (The Orthopaedic Department, Faculty of Medicine, October 6 University). The reporting of this study follows the Strengthening the Reporting of Observational Studies in Epidemiology checklist,[10] the version for cross-sectional studies [Supplementary Table 1].

Data collection

All patients had their simBTKA done by the same surgeon (MAH) from June 2019 to May 2022. Records from the Egyptian Community Arthroplasty Register (ECAR), which is a member of the International Society of Arthroplasty Registers, were obtained.

Sample size

The sample size was calculated based on Pinsornsak *et al*.'s in 2018 study who estimated that when the power of the study was 80% to detect the difference between the component sizes with standard deviations (SD) of 0.21 and a 5% one-sided Type 1 error.[11] Finally, we estimated that 60 patients will suffice for our purpose.

Inclusion/exclusion criteria

Patients were included if they had osteoarthritis of Grade 3-4 osteoarthritis according to Kellgren–Lawrence classification; underwent simBTKA; had complete recorded preoperative and postoperative alignment data, implant details (femoral and tibial components), Knee Society Score (KSS), and range of motion (ROM); and completed at least 6-month follow-up after the operation. Patients were, however, excluded if they had staBTKA, previous TKA, anteromedial knee osteoarthritis, extra-articular deformity, bone defects, valgus deformity, or severe varus deformity (defined as varus deformity of more than twenty degrees).

Operative procedure

In the preoperative period history, clinical examination, standing anteroposterior and lateral x-rays as well as preoperative deformities were measured, and a routine hematological workup was done. The difference between pre- and postoperative change in the KSS and ROM was calculated as delta (Δ).

Routine antibiotics prophylaxis was given before skin incision and then every 8 h for 24 h. The surgery was performed under a single anesthesia by the same surgical team. Neuroaxial anesthesia (spinal ± epidural) was the preferred anesthetic method, but general anesthesia was administered if the regional anesthesia was not achieved.

A standard medial parapatellar approach was used on all patients following the preoperative planning for patient-specific templating (PST). The size of the femoral component was decided to optimally match femoral anatomy and create balanced flexion and extension gaps. The proper tibial component sizing was also done meticulously to maximize the coverage of the resected surface and maintain proper component rotation. Finally, ligament balancing was checked, alignment of both legs was measured, and varus–valgus stability was tested. Follow-up assessment of KSS, ROM, and radiography was done at 6 months.

Outcome measures

The primary outcome was to detect the interlimb asymmetry in the component size in patients undergoing simBTKA. The secondary outcome measures were to assess the change in pre-and postoperative KSS and ROM. Furthermore, complications were reported.

Statistical analysis

Data were collected in an Excel sheet and kept in a safe place, statistical analysis using Statistical Package for the Social Science (SPSS)® Version 20 (IBM, Armonk, NY, USA), and component asymmetry among both knees were analyzed. Comparative analysis was carried out between cases either with component symmetry or asymmetry, individually in both the groups. Radiological and clinical data were analyzed as means and SD. A dependent sample *t*-test was used to analyze the difference between both sides in each patient and the change in ROM and KSS between symmetrical and asymmetrical joints. A $P < 5\%$ was considered statistically significant.

Results

The total number of included patients was 60 patients, with 120 knees, who underwent simBTKA. The mean age was 64 years with an SD of 7.5. The female-to-male ratio was 3:1. The mean varus, valgus, and fixed flexion deformities of the patients were 14 (SD = 6), 22 (SD = 8), and 12 (SD = 7) degrees [Table 1].

As for the component size symmetry, nearly half (n = 29, 48.3%) of the patients had symmetrical femoral and tibial components, whereas the rest had femoral and tibial, only femoral, or only tibial asymmetry [Table 2].

Table 1: Baseline characteristics of the included patients

	Total (n=60)
Age (years), mean±SD	64±7.5
Sex, *n* (%)	
Male	15 (25)
Female	35 (75)
Deformities (n=120), mean±SD	
Varus deformity angle	14±6
Valgus deformity angle	22±8
Fixed flexion deformity angle	12±7

SD: Standard deviation

Nearly, all patients (97%) had statistically significant improvement in KSS (P = 0.020), whereas only 82.5% had statistically significant improvement in arc ROM (P = 0.007). Naturally, the minimum and maximum ROM has also improved significantly (P < 0.001). Further details are provided in Table 3. In addition, no statistically significant differences were found between the KSS and ROM (P = 0.5 and P = 0.4, respectively) between the smaller and larger implants [Table 4].

Finally, only a few complications were reported, where the total number of complications was eight and are as follows: superficial infection, aseptic loosening, rupture patellar tendon after a bathroom fall, anemia requiring blood transfusion, residual varus deformity, deep venous thrombosis, periprosthetic fracture, and malalignment [Table 5].

Discussion

In this study, we aimed to evaluate the rate of asymmetry of component size in patients undergoing simBTKA and its impact on knee function. This is because we believe that the TKA prosthesis components must be properly sized to maximize stability and joint function. In our study, nearly half of the patients had implant size asymmetry between the two limbs. Most of the asymmetry originated from the tibial component, which took part in 38.4% of all asymmetries, whereas the femoral component was asymmetric in 25% of the limbs included in the study. Regardless, most patients (97%) had improvement in the KSS, and 82.5% had improvement in the arc ROM. Finally, out of the 120 knees, only eight reported complications, which were handled well, except for one (residual varus deformity that resulted in patient dissatisfaction).

A flexion–extension gap mismatch can be caused by several critical factors, one of which is an improperly sized femoral component, where an enlarged femoral component may reduce ROM, whereas a femoral component that is too small could cause flexion instability, which would then lead to a chronic effusion.[11]

Table 2: Component size asymmetry in the whole sample

Component symmetry	Total (n=60), n (%)
Symmetry in both femoral and tibial components	29 (48.3)
Asymmetry in the tibial component only	16 (26.7)
Asymmetry in the femoral component only	8 (13.3)
Asymmetry in both femoral and tibial components	7 (11.7)

Inadequate tibial component sizing can result in impingement of the popliteus tendon or iliotibial band which can lead to pain or tibial component internal rotation or lateral overhang. It is important to optimize patellofemoral tracking which is one of the main causes of postoperative pain.[12]

In another study by Brown *et al*. in 2001,[13] the authors reviewed 268 patients who underwent BTKA and reported less asymmetry rates of femoral (6.7%), tibial (1.1%), and patellar (0.3%) components. Similarly, Capeci *et al*. in 2006[14] reviewed 253 subjects with asymmetry rates of 8.7% in the femoral component, 6.7% asymmetry in the tibial component, and 5.1% in the patellar component. Third, Reddy *et al*. in 2011[12] revealed that the incidence of femoral and tibial component asymmetry was 9.3% and 8.6%, respectively. Pinsornsak *et al*. in 2018[11] reported that the incidence of asymmetric femoral components was less than 10%. Finally, Bajwa *et al*. in 2020[15] showed that the proportion of patients with component size imbalance, out of 100, in a subgroup of the Pakistani population component size asymmetry was detected in 20% of cases. As for the functional outcomes in the similar studies, no differences were found between both arms in all studies[5,11,13,14] but all patients had naturally better KSS and ROM postoperatively.

Moreover, in our study, we only had one concern which was about the safety and efficacy of simBTKA as many studies showed the increased incidence of complications when compared with staBTKA due to the increased intraoperative time.[16] However, most patients in our study tolerated the procedures well, and only a few complications were reported.

As a result, we believe that our findings may pave the way for a wider utility of simBTKA using PST or other templating technology. This is based on studies that have shown that PST can reduce intraoperative time.[17,18]

Limitations

Although this study may provide some aspects of simBTKA in a low-income setting, it still suffers from some limitations. The retrospective design (although it is a cross-sectional study) and the small sample size are the major limitations. The results were reviewed from a single center by the same surgeon, limiting the external validity of the study. Finally, the follow-up period was different in all patients.

Conclusion

SimBTKA using PST is considered a safe method for TKA in patients complaining of bilateral osteoarthritis, especially in

Table 3: The preoperative, postoperative, and percentage of patients with improvement in Knee Society Score, minimum range of motion, maximum range of motion, and arc range of motion

Total (n=120)	Preoperative	Postoperative	Percentage of improvement	P
KSS	32±10	97±9	97	0.020
Minimum ROM	12±7	1.3±3	ND	<0.001
Maximum ROM	92±1	118±11	ND	<0.001
Arc ROM	80±17	117±12	82.5	0.007

KSS: Knee Society Score, ROM: Range of motion, ND: Not determined

Table 4: The change in knee society score and range of motion according to the implant size

	Smaller implant	Larger implant	*P*
Δ KSS	67±10	67±11	0.5
Δ ROM	36±17	39±16	0.4

KSS: Knee Society Score, ROM: Range of motion

Table 5: The complications reported in the sample of knee

Complication Intervention	Total (*n*=120)
Superficial infection	1
Debridement and polyethylene exchange	
Aseptic loosening	1
Revision arthroplasty	
Rupture of patellar tendon after a fall in the bathroom	1
Plaster cast and follow-up	
Postoperative anemia requiring transfusion	1
Transfusion of two packs of RBCs	
Residual varus deformity that led to dissatisfaction	1
No intervention and follow-up	
Deep venous thrombosis after 3 months	1
Medical treatment	
Periprosthetic fracture after a month	1
Fixed by screws and plates	
Malalignment of the tibial component	1
No intervention and follow-up	

RBC: Red blood cell

developing countries. In this study, we found that nearly half of the patients who have undergone simBTKA had component size asymmetry between both knees. This is a crucial point to keep in mind before inserting the implant during BTKA, and every side should be considered a separate entity rather than using the measurements of one knee for the other one without revising the size. Further research is needed in this area in a prospective manner with the appropriate sample to study the incidence of component size asymmetry and its correlation with the functional outcomes.

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Conflicts of interest

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Supplementary Table 1: Strengthening the reporting of observational studies in epidemiology statement – checklist of items that should be included in reports of cross-sectional studies

	Item number	Recommendation	Page number
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	1
Objectives	3	State-specific objectives, including any prespecified hypotheses	1
Methods			
Study design	4	Present key elements of study design early in the paper	2
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	2
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	2
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	2
Data sources/measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	2
Bias	9	Describe any efforts to address potential sources of bias	2
Study size	10	Explain how the study size was arrived at	2
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	2
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	2
		(b) Describe any methods used to examine subgroups and interactions	NA
		(c) Explain how missing data were addressed	NA
		(d) If applicable, describe analytical methods taking account of sampling strategy	NA
		(e) Describe any sensitivity analyses	NA
Results			
Participants	13	(a) Report numbers of individuals at each stage of study – e.g., numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analyzed	2
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14	(a) Give characteristics of study participants (e.g., demographic, clinical, social) and information on exposures and potential confounders	2
		(b) Indicate number of participants with missing data for each variable of interest	NA
Outcome data	15	Report numbers of outcome events or summary measures	3
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included	NA
		(b) Report category boundaries when continuous variables were categorized	NA
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful period	NA
Other analyses	17	Report other analyses done – e.g., analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	3
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	3
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	3
Generalisability	21	Discuss the generalisability (external validity) of the study results	3
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	4

NA: Not available

Original Article

Functional and Radiological Outcomes of a Newly Introduced Modified Manual Cementation Technique Versus Second-Generation Technique in Primary Cemented Hip Arthroplasty

Abdoulrahman Elsayed Youssef, Mohamed Taha Mehanna, Mohamed Saleh Mustafa, Ayman Tawfik Henawy

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Abstract

Background: Hip arthroplasty is one of the most common reconstructive procedures done in adults.[1] The main purpose of this surgery is to eliminate pain, regain full extent of joint motion, maintaining hip stability, and improve the quality of life for patients. **Objectives:** This work aims to compare the clinical and radiological outcomes of two techniques; the second-generation cementation technique and a newly introduced modification of the manual technique in primary cemented hip arthroplasty. **Patients and Methods:** This prospective, randomized clinical trial included 44 patients. Patients were allocated into two equal groups: the case Group A; who had primary hip arthroplasty operation with the modified manual cementation technique and the control Group B; who had arthroplasty using the second generation cementation technique. The average follow-up period was about 12 months after the operation. Operation time, intraoperative parameters, postoperative clinical and radiological outcomes, and complications were compared between the two groups. **Results:** The operation duration was significantly longer in Group B (123.4 ± 9.0 vs. 107.5 ± 15.2, $P = 0.001$). No intraoperative complications were found among 77% while 13.6% showed allergic reaction to cementation 72% of them are in Group B, 6.8% needed blood transfusion, and 2.3% had pulmonary embolism on cementation. No significant difference between the two studied groups regarding postoperative Visual Analog Scale (VAS) score,[2] barrack grading,[3] complications and Harris hip score[4] at 3 months, 9 months, and 12 months was noted. **Conclusion:** In conclusion, this study concluded that Group A the newly introduced modified manual cementation technique might provide a cheaper and effective alternative to Group B the second-generation technique, with relatively less intraoperative complications and almost no difference in postoperative VAS, Harris hip score, and radiological outcomes over a period of 1-year follow-up.

Keywords: Barrack classification, cemented hip arthroplasty, comparative, Hip Harris score, intraoperative monitoring during cementation, modified manual technique, prospective study, radiological and clinical outcomes

Introduction

Hip arthroplasty is one of the most common surgeries nowadays. It covers a wide spectrum of ages, as hip arthroplasty is increasingly offered to young and active patients as well as to the elderly and less demanding ones with advanced osteoarthritis of the hip.[1]

Many factors affect the outcomes of this procedure. Femoral stem geometry and cementation technique are suggested as the most important among these factors.[5] And as any other operation, hip arthroplasty has its complications including: (intraoperative allergic reaction, pulmonary embolism, blood loss, infection, implant instability, peri-prosthetic fracture, thigh pain, implant loosening, and consequent loss of bone stock at revision surgery).

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Cementation techniques used in hip arthroplasty have developed over the years. The issue of whether these developments that involve an increase in operation time and expense will improve intraoperative complication rates, prosthesis survival is a matter of debate.

Aim of work

The aim of this study is to introduce a modification over the conventional manual cementation technique and to assess its effect on operation time, rate of intraoperative complications, its radiological and clinical outcomes in primary hip arthroplasty surgeries compared to second-generation cementation technique thus providing a cheaper and more simple alternative for second-generation cementation technique.

Patients and Methods

This prospective, randomized controlled trial study will be carried out in Suez Canal University Hospitals, Orthopedic Surgery Department. A total of 44 patients were allocated into two equal groups. subjects allocation was randomized to avoid any bias. Randomization of patients was done using computer-generated randomization by random allocation software into two groups: Group A (patients treated by newly introduced modified manual technique) and Group B (patients treated by second-generation technique) [Figures 1 and 2].

Study participants

Patients attending emergency and outpatient clinics of Orthopedic Surgery in Suez Canal University Hospitals in Ismailia are eligible for this study and all patients consented before operation and approval of IRB (Research 4979#) done, complying with the following inclusion and exclusion criteria:

Inclusion criteria

- Age: 50–85 years
- Gender: Both genders are included in the study
- Patients with femoral shape type C according to Dorr classification.[6]
- Patients with unilateral hip involvement that needs cemented total or hemi-arthroplasty.

Exclusion criteria

- Patients refusing intervention
- Body mass index (BMI) >35
- Bilateral involvement of both hips in the same patient
- Congenital bone abnormalities
- Previous hip surgery
- Patients with autoimmune diseases, blood diseases, and immune-compromised patients
- Patients with neurospasticity affecting the involved hip
- Loss of follow-up (<6 months postoperative follow-up).

Operative technique

Newly introduced modified manual cementation technique

After preoperative evaluation and preparation of the patients, the operation was done under general or spinal anesthesia.

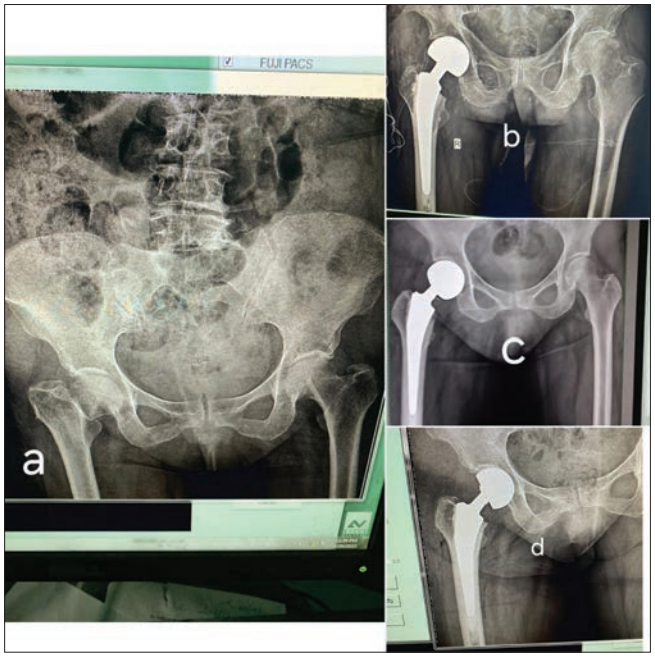

Figure 1: Radiological assessment and follow-up of a case from Group A (modified manual technique) A posterior-anterior plain X-ray of pelvis and both hips showing Right neck of femur fracture B postoperative follow-up day 1 showing Right cemented bipolar hip arthroplasty with barrack grading A C 3 months postoperative follow-up with no change in barrack grading D 12 months postoperative follow-up

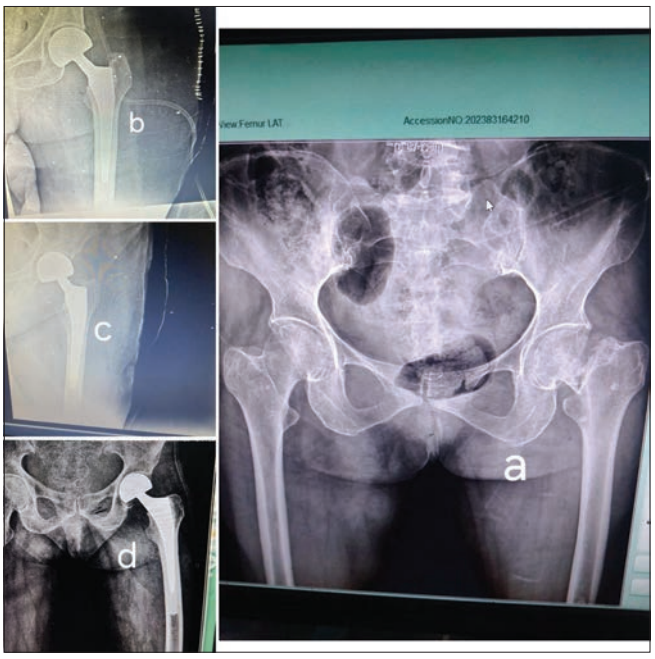

Figure 2: Radiological assessment and follow-up of a case from group B (second generation technique) A posterior-anterior plain X-ray of pelvis and both hips showing Left neck of femur fracture B postoperative follow-up day 1 showing Left cemented bipolar hip arthroplasty with barrack grading A C 3 months' postoperative follow-up with no change in barrack grading D 12 months' postoperative follow-up

Table 1: Sociodemographic data of the included groups

Variable	Group A (*n*=22), *n* (%)	Group B (*n*=22), *n* (%)	Total, *n* (%)	*P*
Age (years)				
Mean±SD	72.8±10.3	69.6±6.0	71.2±8.4	0.354
Median (range)	75 (55–85)	69 (61–80)	70 (55–85)	
Gender				
Male	10 (45.5)	9 (40.9)	19 (43.2)	>0.999
Female	12 (54.5)	13 (59.1)	25 (56.8)	
Occupation				
Retired	20 (90.9)	20 (90.9)	40 (90.9)	>0.999
Lawyer	1 (4.5)	0	1 (2.3)	
BMI (kg/m^2)				
Mean±SD	28.6±3.1	28.9±2.8	28.7±2.9	0.464
Median (range)	28.3 (23.6–34.5)	29.4 (23.4–34)	28.8 (23.4–34.5)	

SD: Standard deviation, BMI: Body mass index, *P*: *P* value is significant < 0.05. Student t test, Chi-square test, Fisher Exact test

Hip direct lateral approach.[7] preparation of proximal femur including: Reaming, insertion of cement restrictor; a synthetic plug, manual cement mixing,[8,9] introduction of a red Ryle tube connected to a suction device was kept inside the medulla, then inserting the cement by manual technique while the catheter inside creating a negative pressure to increase the engagement and even distribution of cement inside the medulla and reduce the risk of pulmonary embolism and cement allergic reaction. Red Ryle costs at time of the study 0.36 USD, on the other hand, Zimmer cement gun costs 35 USD [Figure 3].

The second-generation technique

Hip direct lateral approach, preparation of proximal femur including: Reaming, insertion of cement restrictor; a synthetic plug, manual cement mixing, retrograde insertion of cement via a cement gun.

Postoperative assessment

Immediately, after surgery, X-ray pelvis and both hips (anterior-posterior and lateral views); overnight stay for pain management, anti-coagulant, anti-inflammatory drugs, broad-spectrum antibiotic for 14 days postoperative.

Patients were assessed to evaluate functional and radiological assessment by using the Visual Analog Scale of pain (VAS), hip Harris score, and radiological assessment cement mantle through barrack grading.

Statistical analysis

Data were collected, revised, coded, and entered into the Spss Statistical Package for the Social Sciences (IBM SPSS) for windows, version 20.[10] The quantitative data were presented as mean, standard deviations, and ranges when their distribution was found parametric and median with inter-quartile range when their distribution was found nonparametric. Furthermore, qualitative variables were presented as numbers and percentages. The *P* value was considered significant as the following: $P > 0.05$: Nonsignificant, $P < 0.05$: Significant, $P < 0.01$: Highly significant.

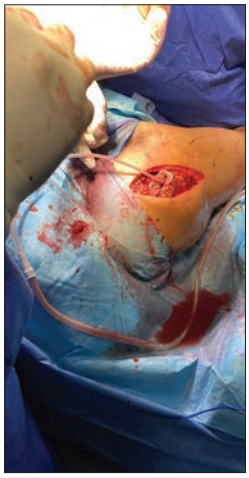

Figure 3: A red Ryle is inserted inside the medulla and connected to a suction device to allow applying negative pressure while manually inserting the cement thus, enhancing cement mantle and decreasing the intraoperative complications caused by reaming and cementation

Results

A total of 44 patients were included in this study, their sociodemographic data were collected and shown in Table 1. The mean age was 71.2 ± 8.4 years. There were 57% females and 43% males with mean BMI 28.7 ± 2.9 kg/m2. 91% of patients were retired and 75% were married. No significant difference was found between the two studied groups regarding basic characteristics. 54.5% of patients had right-sided affection and 45.5% of patients had left-sided affection. Fifty-two percent of patients (52%) had femur neck fracture and 47.7% of patients had osteoarthritis. No significant difference between the two studied groups regarding side and type of hip affection was noted. 31.8% of patients had no chronic illnesses, 29.5% of patients had hypertension, 25% had diabetes type 2, and 9% had both hypertension and diabetes type 2. Only 2.3% of patients had type 1 diabetes and 2.3% of them had chronic liver disease. had chronic liver disease.

Regarding preoperative evaluation; all the participants were type C by Dorr classification,[10] the mean preoperative VAS was 9.1 ± 0.8, cemented bipolar was done among 63.6%, and cemented total hip replacement (THR) was done among 31.9%. The mean preoperative Harris score was 66.8 ± 2.3. No significant difference was found between the two studied groups regarding preoperative VAS, implant decision and Harris hip score (HHS).

The operation duration was significantly longer in Group B (123.4 ± 9.0 vs. 107.5 ± 15.2, *P* = 0.001). No intraoperative complications were found among 77% while 13.6% showed allergic reaction to cementation 72% of them are in Group B, 6.8% needed blood transfusion, and 2.3% had pulmonary embolism on cementation.

The mean postoperative VAS score was 4.7 ± 0.3 at 3 months, 2.5 ± 0.2 at 6 months, 1.5 ± 0.2 at 9 months, and 1.5 ± 0.2 at 12 months with no significant differences between the two groups.

The mean postoperative hip Harris score was 90.1 ± 1.9 at 3 months, 91.4 ± 2.3 at 6 months, 92.5 ± 2.3 at 9 months, and 94 ± 1.4 at 12 months with no significant differences between the two groups.

Table 2: Pre- and post-operative assessment

Variable	Mean±SD		*P*
	Group A (*n*=22)	Group B (*n*=22)	
VAS score preoperative	9.3±0.7	8.9±0.8	0.113
HHS score preoperative	67.4 (63.5–70.3)	66 (62–70)	0.114
VAS score at 3 months	2.5±0.4	2.9±0.7	0.024*
HHS score at 3 months	89.9±1.8	90.3±1.8	0.598
VAS score at 6 months	1.5±0.2	1.8±0.2	0.991
HHS score at 6 months	91.9±2.5	90.8±1.9	0.145
VAS score at 9 months	1.5±0.2	1.7±0.2	0.317
HHS score at 9 months	92.6±2.5	92.4±1.9	0.561
VAS score at 12 months	1.3±0.2	1.6±0.2	>0.999
HHS score at 12 months	93.2±3.4	93.8±3.1	0.524
P (pre- and post-operative)	<0.001*	<0.001*	

HHS: Harris hip score, VAS: Visual Analog Scale, SD: Standard deviation

As shown in figure 4, day 1 postoperative VAS score showed significantly lower score among Group B compared to Group A (3.5 ± 0.5 vs. 4.2 ± 0.9, *P* = 0.035). There is no significant difference between the two groups regarding postoperative HHS score, VAS score, and barrack grading, as shown in Table 2.

Discussion

Hip arthroplasty is a common surgical procedure aiming to improve mobility and quality of life in patients suffering from hip pain.[11]

Adequate analgesia with minimal side effects allows for early postoperative mobility, optimal functional recovery, and decreased postoperative morbidity.[12]

Despite being a frequently performed surgical procedure, there is high variability in the peri-operative anesthetic and analgesic management for total hip arthroplasty.[13]

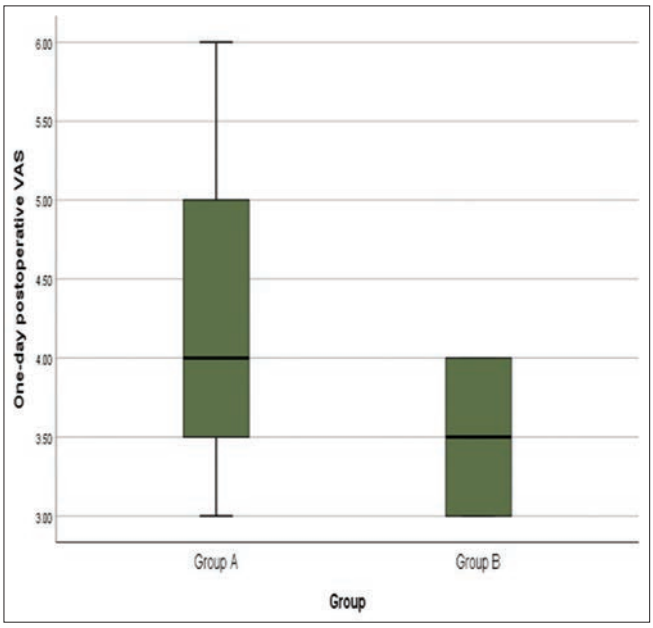

Figure 4: Shows day 1 postoperative assesment of pain via VAS score through Visual Analog Scale score among the two studied groups. VAS score was significantly lower among group B compared to group A (3.5 ± 0.5 vs. 4.2 ± 0.9, *P*= 0.035) at time of assessment

Table 3: Intra-operative data of the participants

Variable	Group A (*n*=22)	Group B (*n*=22)	Total	*P*
Operation duration (min)				
Mean±SD	107.5±15.2	123.4±9.0	115.7±14.7	0.001*
Median (range)	100 (90–138)	123.5 (110–138)	116 (90–138)	
Intra-operative complications, *n* (%)				
No	18 (81.8)	16 (72.7)	34 (77.3)	0.867
Allergic reaction to cementation	3 (13.6)	3 (13.6)	6 (13.6)	
Needed blood transfusion	1 (4.5)	2 (9.1)	3 (6.8)	
PE on cementation	0	1 (4.5)	1 (2.3)	

SD: Standard deviation, PE: Pulmonary embolism. The operation duration was significantly longer in Group B (123.4 ± 9.0 vs. 107.5 ± 15.2, P = 0.001). No intraoperative complications were found among 77% while 13.6% showed allergic reaction to cementation 72% of them are in Group B, 6.8% needed blood transfusion, and 2.3% had pulmonary embolism on cementation

As shown in Table 3; The operation duration was longer in Group B compared to GroupA(123.4 ± 9.0 vs. 107.5 ± 15.2, P = 0.001). Intraoperative patient parameters during cementation were more stable among Group A compared to Group B. This supports that the use of a negative intramedullary pressure produced by the catheter helps in creating a powerful suction force resulting in the fast and unified cement mantle layering inside the femoral component through duration less than the second-generation technique which needs more time for preparation. Further, less intraoperative complications were recorded in Group A versus Group B. This goes in line with Shukla *et al*., who stated that the mean operative duration was ranging from 82 to 110 min in THR and bipolar prosthesis groups, respectively.[14]

In our study, the mean preoperative VAS was 9.1 ± 0.8, as shown in figure 4, day 1 postoperative VAS score showed significantly lower score among Group B compared to Group A (3.5 ± 0.5 vs. 4.2 ± 0.9, P = 0.035). Three days postoperative, the VAS score was 0.9 ± 0.9 versus 1.7 ± 0.8 among Group A and B, respectively. On all the subsequent follow-up sessions, there was no significant difference between the two studied groups. This highlights one of the main objectives of hip arthroplasty procedures which are to reduce hip pain resulting from femoral neck fractures and hip osteoarthritis and to improve the quality of life for the patients. Nouri et al. reported that patients after total hip arthroplasty with cemented femoral component had the mean pain score was 2.73 preoperatively compared with 0.8 at the latest follow-up.[15]

The mean preoperative Harris score was 66.8 ± 2.3. Day 1 postoperative assessment, the HHS was 82.9 ± 2.1 and 84.3 ± 1.0 among Group A and B. On day 3 postoperative assessment, the HHS showed higher levels among Group B compared to Group A (84.9 ± 1.9 vs. 83.3 ± 3.1 respectively). No significant differences were recorded between the two groups regarding the hip Harris score. Hence, according to our study, based on the clinical evaluation of patients, both cementation techniques provide almost similar clinical outcomes that resemble the average HHS scores that are internationally expected in patients who underwent 1 ry cemented hip arthroplasty.

Conclusion

Our study concluded that Group A the newly introduced modified manual cementation technique might provide a cheaper and effective alternative to Group B the second-generation technique with relatively less intraoperative complications and almost no difference in postoperative VAS, HHS, and radiological outcomes over a period of 1-year follow-up.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Original Article

Trabecular Metal Augments for Reconstruction of Acetabular Bone Defects in Revision Total Hip Replacement: Short-Term Outcomes

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Abstract

Background: Revision hip surgeries are increasing dramatically nowadays, and achieving hip center of rotation is challenging. Obtaining a press-fit implant and restoring the hip's center of rotation might be difficult during the restoration of acetabular deformities during revision total hip arthroplasty (THA). **Aim:** The aim of the study was to evaluate the outcomes of using trabecular metal augments for reconstruction of the acetabulum in patients undergoing revision THA with short-term follow-up. **Patients and Methods:** This study was conducted in Benha University Hospital between April 2019 and March 2023. It is a prospective cohort study including 20 patients who are undergoing revision THA with acetabular defects. **Results:** The mean age of patients in this study was 59 years old. According to Paprosky classification: 45% of type 2B. The postoperative Oxford Hip Score showed marked improvement in the outcomes, the score was excellent in 55% (11 patients), good in 40% (8 patients), and fair in only 5% (1 patient) over 16 months' mean follow-up period. **Conclusion:** Due to its modularity, tantalum augments are considered a valuable method in the reconstruction of acetabular defects.

Keywords: Acetabular defects, Paprosky classification, trabecular metal augment

Introduction

The yearly number of revision hip surgeries and total hip arthroplasties (THAs) is increasing.[1] Obtaining a press-fit implant, bridging any bone abnormalities, and restoring the hip's center of rotation might be difficult during the restoration of acetabular deformities during revision THA. Various methods have been utilized to accomplish these goals. A suitable shell can provide sufficient stability for people with modest oval deformities. However, those with greater oval faults may require jumbo components to attain stability.[2]

Allografts, cemented shells, rings, or cages, high-center-of-rotation shells, cup-cage constructions, and elliptical shells are further approaches for reconstructing acetabular defects in revision THA. However, poor primary stability and host-bone contact below 50% may limit osseous fixation and cause early failure. The use of cages and reinforcement rings may fail due to breakage or loosening, while graft resorption and late failure may occur when allograft bone is utilized with earlier designs of acetabular components.[3]

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Antiprotrusio devices and cages, in conjunction with cemented acetabular components, have been used to treat these problematic conditions, but their mid- and long-term results have been poor. Custom triflange acetabular components from Zimmer Biomet are a promising option, especially in situations of chronic pelvic discontinuity.[4] However, this procedure is expensive, needs a 6-week manufacturing time, and may not match the original defect if bone loss happens during the removal of the old component.[5]

Various studies indicate that the use of modular trabecular metal augments (TMAs) combined with a porous tantalum acetabular component for severe acetabular bone loss has demonstrated encouraging mid-term effects.[5,6]

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Patients and Methods Preoperative Evaluation

A prospective cohort study was conducted in Benha University Hospital, including 20 patients undergoing revision THA with acetabular defects that necessitate reconstruction. A written consent was obtained, and the patients were informed about the surgical procedure.

Inclusion criteria: Patients who are undergoing rTHA with loose acetabular components with acetabular defects (Paprosky type II and type III "A, B")[7] that necessitate reconstruction. Exclusion criteria: Patient with pelvic discontinuity.

All patients were subjected to personal history, present illness history, past history, general examination, and local neurovascular assessment of the affected limb. Abductor muscle status was tested using the Trendelenburg test, and leg length discrepancy was evaluated. All patients were examined radiologically by X-ray and computed tomography scan to clarify the type of the defects. Laboratory assessments, including complete blood count, erythrocyte sedimentation rate, C-reactive protein, R.B.S, glycosylated hemoglobin, urine analysis, urea, and electrolytes, were done.

The study was done after being approved by the Institutional Ethics Committee of the Faculty of Medicine, Benha University (study code [MD 7-1-2020]).

The preoperative X-ray is very helpful in determining the type of augment that should be used; as achieving a good cup stability is the aim goal while placing the augment in the acetabulum. There are some common situations: when the acetabular rim is intact and the column defect is within 30 mm from the outer edge of the acetabular cup, the largest augment thickness will match that defect. One or two conventional wedge augments can be used to fill that defect.[8]

With an absent acetabular rim and the defect within 30 mm from the cup with a good bony bed, the wedge-shaped augment can be placed in a reverse manner. The flying buttress augments can be added to support the cup if the shear force on the augment is expected to be moderate, with minor column defects.[8]

In this study, wedge-shaped augments were used in the reconstruction of the acetabular defects in all patients.

Operative intervention

All patients were operated upon while lying in a lateral position. The patients received combined spinal (subarachnoid) anesthesia and epidural anesthesia. IV tranexamic acid (15 mg/kg) was taken routinely in the OR and intravenous antibiotic a double dose (2 g) of third-generation cephalosporin intravenously with the induction of anesthesia.

Through the posterior approach, old incisions were used whenever possible. However, skin incision was modified on many occasions to allow for a posterior approach or incorporate draining sinuses. The sciatic nerve was located and palpated frequently.

The scarred external rotators were detached and reflected posteriorly. The preceding acetabular component was removed along with debridement and excision of fibrous tissue.

Preparation of the bony bed for fixation of the augments using a curette or a reamer. Impaction bone grafting was used in five cases where the segmental defect was associated with a cavitary one (cases number 1, 3, 4, 7, and 12).

Cemented (Zimmer ZCA) high cross-linked all-poly cup (Longevity HCLP) was used in nine cases. Seven cases had MOP bearing and 36 mm head. The other two (cases 2, 9) had COP with 36 mm head. A cementless cup (Zimmer) was used in 11 cases. Eight of them had MOP bearing with 36 mm head and 2 cases had COP with 32 mm head and one case had COP with 36 mm head.

Closure of the wound by reattachment of the posterior soft tissues including short external rotators to the greater trochanter was done. The iliotibial band was then closed after the application of a suction drain. Skin closure using skin clips and sterile dressing was applied.

Postoperative care

The postoperative antibiotic regimen was given as ceftriaxone 2 g infusion every 24 h for 48 h. In the infected cases, antibiotics were given according to the results of intraoperative samples. Low-molecular-weight heparin 40 I.U. once daily started 12 h after the surgery and maintained for 1 month. Proton pump inhibitors were given till discharge. Hemoglobin concentration was assessed for every case at least 6 h after the last transfused blood unit. A blood transfusion was given if HB concentration was <9 g/dl.

Static quadriceps and hamstring exercises and straight leg raising exercises were encouraged from day one postoperative. The timing of postoperative partial weight bearing was variable according to the structural integrity of the acetabular reconstruction. Cases started full weight bearing at 6 weeks.

Postoperative evaluation clinical evaluation

All patients were followed up at 2 weeks, 6 weeks, 12 weeks, and 6 months, then annually thereafter to assess incision condition, ROM, and abductor strength. Patients progressed to full weight bearing at the 6 weeks.

Radiological evaluation

All postoperative patients received anteroposterior and cross-table lateral plain X-ray examinations at 2, 6, 12 weeks, 6 months, and subsequently annually. Moore's categorization system describes the radiographic indications of osseointegration in noncemented shells. Gross *et al*. updated this approach to assess the likelihood of osseointegration of the shell and augment build. According to this new categorization, augmentations are deemed unstable if there is more than 3 mm of migration from the early postoperative radiograph, a radiolucent line at the augment-bone interface, radiolucent lines surrounding all screws, or screw breakage.[12] The hip center of rotation (HCOR) following surgery is measured

relative to the inter-teardrop line and, if available, the contralateral natural HCOR.

Functional outcomes will be measured with Oxford Hip Score

The evaluation of complications was carried out, which encompassed complications that occurred during the operation, soon after the operation, and during the follow-up period.[9]

Statistical methods

For data management and statistical analysis, version 25 of SPSS (IBM, Armonk, New York, USA) was utilized. The normality of data was evaluated, and different statistical tests were performed depending on the kind of data and the number of groups being compared. Student's-*t*-test was utilized to compare the means of two sets of parametric data, whereas the Mann–Whitney *U*-test was utilized for continuous nonparametric data. Analysis of variance was used to compare more than two groups of parametric data, whereas the Kruskal–Wallis test was applied to continuous nonparametric data. Correlation between different parameters was examined using the Pearson and Spearman rank correlation coefficient (*r*) test. A $P < 0.05$ was deemed statistically significant (*S*).

Results

Patient characteristics

The 20 patients had revision components for a failed previous hip intervention with ages ranging from 49 to 70 years with a mean of 59 years. There were 12 males and 8 females. The infected cases underwent revision of the component after debridement with removal of the component and their laboratory study being negative. Patients were evaluated clinically using the Oxford Hip Score (OHS) and at the last follow-up.

The mean follow-up period was 18 months (range, 12–30 months). Paprosky classification was used to classify the acetabular defects, nine patients with Paprosky type 2B defect, six patients with Paprosky type 2C defects, and five patients with Paprosky type 3A defect. The body mass index (BMI) in the current study was 28.9 (range, 23.1–37.4) [Table 1].

Radiological results

All patients were radiographically examined for restoration of the center of rotation, inclination of the acetabular component, location of the stem, position of the TMA, repair of acetabular deformities, and evidence of osteointegration. The radiographs were acquired immediately after surgery and sequentially over the follow-up period.

All patients showed radiographic signs of osteointegration. According to Moore's classification of osteointegration, 3 cases showed 5 signs, 12 cases showed 4 signs and 5 patients had 3 signs of osteointegration. One patient (case 3) started to have a radiolucent line in zone 1; this line was stable and did not extend in the next follow-up visit.

IBG was observed in this series. It was used in five patients in combination with a cemented polyethylene cup. All cases show the incorporation of bone grafts and stable augments with osteointegration. RLL appeared in a single case (case 3) in zone 1 that did not progress or needed revision.

Functional results

OHS has improved in this study from 12.85 preoperatively to 38.9 at the latest follow-up visit. According to OHS grading, 11 cases (55%) were excellent at the last follow-up. Eight cases had a good result and one patient ended up with a fair result [Table 2].

Results of complications

There were 2 patients (10%) with postoperative infection for which debridement was done after 3 weeks with no recurrence of infection. One patient (case 3) started to have a radiolucent line in zone 1; this line was stable and did not extend in the next follow-up visit. It did not affect the result of the patient, which was excellent according to OHS grading. Another patient had sciatic nerve affection in the form of neurotmesis and the patient refused to do exploration. No dislocation occurred postoperatively.

Discussion

The reconstruction of acetabular bone defects encountered during revision hip arthroplasty is a challenging task for the surgeon, especially in large defects, Paprosky type II and III. A literature review confirms that a gold-standard surgical

Table 1: Patient's characteristics of the studied patients

Patient characteristic	Study group (*n*=20)
Age (mean)	49–70 years with mean of 59
Sex	
Male	12 (60)
Female	8 (40)
HTN	4 (20)
Medical history*	
DM	4 (20)
Rheumatoid	1 (5)
BMI, mean (range)	28.9 (23.1–37.4)
Paprosky classification	
2B	9 (45)
2C	6 (30)
3A	5 (25)
Follow-up duration/months, mean±SD (range)	18 (12–30)

*More than one disease in the same patient. SD: Standard deviation, BMI: Body mass index, HTN: Hypertension, DM: Diabetes mellitus

Table 2: Grading of Oxford Hip Score at last follow-up visit

OHS grade	Number of patient (%)
Fair	1 (5)
Good	8 (40)
Excellent	11 (45)
Total	20 (100)

OHS: Oxford hip score

Table 3: Comparison between the results of different studies[1,12-14]

	SF-12		OHS		HCOR		Signs of osseointegration
	Preoperative	Postoperative	Preoperative	Postoperative	Preoperative (mm)	Postoperative (mm)	
This study	29.5 (SD 5.2)	50.5 (SD 2.6)	12.85	38.9	VHCOR 38	VHCOR 22	Five patients (25%) showing five signs thirteen patients (65%) had four signs
Gross *et al*.[12]	-	-	15.4	37.7	-	-	Two constructs showed five signs of osseointegration, 13 showed four signs
Grappiolo *et al*.[13]	-	-	40*	90.5*	VHCOR 42.3	VHCOR 25.7	-
Lochel *et al*.[1]	-	-	55*	81*	-	-	Five signs of osseointegration in four hips, four signs in 29 hips
Whitehouse *et al*.[14]	-	-	-	-	VHCOR 48	VHCOR 28	-

*HHS was used. OHS: Oxford hip score, HCOR: Hip center of rotation, SD: Standard deviation, SF: Short form, VHCOR: Vertical hip center of rotation, HHS: Harris hip score

technique for the reconstruction of these defects is not agreed upon. The decision depends on type of the defect, available resources, and surgeon preference.

Historically, cages and rings were the standard practice during acetabular reconstruction; however, these methods fell out of favor with evidence of a high rate of complications and revisions contributed mainly to the fact that they are more difficult to implant and lack structural stability. Most of these implants have no potential for biological bone ingrowth and, thus, eventually, may lead to mechanical failure.[10]

TMAs have gained a lot of momentum in the management of moderate-to-severe acetabular bone defects, with a wide spectrum of sizes and shapes allowing customized reconstruction of the bony defect. The high coefficient of friction of tantalum contributes to primary stability, while the high three-dimensional porosity allows bony ingrowth and secondary biologic fixation. The TMAs has been approved to be a valid method in the reconstruction of moderate-to-severe acetabular bone defects.

Other currently utilized methods for acetabular reconstruction include impaction bone grafting and oversized components such as jumbo and bilobed cups.

Assessment of the short-term clinical outcomes for patients in this thesis showed marked improvement; the mean value of short-form 12 health survey (SF-12)[11] has increased from 29.5 (standard deviation [SD] 5.2; range 18.6–37.9) preoperatively to 50.5 (SD 2.6; range 45.4–55) postoperative. Mean OHS had improved from 12.85 (range 5–20) preoperatively to 38.9 (range 27–46) at the latest assessment. The stratification of OHS grading shows that 11 (55%) cases were excellent at the last follow-up. Eight cases had a good result, and one patient's outcome was fair.

The results of this study conform with other recent research [Table 3], Abolghasemian *et al*.[12] published his clinical results of 34 patients showing that the OHS increased from a mean of 15.4 points (6–25) before the revision to a mean of 37.7 (range 29–47) at the final follow-up of 9 years (68). Grappiolo *et al*.[13] prospectively followed up 55 patients for about 7 years with Paprosky type III defects, average HHS increased from 40 (range 27–52) preoperatively to 90.5 (range 61–100) postoperatively. Löchel *et al*. showed that HHS increased from a mean of 55 preoperatively to 81 points postoperatively after a mean of 10 years follow-up of 62 hips.[1]

The radiological assessment in this research showed improvement in restoration of the HCOR in most cases, the vertical distance between HCOR and teardrop was improved from a mean of 38 mm (range, 22–60) preoperative to a mean of 22 mm (range 11–35) postoperatively and the horizontal distance was restored from mean of 35 mm (range, 15–60) preoperative to mean of 30 mm (range 21–45) postoperatively.

The results of this cohort study are similar to the findings of Whitehouse *et al*.[14] who used TMAs for the reconstruction of acetabular defects in 56 patients and showed that the HCOR is restored in the majority of the patients. Preoperatively, the hip center was located at a mean of 48 mm above the inter-teardrop line (range, 29–77 mm). Postoperatively, the mean hip center was 28 mm (range 16–48 mm) above the inter-teardrop line.

The systematic review carried out by Xiong *et al*.[15] including 647 patients (655 hips) used TMA showed that the vertical distance between HCOR and teardrop was restored from a preoperative distance of 42 mm (range 22–96) to 22 mm (range 12–44) postoperatively and the horizontal distance was restored from a preoperative distance of 40 mm (range 15–86) to 35 mm (range 21–53) postoperatively). Grappiolo *et al*.[13] published similar results, the mean vertical position

of HCOR from the inter-teardrop line changed from a mean of 42.3 mm (range 22–63 mm) preoperatively to 25.7 mm (range 17–44 mm) postoperatively and the mean horizontal position of HCOR from the teardrop changed from 37.8 mm (range 15–61 mm) preoperatively to 39.2 mm (range 24–53 mm) postoperatively.

The evaluation of radiological signs of osseointegration, TMAs showed a good biological fixation as its porous surface configuration enabled rapid and extensive bone ingrowth of the host bone, and the structural reliability of the metal augment imparted by its inherent resistance to fracture and failure.[10] Almost all patients in this study showed satisfactory results to biological fixation, according to Moore's criteria, there was a minimum of three criteria of osseointegration in all patients; furthermore, there was five patients (25%) showed five signs, and thirteen patients (65%) had four signs.

These results conform with the previous research investigating the biological fixation of TMA, Abolghasemian *et al*.[12] showed that all 34 revisions of total hip replacement had good signs of osseointegration except for only two failed cases; according to Moore criteria, there were 5 signs of osseointegration in 2 constructs, 4 signs in 13, 3 signs in 13 constructs, and 2 showed 2 signs. One of the two patients received two augments. The radiological assessment showed cup migration, which was revised using cup-cage construct. The second patient was an elderly woman with pelvic discontinuity managed with an 80 mm shell and a column-buttress augment. The construct migrated after 6 months follow-up, but no intervention was done as the patient refused further surgeries. Löchel *et al*.[1] study in 62 hips with 10-year follow-up revealed excellent results after using TMA in the reconstruction of the acetabular defects; according to Moore's classification, there were 4 cups with 5 signs of osseointegration (7.5%), 29 cups with 4 signs (54.7%), 3 signs in 15 hips (28.3%), and 2 signs in 5 hips (9.5%).

Operative time is a key factor in revision THA, use of TMAs influenced the mean operative time due to its modularity and ease of application. In this study, the mean operative time was 210 min, and the mean blood loss was 800 cc.

There are variable methods of reconstruction of acetabular defects during revision THA. One of the popular methods is using impaction allograft with cemented polyethylene cups. Reconstruction with restoration of bone stock is one of the major advantages of this technique which is why it is commonly used in the young patients as multiple revision surgeries are anticipated and showed good results in the restoration of HCOR.[16] The drawbacks of this technique, require the availability of allografts/bone bank facilities. Risks include graft resorption and implant migration. The use of structural allografts to support the shell in the weight-bearing zone, or when >50% of the shell was supported by the allograft, showed poor survival of 55% at 7-year follow-up.[1] The series of Lee *et al*.[17] showed that reconstruction of defects which involve 30%–50% of the acetabulum using allografts, early failure was reported in about 30% of the hips at 15 years' follow-up.

Butscheidt *et al*.[18] prospectively followed up 23 acetabular reconstructions for an average of 10.3 (1.2–19 years) using impaction bone graft with morselized allograft, showed excellent ingrowth in 91.3% but complete remodeling was not observed and with large defects were associated with fibrosis which may compromise stability. Similar results were published by Schreurs *et al*.[19,20] After a follow-up 20–25 years, there was a good incorporation of the graft with the host bone, but the aseptic loosening was the major problem after long-term follow-up. van Haaren *et al*.[21] used impacted allograft combined with a metal mesh in 71 revised hips (68 patients) with AAOS type III or IV bone defect; 25 (24 patients) needed to be re-revised and were considered failures. In five hips, the reason for the re-operation was infection and 20 patients were aseptic loosening; the overall survival was 72% after mean follow-up of 7.2 years.

Jumbo cups are one of the popular methods to overcome large acetabular defects. The simplicity and the maximal surface contact between the cup and host bone, besides the reduction of the need for bone-grafting, and possible normalization of the HCOR are advantages of this technique. The drawbacks of Jumbo components are that the enlarged cephalad-caudal dimension may require reaming of the anterior column with an insult to the native bone to accommodate the cup, higher risk of aseptic loosening as no osseointegration and may cause impingement by the iliopsoas tendon.[22] Babis *et al*.[23] published the results after using jumbo cups in 62 patients and the aseptic loosening rates were about (30%).

This cohort study conforms with recent research showing that TMAs are a safe and efficient method in the reconstruction of acetabular bone defects with the reported complications are similar to short-term to medium-term outcomes reported in other series, good restoration of HCOR, and biologic fixation. Another potential advantage is shorter operative time compared to impaction bone grafting.

The limitations of this study include the absence of a control group, and there is significant case heterogenicity which could not be statistically normalized and a relatively small number of patients, as with many other series in the literature. Furthermore, short-term follow up "mean of 16 months" is inadequate to exclude late complications.

Complications

Occurred such as a patient had sciatic nerve affection in the form of neurotemesis and patient refused to do exploration. There were two patients with postoperative infection for which debridement was done after 3 weeks with no recurrence of infection. No dislocation occurred postoperatively. These results are close to the results of other studies.

Conclusion

The promising early results of using this technique for acetabular reconstruction convinced more surgeons to start using this system in revision surgeries. Given its modularity and the ability to reconstruct different types of defects with no

fear of bone resorption, porous metal augments are considered a valuable method in acetabular defect management. Augments are stable at short-term follow-up, can be used in different types of defects, is technically easy and there is no fear of resorption.

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Conflicts of interest

There are no conflicts of interest.

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Original Article

Short-Term Results after Reverse Total Shoulder Arthroplasty

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Abstract

Background: The loss of the shoulder's center of rotation is caused by massive rotator cuff tears, which can occur with or without arthritis and proximal humerus fractures that are nonunion or malunion. Because anatomical total shoulder arthroplasty cannot provide a stable center of rotation, reverse total shoulder arthroplasty (RTSA) is the appropriate procedure for these indications and in older patients who have primary glenohumeral osteoarthritis. Anatomical total shoulder arthroplasty carries a risk of failure because of the loosening of the glenoid component or cuff tear. The purpose of this study was to determine the short-term outcomes following RTSA in patients who had primary glenohumeral osteoarthritis, acute proximal humerus fractures, malunited or nonunited proximal humerus fractures, and massive cuff tears. **Materials and Methods:** This single-arm clinical trial (interventional study) was done in Ain Shams University Hospitals; 16 patients were included who underwent RTSA. Constant score, American Shoulder and Elbow Surgeon score, Visual Analog Scale score, and range of motion (ROM) were the short-term outcomes. Patients with cuff tear arthropathy, irreparable cuff tear with or without glenohumeral arthritis, elderly patients with unreconstructable proximal humerus fracture, proximal humerus fracture malunion or nonunion, and patients with glenohumeral osteoarthritis were included. Patients under the age of 50, as well as those with deltoid muscle dysfunction or injuries to the axillary nerve, were excluded. **Results:** There were 16 patients in this study, 8 of whom were male and 8 of whom were female. The follow-up period lasted 2 years following surgery, with a mean age of 64.19 years. The study included 7 patients with irreparable cuff tears one of them had associated anterior shoulder instability and recurrent anterior shoulder dislocation. One patient had a neglected shoulder dislocation, two patients had proximal humerus fracture dislocation, two patients had a nonunited proximal humerus fracture, three patients had unreconstructable proximal humerus fracture, and two had glenohumeral osteoarthritis. **Conclusion:** Not only did RTSA provide good clinical and functional outcomes for the standard indication of a massive cuff tear, but it also proved beneficial for other disorders such as primary glenohumeral osteoarthritis, nonunited fracture, and acute proximal humerus fracture. Among all indications, irreparable cuff tears yielded the highest results; nonunited fractures displayed the least improvement regarding clinical outcomes. Enhancements in the design of prostheses, the expertise of surgeons, and clinical outcomes are crucial to maximize their effectiveness in treating various shoulder disorders.

Keywords: Cuff tear arthropathy, fracture proximal humerus, glenohumeral osteoarthritis, massive cuff tear, non-united proximal humerus fracture, proximal humerus fracture mal-union, reverse total shoulder arthroplasty

Introduction

Rotator cuff arthropathy, with or without arthritis, humerus malunited or non-united fractures, and greater and lesser tuberosity resorption or loss in case of revision arthroplasty lead to loss of joint congruence and loss of action of the rotator cuff muscles as a stabilizer of the center of rotation.[1,2]

Because the head of a humerus migrates cranially when the deltoid muscle contracts during arm elevation, conventional total shoulder arthroplasty fails to maintain a stable center of rotation. In such cases, reverse total shoulder arthroplasty (RTSA) is an effective option for restoring function and relieving pain because it allows for the replacement of the articular surfaces and the restoration of a stable center of rotation.[3-6]

As a classic indication anatomical total shoulder arthroplasty is being indicated in cases with primary glenohumeral osteoarthritis with an intact cuff. Nonetheless, following total shoulder arthroplasty, loosening of the glenoid component

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remains a frequent cause of failure necessitating revision surgery. Hemiarthroplasty was the conventional course of treatment for individuals with cuff tear arthropathy. Regretfully, hemiarthroplasty for these indications led to variable pain relief outcome and minimal improvement in function or range of motion (ROM).[7]

Cuff tear arthropathy is the most common indication for RTSA, but it can also be used to treat a number of other indications that were difficult to treat with anatomical shoulder arthroplasty. These include tumors, immunological arthritis with intact or torn rotator cuff, glenohumeral osteoarthritis, fracture proximal humerus, chronic dislocations, and irreparable rotator cuff tears without osteoarthritis.[8-10] Neuropathic joint, nonfunctioning deltoid muscle, axillary nerve injury, and infection are among the conditions that are contraindications to the use of RTSA.[11]

Materials and Methods

Ethical review and study design

The Research and Ethics Committee of Ain Shams University approved the study with approval number (FWA 000017585 approval FMASU MD 50/2020). One arm clinical trial (interventional study) was conducted beginning in January 2020. Written informed consent was obtained from all patients.

The sample size was determined based on a study conducted by John *et al*., 2010[12] and using PASS 11.0.,[12] who stated that there was a statistically significant difference between the pre-and post-operative total constant score. Preoperative (19.0) and postoperative (29.5) and based on a power of more than 80% and a significant level of <0.5, a sample size of 16 patients will be enrolled in this study, 10% inflation of sample size was taken into consideration due to attrition problems in prospective study.

Level of evidence

One-arm interventional study.

Level three.

Implant and design of prosthesis

Zimmer trabecular metal reverses the shoulder system.

The neck shaft angle is 150°, humeral stem proximally coated nonporous coating, only system. The glenoid base plate is trabecular metal, it accepts two polyaxial screws with locking caps.

Inclusion criteria

All patients with massive irreparable cuff tears with or without glenohumeral arthritis and cuff tear arthropathy, are included, elderly patients with unreconstructable fracture proximal humerus, nonunited or malunited proximal humerus fracture, glenohumeral osteoarthritis, and failed shoulder arthroplasty were included.

Exclusion criteria

We excluded patients <50 years old. Patients who have nonfunctioning deltoid muscles or injuries to the axillary nerve. Patients with neuropathic joints or patients that have local infections.

Preoperative planning

The patients' preoperative clinical and radiological evaluation included recording their whole medical history, performing a thorough physical examination, and performing a local examination that included measuring their ROM, muscular atrophy, pain, and crepitus. Plain X-rays of the shoulder (complete series anteroposterior and true anteroposterior views), magnetic resonance imaging shoulder to evaluate rotator cuff, and computed tomography scan proximal humerus in case of fracture proximal humerus. Assessment of fitness for surgery, preoperative American Shoulder and Elbow Surgeon (ASES), and constant scoring were done preoperative, walch classification, Hamada classification were done, retroversion angle of glenoid and acromiohuemral distance were calculated preoperative.

Surgical procedures

RTSA through deltopectoral approach.

Surgical approach and technique

Deltopectoral approach skin incision. Then exposure of the deltopectoral groove. Identification of the long head of the biceps tendon, incision of rotator interval at the upper portion of the long head of the biceps tendon then tenotomy of the long head of the biceps tendon. Osteotomy of lesser tuberosity with subscapularis muscle attached. External rotation with extension of the humerus is applied to dislocate the joint. The intramedullary guide is inserted superiorly in line with shaft humerus entry point 1 cm behind the bicipital groove. Then cutting jig is slide over the reamer and adjusted to be at the cartilage-bone surface and retroversion at 10° retroversion. Humeral head cut using the saw. Then humeral preparation is done. Humeral stem trial was applied then retraction was done to begin glenoid preparation.

Exposure of the glenoid is necessary for proper reaming and component insertion. The proximal humerus is retracted posteriorly and inferiorly. Circumferential exposure of the glenoid with labral excision. Inferiorly, the glenoid must be exposed to allow palpation of the inferior glenoid pillar and inferior positioning of the glenoid base plate. Glenoid scraper is used to ream the glenoid then a 2.5 mm guide pin is used through the handle, it is centered anteroposterior, while it is aligned to the inferior border of glenoid and inserted while avoiding superior tilt, inferior tilt 10°–15° is done to decrease the risk of scapular notching. Drilling of the center hole by a cannulated drill to create a pilot hole for glenoid reamer is done. Reaming of glenoid by reamer then base plate reamer is used depending on which size of head is used, and then 2.5 guide wire is removed. The final glenoid preparation step is done by enlarging the center hole with the final drill. Base plate insertion is done by using base plate inserter by striking it using hummer until it is flush with the prepared surface. Two polyaxial screws for base plate one at the base of the coracoid and the other at substance of the scapular spine, the locking cap is used to engage screw in one direction. The hemisphere is applied using applicator and hummer. Passing nonabsorbable

suture (ETHIBOND) through holes medial to bicipital groove. Cementation of medulla by cement gun, then application of stem. Final insert applied. Closure of rotator interval using previously passed ethibond and reduction of lesser tuberosity and subscapularis muscle, tenodesis of the long head of biceps, and closure of rotator interval.

In the case of proximal humerus fracture, repair of greater and lesser tuberosities is performed by passing nonabsorbable suture (ethibond) through holes medial to, lateral to, and through bicipital groove before application of cement and final stem, then reduction and restoration of greater and lesser tuberosities are done using these sutures in tuberosities and closure of rotator interval using ethibond.

In the case of patients with multiple anterior dislocations and shoulder instability, humeral preparation and stem were applied in 20° retroversion instead of 10° to decrease the risk of anterior shoulder dislocation.

Reduction of lesser tuberosity and subscapularis muscle tendon was repaired and reattached in all cases.

Postoperative follow up

Every patient was monitored, and wound soaking, amount of drain, and the type of discharge were evaluated. On days 2 and 4 following surgery, the first and second dressing changes, respectively, were performed. It was recommended that all patients start physical therapy. The physiotherapy program was designed individually according to each patient's condition.

Functional outcomes and patient satisfaction using both ASES, constant scoring systems, Visual Analog Scale (VAS) score, and ROM were assessed preoperative, 3 months, 6 months, 12 months, and 24 months postoperative. Pxr also was done each visit.

Statistical analysis

Statistical package for social science (SPSS Inc., Chicago, IL, USA, 2001; version 15.0.1 for Windows). For quantitative parametric data, the presentation will be in the form of mean and standard deviation; for quantitative nonparametric data, it will be in the form of median and interquartile range. The qualitative data will be presented using frequency and percentage. The type of data obtained will determine the appropriate analysis to be performed. $P < 0.05$ is deemed significant.

Results

The clinical trial comprised 16 patients. The mean age is 64.19 ± 4.83. The follow-up period lasted 2 years following surgery. Eight of them were male, another 8 were females. Table 1 shows demographic data.

One of the seven patients, who had a major, irreparable cuff tear, also experienced recurring anterior dislocation and anterior shoulder instability. Three of the patients had an unreconstructable fracture proximal humerus, two had a proximal humerus fracture dislocation, two had a nonunited fracture proximal humerus, one had a neglected shoulder dislocation, and two had glenohumeral osteoarthritis. Table 2 shows diagnoses.

Glenoid Retroversion angle was calculated for all patients and the mean was 3.12. Walch classification was done for all patients and was A1 in five patients, A2 in two patients, B1 in two patients, B2 in five patients, and D in two patients. Hamada classification was done for 11 patients; it was 3 for two patients, 4A for two patients, 4B for three patients, and 5 for four patients. The glenohumeral distance was calculated

Table 1: Demographic data (*n*=16)

Parameter	Value
Age (years)	
Minimum–maximum	58.00–74.00
Mean±SD	64.19±4.83
Gender, *n* (%)	
Male	8 (50.0)
Female	8 (50.0)

SD: Standard deviation

Table 2: Diagnosis

Diagnosis	*n* (%)
Massive irreparable rotator cuff tear	6 (37.5)
Proximal humerus fracture	3 (18.8)
Proximal humerus fracture dislocation	2 (12.5)
Proximal humerus fracture nonunion	2 (12.5)
Glenohumeral osteoarthritis	2 (12.5)
Massive rotator irreparable cuff tear + anterior shoulder instability	1 (6.3)

Table 3: Clinical data

Criteria	Score
Retroversion angle	
Minimum–maximum	0.00–11.00
Mean±SD	4.25±3.26
Side, *n* (%)	
Right	7 (43.8)
Left	9 (56.3)
Hamada classification, *n* (%)	
3	2 (18.2)
5	4 (36.4)
4A	2 (18.2)
4B	3 (27.3
Walch classification, *n* (%)	
A1	5 (31.3)
A2	2 (12.5)
B1	2 (12.5)
B2	5 (31.3)
D	2 (12.5)
Acromiohumeral distance, *n* (%)	
<5	8 (72.7)
>6	3 (27.3)

SD: Standard deviation

for 11 patients and was <5 in eight patients and >6 in three patients. Table 3 shows clinical data.

The mean ASES score for eleven patients including patients with a massive irreparable cuff tear, proximal humerus fracture nonunion, glenohumeral osteoarthritis and massive irreparable cuff tear with anterior shoulder instability, and recurrent dislocation, (excluding proximal humerus fracture and fracture dislocation patients as preoperative scores can't be assessed for those patients) increased from 12.72 ± 4.72 preoperatively to 81.75 ± 10.47 at 2 years of postoperative follow-up, that yields a significant difference ($P < 0.001$). The mean constant score for 11 patients including patients who had diagnoses of an irreparable cuff tear, proximal humerus fracture nonunion, glenohumeral osteoarthritis and massive irreparable cuff tear with anterior shoulder instability, and recurrent dislocation, (excluding proximal humerus fracture and fracture dislocation patients as preoperative scores cannot be assessed for those patients) increased from 10.18 ± 6.16 preoperatively to 59.73 ± 14.35 at 2 years of postoperative follow-up, with a significant difference ($P < 0.001$). The mean VAS score for 11 patients including patients with a massive irreparable cuff tear, proximal humerus fracture non-union, glenohumeral osteoarthritis, and massive irreparable cuff tear with anterior shoulder instability and recurrent dislocation, (excluding proximal humerus fracture and fracture dislocation patients as we did not assess preoperative scores for those patients because it is always very high in acute trauma patients) decreased from 8.25 ± 0.63 preoperatively to 1.31 ± 0.95 at 2 years of postoperative follow-up, with a significant difference ($P < 0.001$).

Following an acute proximal humerus fracture, the mean ASES score for these patients was 83.26 ± 2.86 at 2 years' follow-ups, and postoperative gain was highly significant [Figure 1].

Patients with acute proximal humerus fractures were followed up for 2 years, the mean constant score was 63 ± 5.83, and the postoperative gain was highly significant.

At 2 years' follow-ups, the mean ASES score for patients with proximal humerus fracture dislocation was 84.90, and postoperative gain was highly significant.

In patients with proximal humerus fracture associated with shoulder dislocation, postoperative gain was highly significant with a mean constant score of 65 ± 1.41 at 2-year follow-ups.

In patients with massive irreparable rotator cuff tears, the mean ASES and constant scores increased significantly ($P < 0.001$) from 11.66 ± 3.94 preoperatively to 87.07 ± 2.86 and from 9.71 ± 6.18 preoperatively to 67.71 ± 4.72, respectively, at 2 years postoperative follow-up. The VAS score showed a significant difference ($P < 0.001$) from 8.00 ± 0.48 preoperative to 1.04 ± 0.71 at the final follow-up [Figure 2].

The mean ASES and constant scores for patients with proximal humerus fracture nonunion increased from 12.49 ± 8.22 preoperatively to 73.3 ± 7.07 and from 6.50 ± 6.36 to 44.50 ± 10.61, respectively, at 2 years postoperative follow-up,

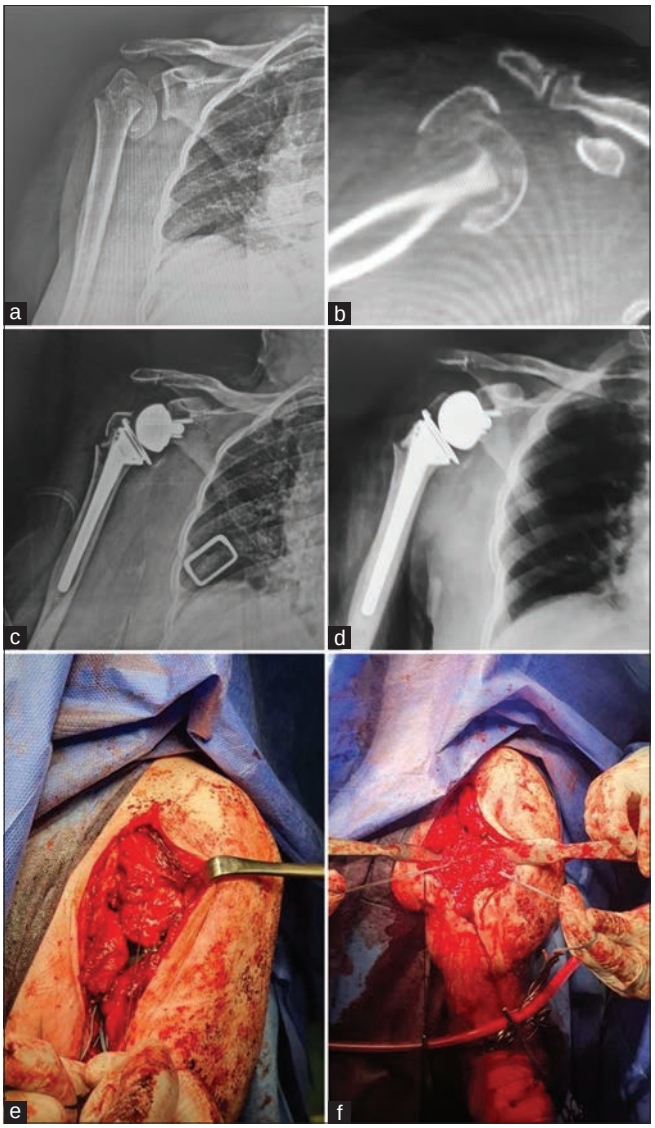

Figure 1: (a) Preoperative plain X-rays of patient with acute proximal humerus fracture, (b) preoperative Computed tomography scan, (c) postoperative X-rays, (d) last follow-up plain X-rays. (e) Sutures passed through holes medial and lateral to bicipital groove, (f) Reduction of both greater and lesser tuberosities

with significant difference ($P = 0.002$). While the VAS score decreased from 9.20 ± 0.28 preoperative to 2.50 ± 0.98 at final follow-up, with a significant difference ($P < 0.001$).

The mean ASES and constant scores for patients with glenohumeral osteoarthritis increased from 16.65 ± 4.74 preoperatively to 71.6 ± 21.21 and from 15.50 ± 4.95 to 56.5 ± 2.12 at 2 years postoperative follow-up, with a significant difference ($P = 0.02$). While the VAS score decreased from 8.20 ± 0.56 preoperative to 1.10 ± 1.27 at final follow-up, with a significant difference ($P = 0.002$) [Figure 3].

There was one case of anterior shoulder instability that had multiple anterior shoulder dislocations complicated with massive cuff tear and increased ASES from 16.6 preoperative to 84.9 at 2 years postoperative follow-up, while the constant

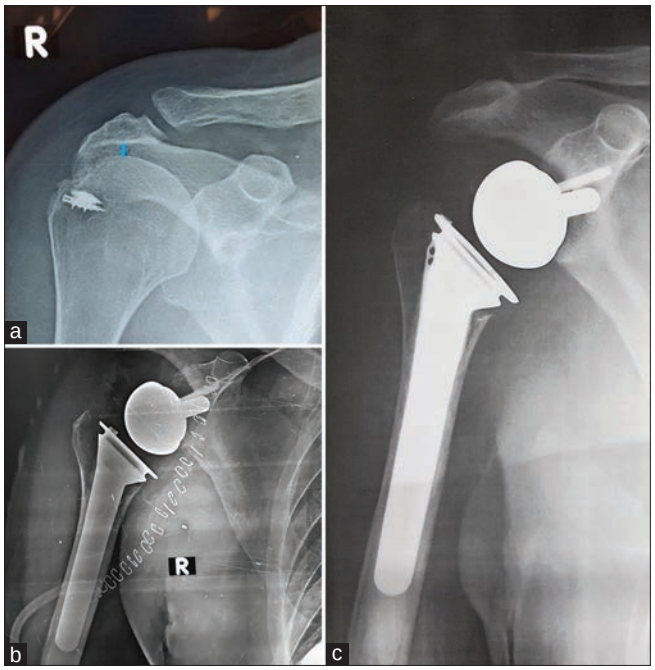

Figure 2: (a) Preoperative plain X-rays, (b) Postoperative X-rays of irreparable cuff tear patient, (c) last follow-up plain X-rays

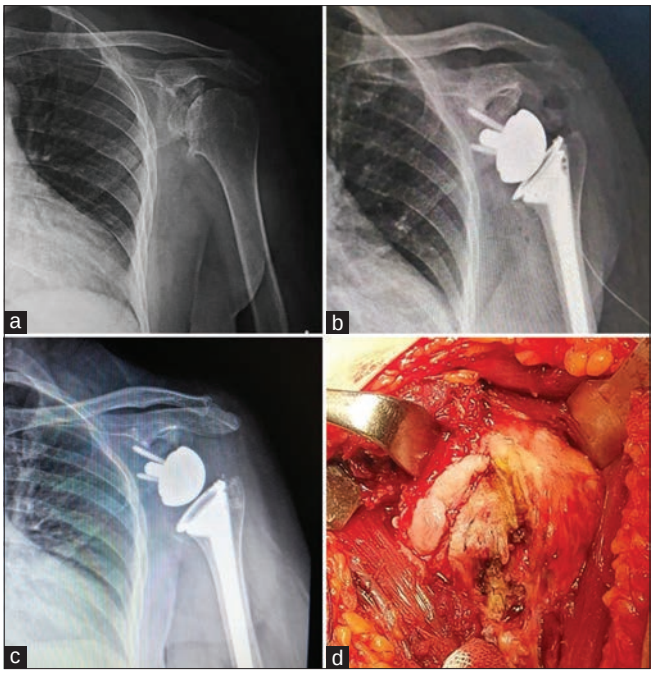

Figure 3: (a) Preoperative plain X-rays of patient with glenohumeral osteoarthritis, (b) Post-operative plain X-rays, (c) last follow-up plain X-rays, (d) Showing osteophytes around the head of humerus

score increased from 12 preoperative to 68 at 2 years follow-up. Meanwhile, at the final follow-up, the VAS score dropped from 7.20 to 0.

Patients with a neglected anterior shoulder dislocation and proximal humerus nonunion had increased ASES and constant scores from 18.3 preoperatively to 78.3 and from 11 preoperative to 52, respectively, at the final follow-up after 2 years. During the last follow-up, the VAS score decreased from 9.40 to 1.80.

The ROM for 11 patients including patients with a massive irreparable cuff tear, proximal humerus fracture nonunion, glenohumeral osteoarthritis and massive irreparable cuff tear with anterior shoulder instability and recurrent dislocation, (excluding proximal humerus fracture and fracture dislocation patients as preoperative ROM can't be assessed for those patients) showed an increase in forward flexion ROM from 39.91 ± 26.88 preoperatively to 121.09 ± 44.18 after 2 years during last follow-up assessment ($P = 0.001$). Active abduction for patients increased from 33.91 ± 17.43 preoperatively to 122.00 ± 29.17 during the last follow-up ($P < 0.001$), while external rotation for those patients increased from 7.5 ± 5.24 preoperatively to 18.00 ± 6.23 at final follow-up 2 years postoperative ($P = 0.002$).

Patients with massive irreparable cuff tears showed an increase of forward flexion ROM from 33.00 ± 21.99 preoperative to 143.43 ± 25.61 during the last follow-up ($P = 0.001$). Active abduction for those patients increased from 34.57 ± 17.99 preoperative to 133.86 ± 26.72 during the last follow-up ($P < 0.001$), while external rotation for those patients elevated from 7.71 ± 3.15 preoperative to 19.57 ± 7.04 at final follow up 2 years postoperative ($P = 0.01$).

Patients with acute proximal humerus fracture had active forward flexion at the final follow-up at 118.20 ± 24.75, abduction was 105.20 ± 19.02, and external rotation was 17.20 ± 6.76.

Patients with proximal humerus fracture dislocation had active forward flexion of 98.50 ± 3.50 at the final follow-up, abduction of 90.50 ± 1.50, and external rotation of 13.00 ± 1.00 at the final follow-up.

Patients group with proximal humerus fracture nonunion ROM improved as follows, active forward flexion improved from 40.00 ± 6.67 to 56.00 ± 5.74 at 2 years follow-ups, abduction from 21.21 ± 2.21 to 86.50 ± 17.68 during the last follow-up, while external rotation elevated from to 0–13.00 ± 4.24 at the 2-year assessment of follow-up.

From preoperative to 2-year follow-up, the patient with neglected shoulder dislocation improved in active forward flexion from 7 to 18, abduction from 6° to 74°, and external rotation from 0° to 14°.

At the final follow-up, patients with glenohumeral osteoarthritis showed increased abduction (from 44.50 ± 9.19 to 116.00 ± 18.38 at 2 years follow-up; $P = 0.06$), forward flexion (from 64.00 ± 25.46 to 108.0 ± 19.80), and external rotation (from 14.50 ± 2.12 to 17.50 ± 2.12).

At the 2-year follow-up, the patient with massive cuff tear and shoulder anterior instability showed remarkable improvement in ROM; flexion went from 10° to 175°, abduction from 15° to 172°, and external rotation went from 5° to 15°.

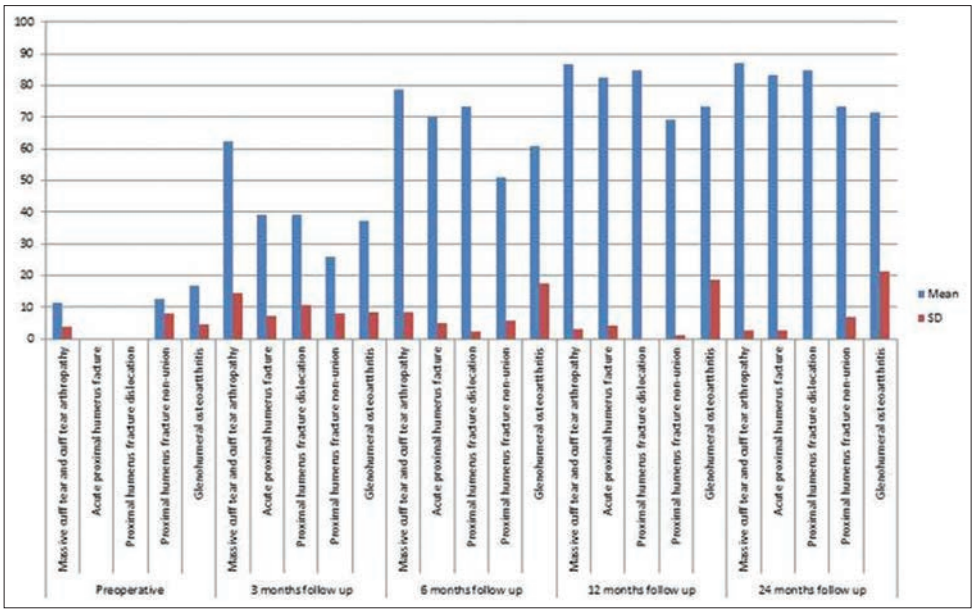

Figure 4: Showing American Shoulder and Elbow Surgeon score for all diagnoses

Tables 4-7 show the ASES scores, constant score, VAS score, and ROM, respectively.

Figures 4-6 show the ASES score, constant score, and VAS scores, respectively.

The improvement included all the score components, particularly pain relief and strength improvement, in patients with the diagnosis of irreparable cuff tear.

Patients with fracture proximal humerus and fracture dislocation scoring could not be preoperatively assessed.

The ROM and strength did not improve a lot but pain relief and overall function of the patients were better than preoperatively in case of proximal humerus fracture non-union.

Cases with glenohumeral osteoarthritis with intact cuff showed marked improvement in pain, strength, and function but the ROM did not increase far more than that before the operation.

The most pronounced pain relief, increased ROM, and improved strength were in patients that had a diagnosis of massive irreparable cuff tear.

As regards complications one case of dislocation was detected who hemisphere revision and plastic needed inserted with a larger size that made the patient stable. This case was a case of RTSA after proximal humerus fracture nonunion. No other complications were reported.

Discussion

The role of RTSA is to achieve a stable center of rotation to provide functional restoration of the shoulder joint depending only on functioning deltoid muscle. Classically, it was used for patients with the diagnosis of irreparable cuff tear but then the indications had been expanded to include fracture proximal humerus and fracture dislocation, nonunited proximal humerus fracture, and glenohumeral osteoarthritis in the elderly, and outcomes were surprisingly good.

Functional improvement increased the most in flexion and abduction, but not in external rotation, which did not significantly improve.

Fifty-nine patients with an average age of 70 were included in the Stechel *et al*.[13] study, which had a mean follow-up of 4 years. Revision of a failed arthroplasty, fracture sequelae, and cuff tear arthropathy were among the indications. The constant score increased from 15 to 55 for the entire patient group, from 26 to 74 for cuff tear arthropathy, and from 12 to 48 for fracture sequelae in the usual follow-up.

All of the constant score's components were improved, especially the strength and pain relief. The group with cuff tear arthropathy experienced the greatest degree of pain relief and strength gain. Concerning complications, there were three occurrences of dislocation, one of acromion fracture and one of coracoid process fractures, and two disconnections of the shaft components because of the severe scapular notching. Five cases were found to have infections. Two patients experienced transient neurological impairments.[13]

These results agree with our study results because the constant score increased and pain relief improved in our study and the best improvement of score was in massive irreparable cuff tear patients. In our study, the only complication was dislocation in a patient with RTSA after proximal humerus fracture nonunion and treated by open reduction and plastic insert revision.

With 97 patients, Kim *et al*.[14] listed the following conditions as indications: rheumatoid arthritis, posttraumatic arthritis, primary osteoarthritis, major rotator cuff tears without

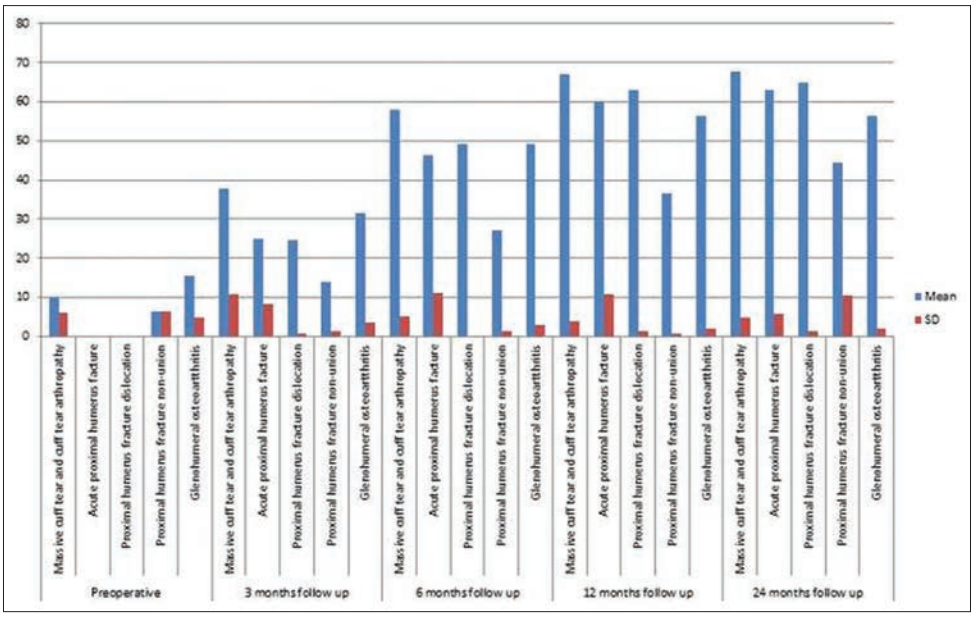

Figure 5: Showing constant score for all diagnoses

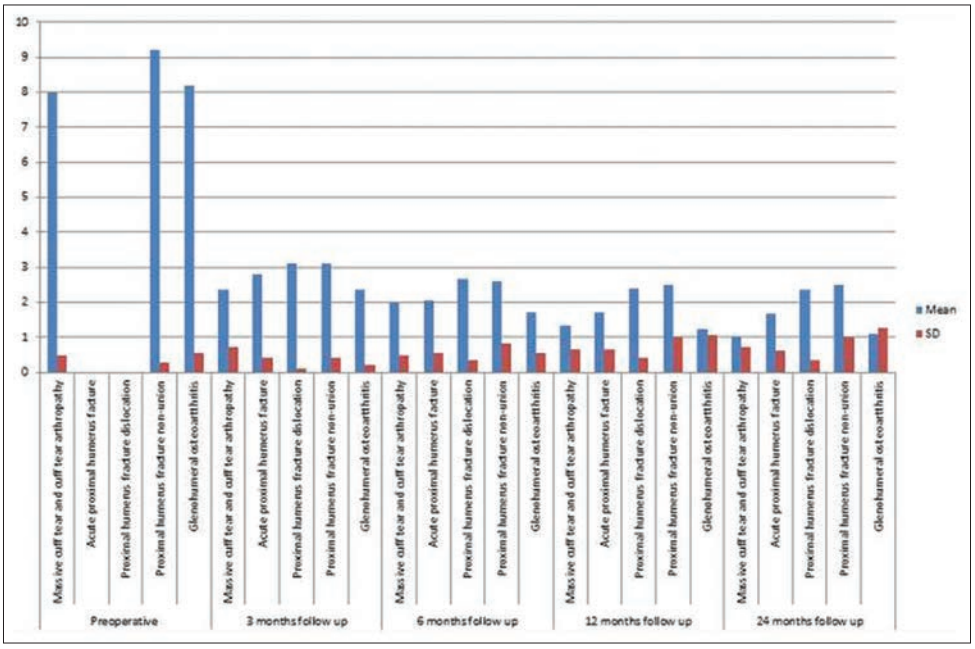

Figure 6: Showing visual analog scale score for all diagnoses

glenohumeral osteoarthritis, cuff tear arthropathy, and arthritis brought on by infection sequelae.

The patients were 68.9 years old on average. The follow-up period was 48.4 months on average. The average constant score improved from 35.4 points preoperatively to 57.8 points at the 2-year postoperative follow-up. Compared to patients with a cuff tear, patients undergoing RTSA for rheumatoid arthritis demonstrated better functional outcomes. On the other hand, patients with posttraumatic arthritis, primary osteoarthritis, and arthritis due to infection sequelae showed worse results.[14]

These results agree with our study as patients with massive cuff tears showed improvement in the constant score that was superior to patients with primary glenohumeral osteoarthritis.

In the study by Shields *et al*.,[15] results from 173 shoulders were analyzed 163 patients' shoulders were used, with 10 of the individuals having bilateral shoulders. It was 68 years old on average. Preoperative, the average ASES score was 33. It rose to 80 at the 1-year assessment, but no further improvements were noted during the 2-year follow-up (ASES 81).[15] This agreed with our study as preoperative ASES was 12.72 ± 4.72

Table 4: American shoulder and elbow surgeon for all diagnoses

	Preoperative					3 months follow up					6 months follow up		
	Massive cuff tear and cuff tear arthropathy	Acute proximal humerus facture	Proximal humerus fracture dislocation	Proximal humerus fracture non-union	Glenohumeral osteoartthritis	Massive cuff tear and cuff tear arthropathy	Acute proximal humerus facture	Proximal humerus fracture dislocation	Proximal humerus fracture non-union	Glenohumeral osteoartthritis	Massive cuff tear and cuff tear arthropathy	Acute proximal humerus facture	Proximal humerus fracture dislocation
Mean	11.66	NA	NA	12.49	16.65	62.34	39.28	39.1	25.8	37.45	78.74	69.94	73.25
SD	3.94	NA	NA	8.22	4.74	14.39	7.12	10.61	8.2	8.27	8.63	4.84	2.33

	6 months follow up		12 months follow up					24 months follow up				
	Proximal humerus fracture non-union	Glenohumeral osteoartthritis	Massive cuff tear and cuff tear arthropathy	Acute proximal humerus facture	Proximal humerus fracture dislocation	Proximal humerus fracture non-union	Glenohumeral osteoartthritis	Massive cuff tear and cuff tear arthropathy	Acute proximal humerus facture	Proximal humerus fracture dislocation	Proximal humerus fracture non-union	Glenohumeral osteoartthritis
Mean	50.8	60.8	86.83	82.58	84.9	69.1	73.3	87.07	83.26	84.9	73.3	71.6
SD	5.94	17.68	2.98	4.35	0	1.13	18.81	2.86	2.86	0	7.07	21.21

Table 5: Constant scoring for all diagnoses

	Preoperative					3 months follow up					6 months follow up	
	Massive cuff tear and cuff tear arthropathy	Acute proximal humerus facture	Proximal humerus fracture dislocation	Proximal humerus fracture non-union	Glenohumeral osteoartthritis	Massive cuff tear and cuff tear arthropathy	Acute proximal humerus facture	Proximal humerus fracture dislocation	Proximal humerus fracture non-union	Glenohumeral osteoartthritis	Massive cuff tear and cuff tear arthropathy	Acute proximal humerus facture
Mean	9.71	NA	NA	6.5	15.5	37.71	25	24.5	14	31.5	58	46.2
SD	6.18	NA	NA	6.36	4.95	10.84	8.28	0.71	1.41	3.54	5.16	11.03

	6 months follow up		12 months follow up					24 months follow up				
	Proximal humerus fracture non-union	Glenohumeral osteoartthritis	Massive cuff tear and cuff tear arthropathy	Acute proximal humerus facture	Proximal humerus fracture dislocation	Proximal humerus fracture non-union	Glenohumeral osteoartthritis	Massive cuff tear and cuff tear arthropathy	Acute proximal humerus facture	Proximal humerus fracture dislocation	Proximal humerus fracture non-union	Glenohumeral osteoartthritis
Mean	27	49	67.14	59.8	63	36.5	56.5	67.71	63	65	44.5	56.5
SD	1.41	2.83	3.85	10.73	1.41	0.71	2.12	4.72	5.83	1.41	10.61	2.12

Table 6: Visual Analog Scale scoring for all diagnoses

	Preoperative					3 months follow up					6 months follow up	
	Massive cuff tear and cuff tear arthropathy	Acute proximal humerus facture	Proximal humerus fracture dislocation	Proximal humerus fracture non-union	Glenohumeral osteoartthritis	Massive cuff tear and cuff tear arthropathy	Acute proximal humerus facture	Proximal humerus fracture dislocation	Proximal humerus fracture non-union	Glenohumeral osteoartthritis	Massive cuff tear and cuff tear arthropathy	Acute proximal humerus facture
Mean	8	NA	NA	9.2	8.2	2.37	2.8	3.1	3.1	2.35	1.97	2.06
SD	0.48	NA	NA	0.28	0.56	0.71	0.42	0.1	0.42	0.21	0.47	0.56

	6 months follow up			12 months follow up					24 months follow up				
	Proximal humerus fracture dislocation	Proximal humerus fracture non-union	Glenohumeral osteoartthritis	Massive cuff tear and cuff tear arthropathy	Acute proximal humerus facture	Proximal humerus fracture dislocation	Proximal humerus fracture non-union	Glenohumeral osteoartthritis	Massive cuff tear and cuff tear arthropathy	Acute proximal humerus facture	Proximal humerus fracture dislocation	Proximal humerus fracture non-union	Glenohumeral osteoartthritis
Mean	2.65	2.6	1.7	1.34	1.7	2.4	2.5	1.25	1.04	1.68	2.35	2.5	1.1
SD	0.35	0.84	0.56	0.66	0.64	0.4	0.98	1.06	0.71	0.61	0.35	0.98	1.27

Table 7: Range of motion for all diagnose

	Preoperative														
	Flexion					Abduction					External rotation				
	Massive cuff tear and cuff tear arthropathy	Acute proximal humerus facture	Proximal humerus fracture dislocation	Proximal humerus fracture non-union	Glenohumeral osteoartthritis	Massive cuff tear and cuff tear arthropathy	Acute proximal humerus facture	Proximal humerus fracture dislocation	Proximal humerus fracture non-union	Glenohumeral osteoartthritis	Massive cuff tear and cuff tear arthropathy	Acute proximal humerus facture	Proximal humerus fracture dislocation	Proximal humerus fracture non-union	Glenohumeral osteoartthritis
Mean	33	NA	NA	40	64	34.57	NA	NA	21	44.5	7.71	NA	NA	0	14.5
SD	21.99	NA	NA	46.67	25.46	17.99	NA	NA	21.21	9.19	3.15	NA	NA	0	2.12

	final follow up														
	Flexion					Abduction					External rotation				
	Massive cuff tear and cuff tear arthropathy	Acute proximal humerus facture	Proximal humerus fracture dislocation	Proximal humerus fracture non-union	Glenohumeral osteoartthritis	Massive cuff tear and cuff tear arthropathy	Acute proximal humerus facture	Proximal humerus fracture dislocation	Proximal humerus fracture non-union	Glenohumeral osteoartthritis	Massive cuff tear and cuff tear arthropathy	Acute proximal humerus facture	Proximal humerus fracture dislocation	Proximal humerus fracture non-union	Glenohumeral osteoartthritis
Mean	143.43	118.2	98.5	56	108	133.86	105.2	90.5	86.5	116	19.57	17.2	13	13	17.5
SD	25.61	24.75	3.5	53.74	19.8	26.72	19.02	1.5	17.68	18.38	7.04	6.76	1	4.24	2.12

and increased to 81.15 ± 10.24 at the 2-year follow-up to all patients excluding acute trauma patients.

Otto *et al*.[16] tracked out 67 individuals under the age of 55 who had undergone RTSA. The patients were split into two groups: group 1 included 35 patients who had undergone failed arthroplasty, while Group 2 included 32 patients who had primary RTSA. Group 1's ASES score increased from 24.4 to 40.8, while Group 2's ASES score increased from 28.1 to 58.6. Patient satisfaction did not differ between the groups. Comparing the preoperative and postoperative function of both groups in terms of ROM and ASES scores, the improvements were comparable.[16] In our study, ASES improved from 12.72 ± 4.72 preoperatively to 81.75 ± 10.47 at the final follow-up with a global postoperative gain that is significant ($P < 0.001$).

Forty-one primary RTSA patients with morbid obesity were reviewed by Statz *et al*.;[17] their mean age was 67.7 years and their mean body mass index was 44 kg/m^2. Nighty-three percent of the patients were postoperatively satisfied. The average postoperative ASES score was 71.1. Three postoperative complications required revision, including two patients with infection and one patient with humerus loosening.[17]

In our study, ASES (for all patients excluding patients with acute proximal humerus fracture) improved from 12.72 ± 4.72 preoperatively to 81.75 ± 10.47 at final follow-up with a global postoperative gain that is significant ($P < 0.001$).

A retrospective study of 27 patients with complicated proximal humerus fractures was conducted by Jonušas *et al*.[18] The age median was 67.5 years. Forty-five months was the average follow-up period. After the procedure, all 27 patients were able to resume their regular schedules for work and recreation. About 57.6 was the mean constant score. During X-ray analysis, one patient had tubercle malposition. The patient receives a constant score of 80.2 and is happy. There were two incidences of heterotopic ossification and no apparent scapular notching in the last patient group. Furthermore, there were no documented indications of infection, loosening, or breakage of the prosthesis.[18]

This is congruent with our study, wherein patients with unreconstructable fracture of the proximal humerus had a final constant score of 63.00 ± 5.83, while patients with fracture dislocation of proximal humerus had a constant score at the final follow-up of 65.00 ± 1.41, and all of them were satisfied and able to get back to their work.

Muh *et al*.[19] conducted a retrospective multicenter review that comprised 66 patients, or 67 RTSAs, with a mean age of 52.2 years. The indications included rheumatoid arthritis, posttraumatic arthritis, failed primary shoulder arthroplasty, massive rotator cuff dysfunction with osteoarthritis, and other illnesses. Nineteen out of the 22 patients who had not had surgery before had an irreparable rotator cuff tear. The three patients who did not have a surgical history experienced proximal humerus nonunion, significant posttraumatic arthritis, impaired rotator cuff function, and pseudoparalysis. The ASES score increased to 72.4 ± 12.75 from 40.0 ± 16.71. Active forward elevation, active external rotation, and ASES scores improved from 34.8 ± 15.9 to 76.7 ± 11.2 in patients without prior surgery. In addition, active forward elevation, active external rotation, and ASES scores improved from 42.8 ± 16.6 to 70.2 ± 13.1 in patients who had previously undergone surgery. The analysis revealed a negative relationship between changes in ASES ratings and the frequency of previous surgical procedures.[19]

In our study, the patients with prior surgery showed inferior results than patients without prior surgery regarding ASES score improvement.

Seidl *et al*.[20] evaluated the results of patients with proximal humerus fractures who had acute RTSA against those who received an alternate initial treatment before needing (secondary) RTSA, involving a total of 47 patients. Patients were split into two groups: 15 patients in the acute group (RTSA of <4 weeks after fracture) and 32 patients in the secondary group. Hemiarthroplasty, open reduction internal fixation (ORIF), and nonoperative treatment comprised the secondary RTSA group.[20] In the analysis of postoperative outcome scores, the average ASES score for the acute RTSA group was 77.0, but the average score for the secondary RTSA group was 72.4. Within the secondary RTSA group, subgroup comparisons revealed that the average ASES for individuals who had undergone hemiarthroplasty, nonoperative treatment, or ORIF treatment were 69.2, 72.6, and 76.4, respectively.

In our study, patients with acute proximal humerus fracture (as patients in the primary group in Seidl *et al*.[20] study) showed superior results to those who had RTSA after another treatment or after conservative management for proximal humerus fracture (as the secondary group in Seidl *et al*.[20] study). As ASES for patients with RTSA after acute proximal humerus fracture was 83.26 ± 2.86 at the final follow-up, while for two patients with RTSA after ORIF or nonoperative management of proximal humerus fracture was 73.30 ± 7.07 at the final follow up. On the contrary in our study, a patient with previous conservative treatment showed an ASES score of 78.30, while the patient who was previously treated with ORIF showed an ASES score of 68.3 at the final follow-up.

Yoon *et al*.[21] included 35 patients, including 25 cuff tear arthropathy and 10 irreparable cuffs with a mean age of 74.77 years. Results showed an increased ASES score from 41.91 to 71.83, as well as an increased constant score from 42.59 to 74.75.[21]

This study is congruent with our study that showed patients with massive irreparable cuff tears had increased ASES scores from 12.72 ± 4.72 preoperatively to 81.75 ± 10.47 at the final follow-up.

There are various restrictions on our study. These include a brief follow-up period and the lack of allocation concealment. The study was conducted in a single facility in a developing nation; the majority of the patients treated there are from lower socioeconomic classes, which may have limited the

applicability of the findings. We tried to use the no inferiority hypothesis to identify the clinical outcomes postoperatively to address the issues brought on by the small sample size. In addition, we made an effort to reduce confounding variables by gathering data prospectively from every patient. Furthermore, all procedures were completed during a short period, and the surgical staff and equipment remained the same throughout.

Conclusion

Satisfactory clinical and functional results were obtained with RTSA. Not just for the classic indication of a large cuff tear, but also for additional conditions such as primary glenohumeral osteoarthritis, fracture nonunion, and acute proximal humerus fracture. Of all the criteria, irreparable cuff tears had the best results; nonunited proximal humerus fracture resulted in the least improvement regarding clinical outcomes. To best treat various shoulder diseases, therefore, advancements in prosthesis design, surgeon experience, and clinical outcomes were still required.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Original Article

Functional Outcome of Patients with Malignant Tumors around the Knee Treated by Modular Endoprosthesis: A Comparative Study between Patellar Resurfacing and Nonresurfacing

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Abstract

Background: Patellar resurfacing with knee arthroplasty has always been controversial. The literature contains data that support both resurfacing and not resurfacing the patella. However, the literature does not review a lot of studies that address the impact of patellar resurfacing on the functional outcome following resection of distal femur tumors and limb salvage using modular prosthesis. **Questions/Purposes:** Is patellar resurfacing better than nonresurfacing as regards functional outcome of modular prosthesis used for the treatment of tumors around the knee? **Patients and Methods:** Two groups of patients; both were subjected to wide excision of tumors around the knee and limb salvage using modular prosthesis. The first group underwent reconstruction with patellar resurfacing, while the second underwent reconstruction without patellar resurfacing. The age of these groups of patients ranged from 11 to 71 years. The patients were 17 males and 19 females. We evaluated patients using the musculoskeletal tumor society scoring system (MSTS), knee society final score, knee society function score, and anterior knee pain score. **Results:** We found that MSTS functional score, knee society final score and knee society function score, and anterior knee pain score were all better in patients who underwent patellar resurfacing compared to nonresurfacing patients. However, only the difference in anterior knee pain score was statistically significant ($P = 0.030$). Differences in other scores between these two groups were all statistically insignificant (P value of the MSTS difference = 0.103, P value of the knee society final score difference = 0.423, and P value of the knee society function score difference = 0.337). **Conclusions:** Patellar resurfacing could be helpful in decreasing anterior knee pain and the necessity to future surgeries addressing patellofemoral pain, especially in revision cases, patients with patellofemoral problems, and patients with extensor mechanism weakness and those with anterior knee pain. Since Anterior Knee Pain Scale was the only scoring system, among all scoring systems used, that confirmed a significant impact of patellar resurfacing on the outcome following resections and reconstructions; we cannot give an explicit strong recommendation favoring the routine patellar resurfacing in all cases undergoing resections and reconstructions using modular prosthesis. We recommend patellar resurfacing in older patients, based on our results, which show possible benefit of patellar resurfacing in older patients. We think that old age and the preexisting knee arthritis could be relative indications for patellar resurfacing.

Keywords: Endoprosthesis, functional outcome, patellar resurfacing

Introduction

Background

Patellar resurfacing in knee replacement surgeries has always been a debatable in the literature. The literature contains data that support both resurfacing and not resurfacing the patella. Those who advocate patellar resurfacing see a lot of proofs confirming that resurfacing decrease anterior knee pain improves functional outcome and diminishes the need to a secondary patellar resurfacing revision surgery.[1] Patellofemoral complications, the greatest argument against resurfacing, include loosening, fracture, patellar maltracking, or subluxation.[2-4] In 1994, Tsuboyama *et al*.[5] studied the impact of quadriceps mass on knee extension after wide excision of malignant bone tumors and limb salvage of the

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distal femur using modular prosthesis and found a significant impact of resurfacing on strength.[5] In 2016, Etchebehere *et al*. studied the effect of resurfacing on modular prosthesis following distal femoral resection and found no differences in anterior knee pain, range of movement, or extension lag between resurfacing and nonresurfacing. He did not report any case of patellar component loosening or revision.[6]

Rationale

Most studies in the literature address patellar resurfacing in primary knee replacement done for patients with osteoarthritis and rheumatoid arthritis. Very few studies addressed patellar resurfacing in modular prosthesis. Patients with tumors undergoing resection and modular prosthesis are expected to be different in many variables. This highlights the need for more studies addressing the various factors affecting the outcome of patients with malignant knee tumors treated by limb salvage using endoprosthesis. The aim of our study is to assess whether patellar resurfacing is better than nonresurfacing as regards the functional outcome of modular prosthesis used for the treatment of tumors around the knee.

Patients and Methods

We did a retrospective analysis of a prospective study. We did an analysis of the data of patients with malignant tumors around the knee who were operated at our unit. Patients were selected randomly and were operated between March 2006 and September 2017. We relied on the database at the Musculoskeletal Oncology Unit of Cairo University Hospital. The same surgical team operated all patients using the same surgical and oncological protocol.

Patients were assigned into two groups: Group A: In which patients underwent modular prosthesis with patellar resurfacing. They were operated between April 2016 and September 2017. Group B: In which patients were selected randomly among patients coming for regular follow-up. Patients in this group underwent modular prosthesis without patellar resurfacing. Patients were selected randomly regardless age, gender, and oncological stage.

Inclusion criteria

All patients with tumors around the knee candidate for modular prosthesis were included in the study. These included patients of both sexes and different age groups. They included bone sarcomas of the distal femur and proximal tibia and benign-aggressive tumors associated with extensive bone destruction. The study included patients of stage I and II. The tumors should be resectable, with an adequate safety margin.

Exclusion criteria

We excluded patients with tumors involving neurovascular structures, patients with infected or fungating biopsy incisions, and patients with mobile pathological fractures.

The patients who met the criteria included 36 patients, diagnosed as follows: 29 osteosarcoma patients, two chondrosarcoma patients, one Ewing sarcoma patient, one giant cell tumor patient, one fibrosarcoma patient, one rhabdomyosarcoma patient, and one adamantinoma patient.

- The study included 17 males and 19 females
- The youngest patient was 11 years old male, the oldest was 71 years old male. The mean age was 26.44 years (range: 11–71). Among 36 patients; 15 patients were under 20 years old, 17 were in age group of (20–45) and only 4 patients were older than 45 years. The wide range of age did not significantly affect the validity of results since the majority of patients were in the same age groups and only 4 patients among 36 patients were older than 45 years.

Study methods

The selected patients were subjected the routine preoperative work-up, including history taking, thorough general and

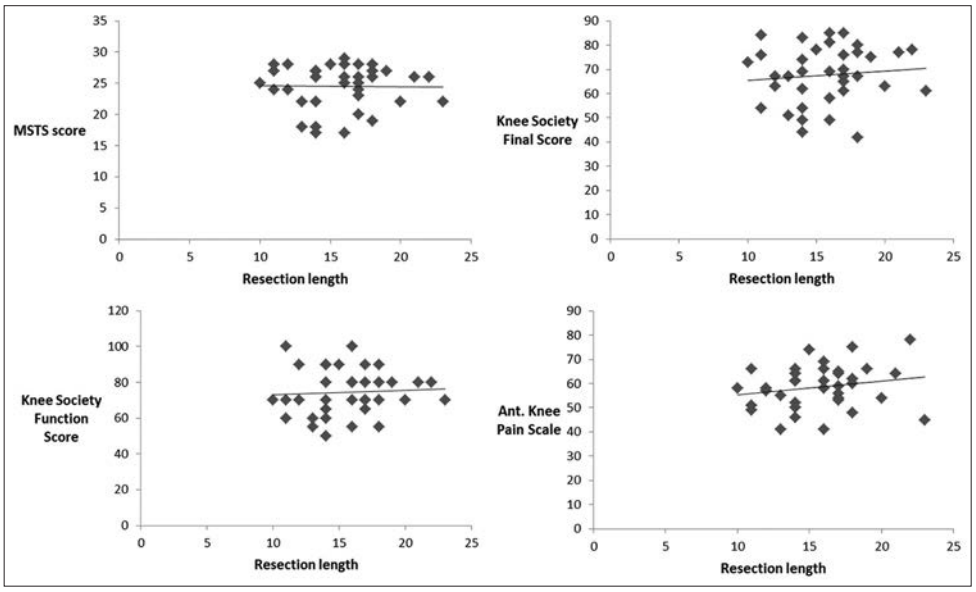

Figure 1: Correlation between resection length and functional score of total number of cases

local examination, laboratory investigations and radiological investigations. These included plain X-ray images, magnetic resonance imaging, bone scan and computed tomography (CT) chest, which were obtained in all cases. All tumors were confirmed pathologically, through either an open or a core biopsy. All patients with osteosarcoma and Ewing sarcoma received neo-adjuvant chemotherapy using the classic first line drugs.

Surgical technique

All patients were subjected to wide excision of tumors and limb salvage using modular prosthesis with modular prosthesis. Eighteen patients underwent reconstruction with patellar resurfacing and 18 patients underwent reconstruction without resurfacing.

We evaluated our patients oncologically and functionally. They were followed up at the outpatient clinic at 1 week, 3, 6, 12, 24 weeks, and 1 year postoperation and then yearly.

During each of the visits to the outpatient clinic, the following was done:

1. Local examination: The affected limb was examined for any evidence of lumps (local recurrence), delayed infection, loosening or dislocation of the prosthesis or patellar component subluxation
2. Functional evaluation; knee range of movement, and extension lag were measured with musculoskeletal tumor society scoring system (MSTS) functional score, as well as the knee society clinical rating system and the anterior knee pain score

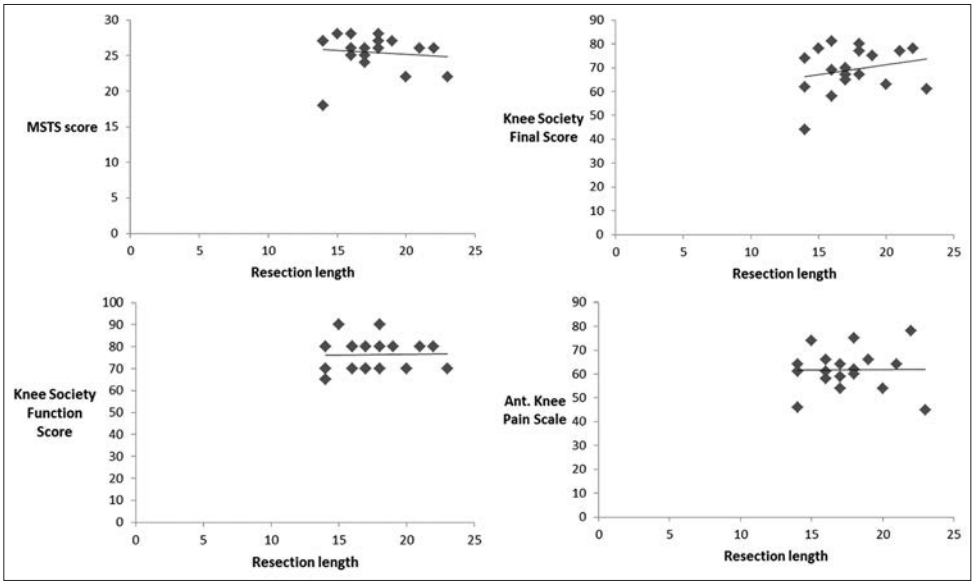

Figure 2: Correlation between resection length and functional score of cases whom reconstructed with patellar resurfacing

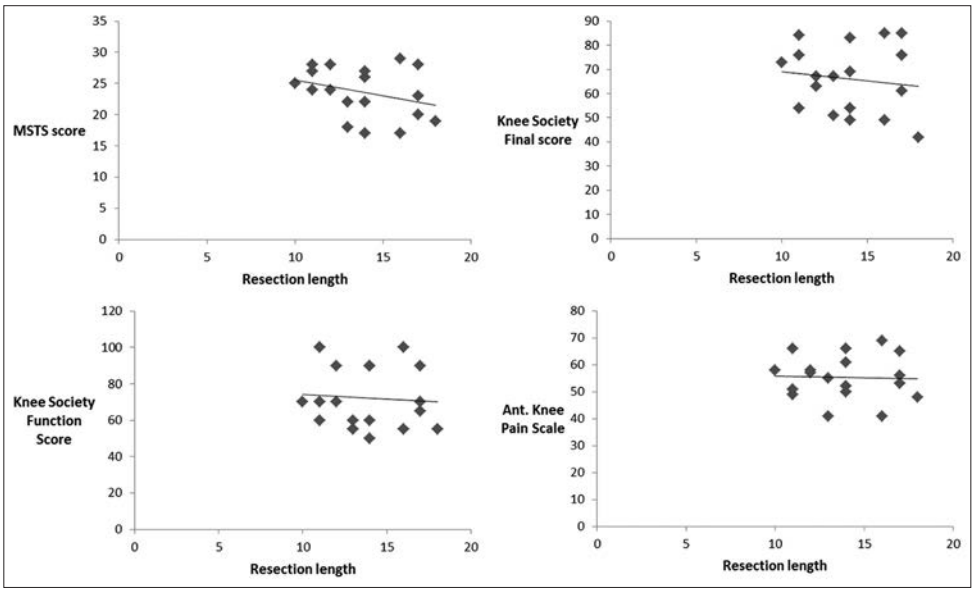

Figure 3: Correlation between resection length and functional score of cases whom reconstructed without patellar resurfacing

3. Plain radiographic examination; anteroposterior and lateral radiographs of the distal femur, proximal tibia, and knee joint were done. The position of prosthesis, loosening, subluxation, stress fractures, and local recurrence were also noted and recorded if present
4. In addition to the previous examinations, a CT chest was done at 3-month interval for the first 2 years postoperative and then once a year thereafter. Furthermore, a bone scan was required every 6 months in the first 2 years postoperative and then once a year thereafter.

During each of the visits to the outpatient clinic, functional assessment was done using the modified MSTS for evaluation of our patients. We used more specific systems for grading of the functional outcome; these are the knee society final score, the knee society function score and the Anterior Knee Pain Scale [Appendix I and II].[7-9] The results of each visit were recorded regularly in the database of the Musculoskeletal Oncology Unit of Cairo University Hospital.

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) software version 20.0 (IBM Corporation, 1 New Orchard Road Armonk, NY 10504-1722, USA, 2011).

Qualitative data were presesnted as the number and percentage while quantitative data as mean ± standard deviation. Statistical analysis was done using the independent *t*-test[10] and Fisher's exact probability test.[11] $P < 0.05$ was considered statistically significant.

Results

We had 36 patients, diagnosed as follows:

- Twenty-nine osteosarcoma patients
- Two chondrosarcoma patients
- One Ewing sarcoma patient, one giant cell tumor patient, one fibrosarcoma patient, one rhabdomyosarcoma patient, and one adamantinoma patient [Table 1].

The youngest was 11 years old while the oldest was 71. Patients included 17 males and 19 females. The mean age was 26.44 years (range: 11–71) [Tables 2 and 3].

In our study, the mean MSTS functional score of patients in the patellar resurfacing was 25.44 = 84.4%, while it was 23.56 = 78.53% in the nonresurfacing group. The difference between both groups was insignificant ($P = 0.103$) [Table 4].

We used other scoring systems to assess other parameters of knee function, which are not assessed by the MSTS score. All scores were higher in patients who underwent patellar resurfacing. However, only the difference in anterior knee pain score was significant ($P = 0.030$) [Tables 5-7].

Four patients among the 18 patients of the nonresurfacing group had an extension lag of >20°, while only one patient among the 18 patellar resurfacing patients had an extension lag of >20° [Table 8].

Table 1: Distribution of cases according to diagnosis

Diagnosis	*n* (%)
Osteosarcoma patients	29 (80.55)
Chondrosarcomas patients	2 (5.55)
Ewing's sarcoma	1 (2.77)
Giant cell tumor of bone	1 (2.77)
Fibrosarcoma	1 (2.77)
Rhabdomyosarcoma	1 (2.77)
Adamantinoma	1 (2.77)
Total	36 (100)

Table 2: Distribution of age group and type of reconstruction

Age	Patellar resurfacing	Nonresurfacing
Range	11–52	16–71
Mean±SD	24.78±13.24	28.11±13.89

SD: Standard deviation

Table 3: Distribution of gender group and type of reconstruction

Gender	Patellar resurfacing	Nonresurfacing	Total
Male (*n*)	10	7	17
Female (*n*)	8	11	19
χ^2	0.446		
P	0.504		

Comparisons were performed by Chi-square test

Table 4: Musculoskeletal tumor society score of total number of cases in both types of prosthetic reconstruction

Score	Patellar resurfacing	Nonresurfacing
Range	18–28	17–29
Mean±SD	25.44±2.75	23.56±4.03
t-test	1.676	
P	0.103	

Values are represented as mean±SD. Comparisons were performed by independent *t*-test. SD: Standard deviation

Table 5: Knee society final score of total number of cases in both types of prosthetic reconstruction

Score	Patellar resurfacing	Nonresurfacing
Range	44–81	42–85
Mean±SD	69.22±9.50	66.00±13.92
t-test	0.811	
P	0.423	

Values are represented as mean±SD. Comparisons were performed by independent *t*-test. SD: Standard deviation

Analysis of our results did not show a statistically significant difference between patients of both groups regarding flexion range of motion ($P = 0.794$) and the extension lag ($P = 0.405$) [Table 9].

We also assessed the distal femoral and the proximal tibial reconstruction separately. Regarding the distal femoral reconstruction, we found that all scores and the main flexion range were all better in the resurfacing group, but the difference was insignificant. On the other hand, Anterior Knee Pain Scale was 63.80 in the resurfacing group in comparison to 56.21 in the nonresurfacing one and this difference was significant ($P = 0.032$).

Similarly, statistical analysis of the effect of patellar resurfacing following resection of proximal tibia tumors was done. All scores were better in the resurfacing group. However, all the differences were insignificant [Tables 10 and 11].

Assessing the relation between age and functional score in the total number of cases of both groups was done using the the one-way ANOVA test[12] and revealed that the MSTS score, knee society final score, and knee society function score were highest in the ≤20 years old category and lowest in the >45 years old category. The highest Anterior Knee Pain Scale was observed in >45 years old category while the lowest was observed in the 25–45 years old category.

Similarly, assessing the relation between age and functional score in the nonresurfacing group only revealed that all scores were the highest in the ≤20 years old category and lowest in the >45 years old category [Tables 12 and 13].

Assessing the relation between age and functional score in the resurfacing group only revealed different results. All scores were highest in the >45 years old category and lowest in the 20–45 years old category [Table 14].

Our study was performed on 36 patients, 17 males (10 in the resurfacing group and 7 in nonresurfacing group) and 19 females (8 in the resurfacing group and 11 in nonresurfacing

Table 6: Knee society function score of total number of cases in both types of prosthetic reconstruction

Score	Patellar resurfacing	Nonresurfacing
Range	65–90	50–100
Mean±SD	76.39±7.24	72.22±16.65
t-test	0.974	
P	0.337	

Values are represented as mean±SD. Comparisons were performed by independent *t*-test. SD: Standard deviation

Table 7: Anterior knee pain score of total number of cases in both types of prosthetic reconstruction

Score	Patellar resurfacing	Nonresurfacing
Range	45–78	41–69
Mean±SD	61.72±8.80	55.33±8.14
t-test	2.26	
P	0.030*	

*Significant difference at $P<0.05$. Comparisons were performed by independent *t*-test. SD: Standard deviation

Table 8: Extension lag score of total number of cases in both types of prosthetic reconstruction

	Patellar resurfacing, *n* (%)	Nonresurfacing, *n* (%)	Total, *n* (%)	*P*
<10°	15 (83.3)	12 (66.6)	27 (75)	0.405
10°–20°	2 (11.1)	2 (11.1)	4 (11.1)	
>20°	1 (5.6)	4 (33.3)	5 (13.9)	
Total	18 (100)	18 (100)	36 (100)	

Comparisons were performed by Fisher's exact probability test for 2×3 contingency table

Table 9: Flexion range of total number of cases in both types of prosthetic reconstruction

Score	Patellar resurfacing	Nonresurfacing
Range	75–105	60–110
Mean±SD	86.67±9.55	85.56±15.14
t-test	0.263	
P	0.794	

Values are represented as mean±SD. Comparisons were performed by independent *t*-test. SD: Standard deviation

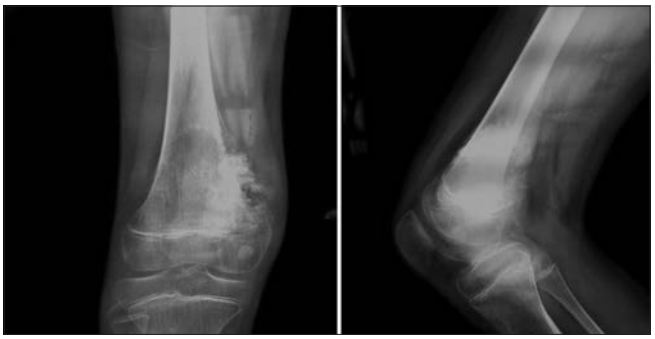

Figure 4: Pre-operative x-ray images

Table 10: Relation between functional score of total number of cases of distal femur tumors who were reconstructed with patellar resurfacing and cases who were reconstructed without patellar resurfacing

	Resurfacing (*n*=10)	Nonresurfacing (*n*=14)	*t*-test	*P*
MSTS score	25.70±1.71	23.71±4.16	1.420	0.170
Knee society final score	71.50±7.66	66.36±13.93	1.055	0.303
Knee society function score	76.00±6.99	73.21±17.39	0.477	0.638
Anterior Knee Pain Scale	63.80±8.07	56.21±7.99	2.284	0.032*
Flexion range	89.50±11.17	86.43±15.62	0.531	0.601

*Significant difference at $P<0.05$. Values are represented as mean±SD. Comparisons were performed by independent *t*-test. SD: Standard deviation, MSTS: Musculoskeletal tumor society

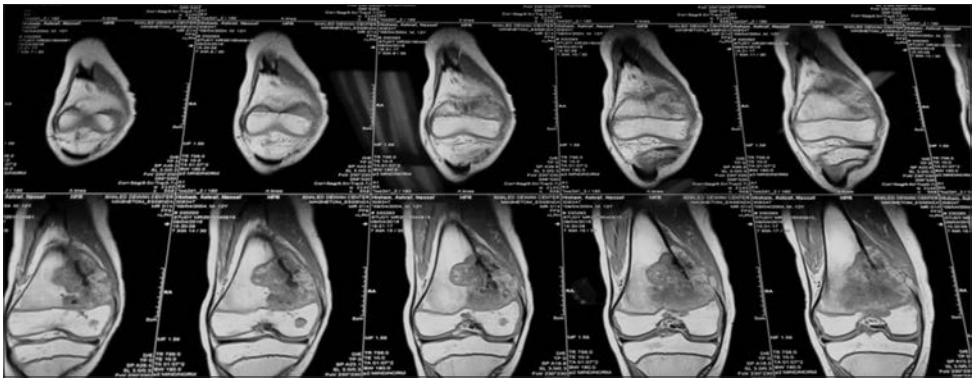

Figure 5: Pre-operative MRI

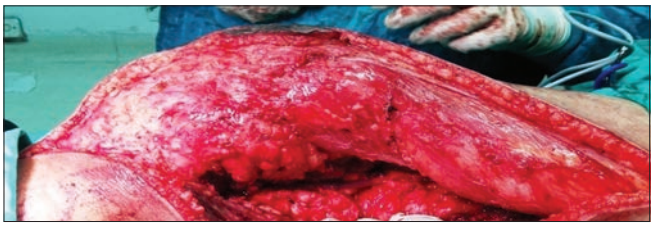

Figure 6: Medial approach to the distal femur & knee

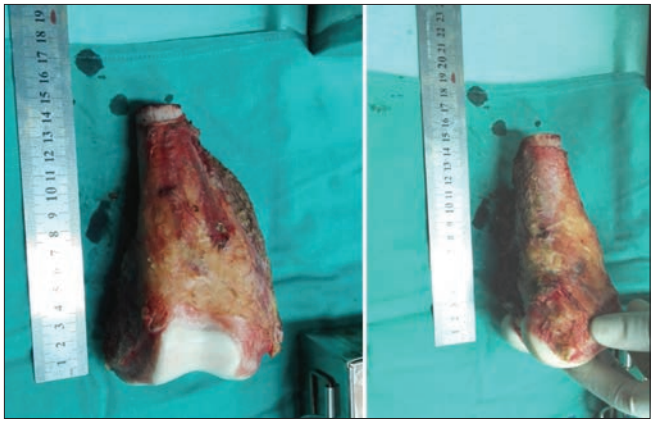

Figure 8: Wide resection of the tumour

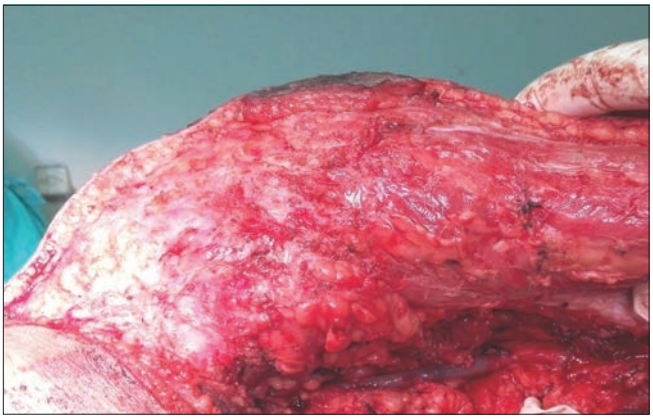

Figure 7: Exploration of profunda femoris & popliteal vessels

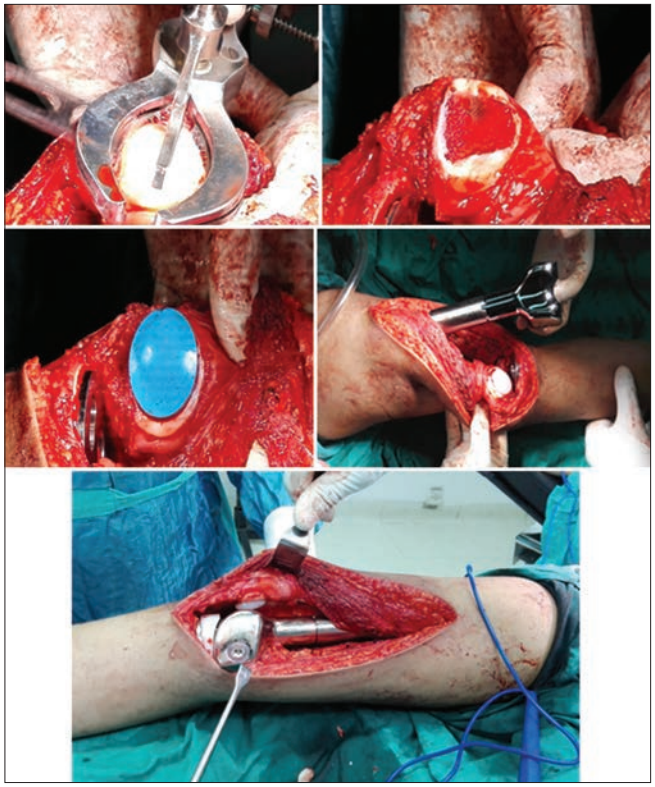

Figure 9: The modular prosthesis with patellar resurfacing

group). There were no significant differences in all scores between male and female patients.

The longest resection length was 23 cm and the shortest was 10 cm. Correlation between resection length and score was assessed by Bivariate Pearson correlation test.[13] There was no significant correlation [Table 15 and Figures 1-3].

Correlation between the number of muscles resected and score was assessed by Bivariate Pearson correlation test. Correlation was insignificant [Tables 16 and 17].

Operative time was longer in the patellar resurfacing group compared to nonresurfacing group, and the difference was significant (P = 0.020) [Table 18].

In our study, complications were reported in 11 patients (61%) of the resurfacing group and 7 patients (38.9%) of the

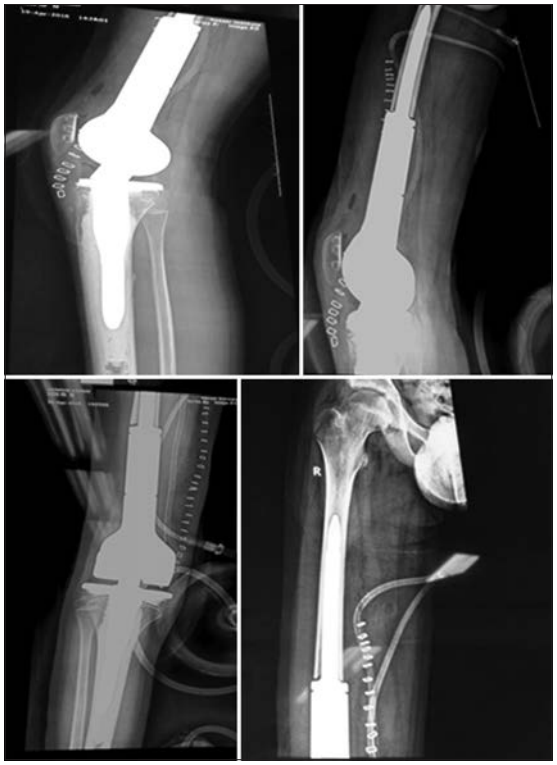

Figure 10: Post-operative x –ray images

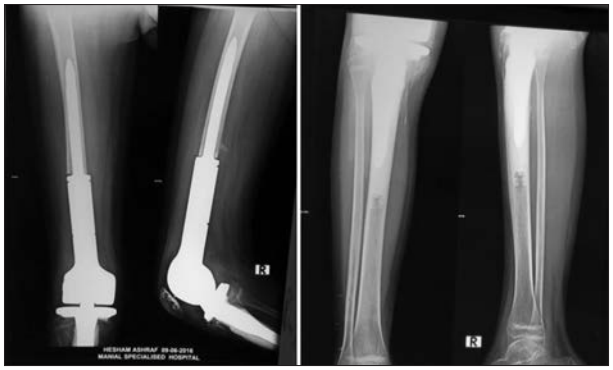

Figure 11: X-ray images after 6 weeks

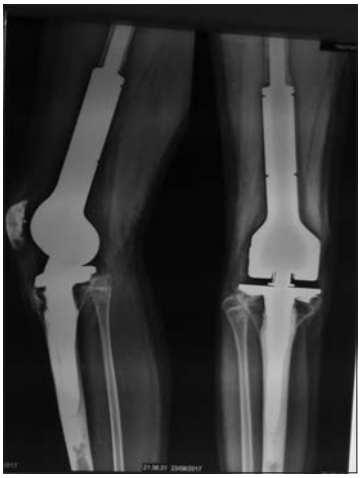

Figure 12: X-ray images after 6 months

nonresurfacing group. The difference between the two groups was insignificant ($P = 0.317$). Only one complication was related to patellar resurfacing among the 11 complications of the patellar resurfacing group. It was patellar subluxation which occurred in one case due to vastus medialis weakness and improved with quadriceps strengthening exercises and physiotherapy.

Case 1

Male Patient, 12 years old, Diagnosis: Osteosarcoma of the distal femur

Surgical Approach: Medial approach to the distal femur and knee [Figures 4 and 5].

Type of margin: Widemargin [Figures 6 and 7]

Type of resection: Intraarticular [Figure 8]

Resection length: 16 cms.

Type of reconstruction: Modular prosthesis with patellar resurfacing, cementless femoral stem on cemented tibial stem [Figures 9 and 10].

Follow-up: 2.5 years

MSTS score: 28, Knee Society Final Score: 81, Knee Society Function Score: 80, Anterior Knee Pain Scale: 66 [Figures 11 and 12].

Discussion

Patellar resurfacing in knee replacement surgeries has always been a debatable in the literature. Similar debates exists for modular endoprosthesis; however, only few authors tackled this issue. Tsuboyama *et al*. studied the impact of quadriceps muscle mass on knee extension after wide excision of malignant bone tumors and limb salvage of the distal femur using modular prosthesis and found a significant effect of patellar resurfacing on strength.[5] Etchebehere *et al*. studied the effect of patellar resurfacing on modular prosthesis following distal femoral resection and found no differences in anterior knee pain, range of movement, or extension lag between resurfacing and nonresurfacing.[6]

Several meta-analyses were performed on patellar resurfacing in primary knee replacement. A systematic review and meta-analysis published by Longo *et al*. found that resurfacing improved functional performance. He used knee society score for pain, knee society score for function, and hospital for special surgery postoperative score.[14] Studies by Pakos, Nizard, Wood and Waters favored patellar resurfacing as well.[15-18]

On the other hand, Smith *et al*. found the difference insignificant in all measured scores between patella resurfacing and nonresurfacing. Anterior knee pain was recorded in 30.1% of the resurfacing group and 20.9% of nonresurfacing group.[19] Moreover, studies by Mayman *et al*., Campbell and Myles found that differences were insignificant in knee scores between patellar resurfacing and nonresurfacing.[20-22]

Table 11: Relation between functional score of total number of cases of proximal tibia tumours whom reconstructed with patellar resurfacing and cases whom reconstructed without patellar resurfacing

	Resurfacing (*n*=8)	Nonresurfacing (*n*=4)	*t*-test	*P*
MSTS score	25.13±3.48	23.00±4.08	0.945	0.367
Knee society final score	66.38±11.27	64.75±15.97	0.206	0.841
Knee society function score	76.88±7.99	68.75±15.48	1.229	0.247
Anterior Knee Pain Scale	59.13±9.51	52.25±9.07	1.197	0.259
Flexion range	83.13±5.94	82.50±15.00	0.106	0.917

Comparisons were performed by independent *t*-test. Values are represented as mean±SD. SD: Standard deviation, MSTS: Musculoskeletal tumor society

Table 12: Relation between age and functional score in total number of cases of both groups

Age (years)	*n*	MSTS score	Knee society final score	Knee society function score	Anterior Knee Pain Scale
≤20	15	24.93±4.15	69.53±12.91	78.33±14.23	59.80±10.61
20–45	17	24.53±2.76	67.06±10.37	71.76±11.31	56.88±6.18
>45	4	22.75±3.77	62.75±15.48	70.00±12.25	60.75±13.30
F		0.613	0.537	1.323	0.547
P		0.548	0.590	0.280	0.584

Comparisons were performed by ANOVA followed by Tukey *post hoc* test for multiple comparisons. MSTS: Musculoskeletal tumor society

Table 13: Relation between age and functional score in the total number of cases whom reconstructed without patellar resurfacing

Age (years)	*n*	MSTS score	Knee society final score	Knee society function score	Anterior Knee Pain Scale
≤20	6	24.17±4.88	69.67±14.53	78.33±19.29	57.17±13.41
20–45	10	24.00±3.10	67.60±11.92	71.00±13.75	56.20±5.78
>45	2	19.50±0.50	51.50±9.50	60.00±5.00	50.50±2.50
F		1.353	1.616	1.124	2.072
P		0.288	0.232	0.429	0.659

Comparisons were performed by the ANOVA followed by Tukey *post hoc* test for multiple comparisons. MSTS: Musculoskeletal tumor society

Table 14: Relation between age and functional score in the total number of cases whom reconstructed with patellar resurfacing

Age (years)	*n*	MSTS score	Knee society final score	Knee society function score	Anterior Knee Pain Scale
≤20	9	25.44±3.39	70.44±11.68	78.33±8.66	62.67±9.12
20–45	7	25.29±1.80	66.29±6.97	72.86±4.88	57.86±6.67
>45	2	26.00±0.00	74.00±5.66	80.00±0.00	71.00±9.90
F		0.053	0.633	1.488	2.072
P		0.948	0.545	0.257	0.161

Comparisons were performed by the ANOVA followed by Tukey *post hoc* test for multiple comparisons. MSTS: Musculoskeletal tumor society

Table 15: Correlation between resection length and functional score of total number of cases who were reconstructed with patellar resurfacing and those who were reconstructed without patellar resurfacing

Score	Total		Resurfacing		Nonresurfacing	
	r	*P*	*r*	*P*	*r*	*P*
MSTS score	−0.12	0.945	−0.111	0.662	−0.312	0.207
Knee society final score	0.097	0.572	0.231	0.357	−0.133	0.598
Knee society function score	0.062	0.719	0.023	0.929	−0.079	0.754
Anterior Knee Pain Scale	0.205	0.229	0.014	0.957	−0.033	0.896

Correlation was assessed by bivariate Pearson correlation test (*r*). MSTS: Musculoskeletal tumor society

There are also a lot of nonrandomized studies enriching literature. One study was a cohort one and included 623 patients who were subjected to knee replacement without patella resurfacing.[23] Twenty patients (3.2%) underwent secondary

Table 16: Relation between the number of muscles resected and functional score in total number of cases whom reconstructed with patellar resurfacing

Number of resected muscles	*n*	MSTS score	Knee society final score	Knee society function score	Anterior Knee Pain Scale
0	4	24.25±4.35	67.50±16.34	76.25±7.50	58.25±8.26
1	8	26.25±1.28	67.63±6.39	75.00±7.56	61.75±5.92
2	4	25.50±2.52	74.25±9.00	80.00±8.16	66.00±14.90
3	2	24.50±3.54	69.00±8.48	75.00±7.07	60.00±8.48
F		0.594	0.444	0.408	0.500
P		0.629	0.725	0.750	0.688

Comparisons were performed by the ANOVA followed by Tukey *post hoc* test for multiple comparisons. MSTS: Musculoskeletal tumor society

Table 17: Relation between number of muscles resected and functional score in the total number of cases whom reconstructed without patellar resurfacing

Number of resected muscles	*n*	MSTS score	Knee society final score	Knee society function score	Anterior Knee Pain Scale
0	5	25.60±4.28	69.40±12.26	81.00±18.17	56.40±10.64
1	8	22.13±3.44	61.50±12.26	64.38±12.37	52.88±6.31
2	5	23.80±4.55	69.80±18.38	76.00±18.51	58.20±8.64
F		1.180	0.729	1.892	0.692
P		0.334	0.499	0.185	0.516

Comparisons were performed by the ANOVA followed by Tukey *post hoc* test for multiple comparisons. MSTS: Musculoskeletal tumor society

Table 18: Comparison between the operative time in patellar resurfacing and nonresurfacing

	Patellar resurfacing	Nonresurfacing
Time (min), mean±SD	208.33±49.58	175.00±29.56
t-test	2.440	
P	0.020*	

*Significant difference at $P<0.05$.[10] Values are represented as mean±SD. Comparisons were performed by independent *t*-test. SD: Standard deviation

patellar resurfacing surgery for persistent anterior knee pain. Follow-up of patients over 36 months showed increases in knee scores and functional scores. However, only 44.4% showed subjective improvement after resurfacing. Complications happened in 30% of the revision patients. Patellar instability occurred in three patients, one patient suffered a patellar fracture, and two underwent tri-compartmental revision for persistent pain. The study clarifies that secondary resurfacing is not beneficial for all patients with persistent anterior knee pain, and unfortunately some patients perform worse after this surgery.[23]

In this study, we evaluated functional outcome of patellar resurfacing versus nonresurfacing in modular endoprosthesis used for the treatment of tumors around the knee. We assumed that a patient with a tumor undergoing resection and modular prosthesis is expected to be different in many variables from a patient with osteoarthritis or rheumatoid arthritis and undergoing primary total knee arthroplasty. A patient undergoing wide resection of a tumor around the knee is expected to undergo muscle and soft-tissue resection as well, which makes him/her more susceptible to extensor mechanism weakness and anterior knee pain.

The mean MSTS functional score in our patients was better in those with patellar resurfacing compared to those without but the difference was insignificant ($P = 0.103$). These results are comparable to the results of Etchebehere *et al*., who found that s difference between the mean MSTS scores of the nonresurfacing (81%) and resurfacing (71%) groups was insignificant ($P = 0.34$).[6]

The MSTS functional evaluation assesses the overall function of the patient but does not specifically evaluate the knee function. Thus, we opted to compare our groups using also scoring systems that are originally used to evaluate regular total knee arthroplasty. The knee society final score and the knee society function score were higher in patients with patellar resurfacing than in patients with nonresurfacing, but the difference was insignificant. Only the difference in anterior knee pain score between the two groups was significant ($P = 0.030$). We could not find any study investigating knee function after modular endoprosthesis using these scoring systems. The results of our study are comparable to the results of Pakos, Nizard, Wood and Waters, who found that anterior knee pain was decreased with patellar resurfacing.[15-18] These results are compatible with the assumption that patellar resurfacing could help decrease anterior knee pain in patients undergoing wide resection of tumors and reconstruction using modular prosthesis. Resection of these tumors with a wide margin necessitates resection of more soft tissue and muscles which decreases the knee extension force and possibly makes these patients more susceptible to develop patellofemoral problems and anterior knee pain.

We found that the mean flexion range in the resurfacing group was 86.67°, while in the nonresurfacing one it was 85.56°. The differences between the two groups were insignificant in

flexion range ($P = 0.794$) and in extension lag ($P = 0.405$). This coincided with the results of Etchebehere *et al*.[6]

When we evaluated the functional outcome of the distal femoral and the proximal tibial endoprosthesis separately, we got slightly different results. All functional scores were higher in the patellar resurfacing group in both locations, but the difference was statistically insignificant. The anterior knee pain scale was also better in patients with patellar resurfacing but the difference was significant only in distal femoral reconstructions and not in the proximal tibial ones. Anterior Knee Pain Scale in distal femoral reconstructions was 63.80 in the resurfacing group in comparison to 56.21 in the nonresurfacing one ($P = 0.032$). In proximal tibial reconstructions, it was 59.13 in the resurfacing group and 52.25 in the nonresurfacing one, but the difference was statistically insignificant.[24]

Whereas gender had no impact on the functional outcome but age did.

Assessing the relation between age and functional score in the nonresurfacing group only revealed that all scores were highest in the ≤20 years old category, and lowest in the >45 years old category whereas it was the opposite in the resurfacing group in which it was highest in the >45 years category.

All these differences were statistically insignificant. However, these results could highlight the possible beneficial impact tof patellar resurfacing on the outcome in older patients, and that old age and the presence of degenerative changes could be relative indications for patellar resurfacing.

In our study the length of resection and number of resected muscles did not impact the functional ourcome. This does not coincide with the study of Tsuboyama *et al*. in which patients with less muscle mass benefitted from patellar resurfacing.[5]

The operative time was longer with patellar resurfacing than with nonresurfacing group, and the difference was statistically significant ($P = 0.020$). This did not increase the rate of infection. None of our patients developed infection and only one complication was related to patellar resurfacing. It was a patellar sublaxation due to muscle imbalance.

Orthopedic surgeons who do not favor patellar resurfacing claim that it increases the risk of complications. In our study, the difference in the rate of complications between resurfacing and nonresurfacing was insignificant.($P = 0.317$).

There are two points of strength in this study. First, it investigates a topic which has been intensely investigated for total knee replacements but rarely investigated for modular endoprosthesis. The latest being published in 2016 by Etchebehere *et al*.[6] Second, it uses knee scoring systems that are not commonly used by orthopedic oncologists but are very useful in analyzing the knee joint specifically. The MSTS scoring system is not specifically designed for addressing the knee joint, extensor mechanism and anterior knee pain. However, adding the knee society final score, knee society function score, Anterior Knee Pain Scale, flexion range of motion, and extension lag to the assessment of functional score in our study seemed to be appropriate and more specific.

The limitations of our study was the small number of patients and the relatively short follow-up time in patellar resurfacing cases, which ranged between 24 and 30 months. We also used the convenience sampling method, which is less accurate than the simple or systematic random sampling method. We assigned patients into two groups: Group A: In which patients underwent modular prosthesis with patellar resurfacing. They were operated between April 2016 and September 2017. Group B: In which patients were selected randomly among patients coming for regular follow-up. Patients in this group underwent modular prosthesis without patellar resurfacing. Patients were selected randomly regardless age, gender, and oncological stage.

Another limitation was that we did retrospective analysis, relying on the database at the Musculoskeletal Oncology Unit of Cairo University Hospital. To minimize bias, we tried to make sure that all patients were assessed and examined using the same follow-up protocol and for the same parameters. Parameters were recorded in the database using the same protocol. The same surgical team operated all patients using the same surgical and oncological protocol.

This study proves that a precise and accurate evaluation of the influence of patellar resurfacing on the outcome following wide resection and reconstruction with modular endoprosthesis cannot be achieved using the usual MSTS scoring system alone. Adding the knee society final score and Anterior Knee Pain Scale gives more accurate and precise evaluation. Since Anterior Knee Pain Scale was the only scoring system that confirmed a significant influence of patellar resurfacing on the functional outcome, we cannot give an explicit strong recommendation favoring the routine patellar resurfacing in all patients. The final decision of whether to do patellar resurfacing or not should depend on the clinical judgment of the surgeon. We recommend patellar resurfacing in older patients, which show possible beneficial effect on the functional outcome provided that the patella is of an adequate thickness and not sclerotic. We think that old age and the presence of degenerative changes could be relative indications for patellar resurfacing.

Conclusions

Patellar resurfacing could be helpful in decreasing anterior knee pain and the necessity to future surgeries addressing patellofemoral pain, especially in revision cases, patients with patellofemoral problems, and patients with extensor mechanism weakness and those with anterior knee pain. Since Anterior Knee Pain Scale was the only scoring system, among all scoring systems used, that confirmed a significant impact of patellar resurfacing on the outcome following resections and reconstructions; we cannot give an explicit strong recommendation favoring the routine patellar resurfacing in all cases undergoing resections and reconstructions using modular prosthesis. We recommend patellar resurfacing in older

patients, based on our results, which show possible benefit of patellar resurfacing in older patients. We think that old age and the preexisting knee arthritis could be relative indications for patellar resurfacing.

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Conflicts of interest

Each author certifies that he or she has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection + with the submitted article.

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Original Article

Is Partial ACL Tear a Cause of Painful Swollen Knees?

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Abstract

Study Design: Retrospective case series. **Objective:** In this study, we will identify if partial ACL tear is a common hidden cause of chronic pain and swelling of the knee in adults. And we will evaluate the effectiveness of arthroscopic selective bundle reconstruction in the management of this condition. **Background:** The Anterior Cruciate Ligament (ACL) has two anatomical bundles, the anteromedial (AM) and the posterolateral (PL), each bundle was named according to the site of its tibial insertion.[1] Partial ACL tear is evident and symptomatic when the percentage of the torn fibers is more than 50% of ligament fibers. AM bundle is more liable to injury than PL.[2] Symptomps of partial ACL tear may be giving way and instability but persistent knee pain and swelling is often present as the main presenting symptom of the patient due to micro-instability of the knee, The primary complication of longstanding partial ACL tears is early knee degeneration.[3] **Patients and Methods:** 37 patients with chronic knee pain and swelling, related to activity and resistant to non-operative treatment, underwent diagnostic knee arthroscopy. In 3 cases diagnostic arthroscopy revealed osteochondral ulcers of the medial compartment of the knee managed by drilling and 4 cases showed non-specific synovitis managed by arthroscopic synovectomy. 30 of these patients, who were included in this study, were found to suffer from partial ACL tear and underwent single bundle reconstruction, 18 of them underwent selective AM bundle reconstruction while preserving PL bundle. Twelve patients underwent selective PL bundle reconstruction with AM bundle preservation. Semitendinosus tendon graft was utilized for all reconstructions. The femoral side was always fixed with an adjustable loop (Zimmer), and the tibial side with a biodegradable interference screw. Lysholm score[4] was used to assess the outcomes. Patients with severe degenerative disorders, lower limb mal-alignment and multiple ligamentous injuries of the knee were excluded from our study. **Results:** Marked decrease in the knee pain and swelling postoperatively. The preoperative score had a mean value of 66.17±10.39. At 2 years, the postoperative score was 96.1±6.71, indicating a highly statistically significant improvement (P value 0.001). **Hypothesis:** Partial ACL tears are the commonest hidden cause of pain and swelling of the knee among young adults. **Conclusion:** Arthroscopic selective bundle reconstruction diminishes knee pain and swelling with a very satisfactory postoperative clinical outcomes.

Keywords: Knee arthroscopy, knee pain, knee swelling, partial anterior cruciate ligament tears, single-bundle reconstruction

Introduction

The anterior cruciate ligament (ACL) has two anatomical bundles, the anteromedial (AM) and the posterolateral (PL), each bundle was named according to the site of its tibial insertion.[1]

Partial ACL tear is evident and symptomatic when the percentage of the torn fibers is more than 50% of ligament fibers. AM bundle is more liable to injury than PL.[2] Symptoms of partial ACL tear may be giving way and instability but persistent knee pain and swelling are often present as the main presenting symptom of the patient. The primary complication of longstanding partial ACL tears is early knee degeneration.[3]

The diagnosis of a partial ACL injury is difficult to confirm by magnetic resonance imaging (MRI) and clinical evaluation. Only arthroscopic probing could provide the definitive diagnosis of partial ACL tear.[3]

While the graft strength primarily depends on the fixation mechanism, ACL remnants may add instant biomechanical strength to the graft. Both of these factors may allow for quicker recovery and an earlier return to sports.[4]

The procedure uses the three classic main portals of the knee arthroscopy: the anterolateral, AM, and the accessory AM portals.[3]

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Contraindications to knee arthroscopy include infection, bleeding tendency, arthrofibrosis, and ankylosis.[5]

A classification of ACL tear is proposed, partial ACL rupture corresponds to the second degree: moderate sprain caused by direct or indirect trauma to the knee joint. The clinical presentation is characterized by pain with moderate disability, joint tenderness, slight to moderate abnormal motion, swelling, localized hemorrhage, moderate loss of function, and a tendency to recur. Giving way and evident instability are not always found in cases of partial ACL tear. The main issue is microinstability which expresses itself in the form of recurrent pain, swelling, and joint line tenderness after exertion.[3,4]

Partial ACL tears are more often suspected; their frequency is ranged from 10% to 27% of isolated ACL tears. The definition needs to be clear and consensual; confusion exists between partial rupture and healing. Continuous remnant ACL fibers bridging the femur and tibia, from native femoral ACL footprint to native tibial ACL footprint could be a good definition. Partial ACL is suspected upon clinical and radiological evidence but the only sure diagnosis is based upon arthroscopic examination.[1,3-5] That is why we used the word "hidden" cause of pain and swelling of the knee as the diagnosis is only confirmed by arthroscopic probing.

Patients and Methods

Thirty-seven patients with chronic knee pain and swelling related to activity and resistant to nonoperative treatment underwent diagnostic knee arthroscopy. In three cases, diagnostic arthroscopy revealed osteochondral ulcers of the medial compartment of the knee managed by drilling and four cases showed nonspecific synovitis managed by arthroscopic synovectomy. Thirty of these patients, who are included in the statistical analysis, were found to suffer from partial ACL tear and underwent single bundle reconstruction, 18 of them underwent selective AM bundle reconstruction while preserving the PL bundle. Twelve patients underwent selective PL bundle reconstruction with AM bundle preservation. Semitendinosus tendon graft was utilized for all reconstructions. The femoral side was always fixed with an adjustable loop (Zimmer), and the tibial side with a biodegradable interference screw. Lysholm score[4] was used to assess the outcomes. Twenty-seven patients were males and only three cases were females. We used fiber-wire to augment the graft in all cases. The time interval from injury to reconstruction ranges between 6 and 36 months with a mean of 7.93 ± 6.39 months.

Inclusion criteria

1. Young adult or middle-aged patient 18–38 years
2. Unilateral recurrent pain and swelling of the knee related to exertion
3. Investigations: X-rays and MRI are irrelevant, diagnostic knee arthroscopy is indicated to reach diagnosis.

Exclusion criteria

1. Severe knee degenerative changes amenable for arthroplasty
2. Multiple ligamentous injury
3. Lower limb malalignment
4. Infections.

Preoperative evaluation

Clinical evaluation

History

The patients were asked about the level of their activity, presence of previous knee problems or surgical intervention, history of trauma, and how it was happened, the patient was also asked for knee symptoms such as giving way, locking, hemarthrosis or swelling, and any associated medical problems.

Examination

All patients were subjected to careful clinical examination before surgery. Partial ACL tears were suspected in patients with ACL insufficiency who have a positive The Lachman test Grade I or II with hard endpoint and positive anterior drawer test. The pivot shift test was done only intraoperative by examination under anesthesia and it was usually negative. Confirmation of the diagnosis of partial ACL tear was done usually by arthroscopic probing.

Imaging

Plain X-ray

Weight-bearing AP and lateral views were done on all patients and showed to be normal.

Computed tomography scanogram

This was done in cases where we suspected malalignment to exclude it as a cause of chronic knee pain and swelling.

Magnetic resonance imaging

MRI was done for all patients, it was not usually enough to confirm the diagnosis but it might show intersubstance tears or fuzzy appearance which increases the suspicion of partial ACL tear; however, in most cases, ACL was of normal appearance with no evidence of interruption. MRI was also useful to confirm the integrity of the other ligaments and menisci.

Rating scales

Lysholm knee score.[4]

Operative technique

All surgeries were done under spinal anesthesia with well-padded thigh tourniquet. Examination under anesthesia was done for all patients by Lachman with a firm endpoint (found in 18 patients and absent in 12 patients) and negative pivot shift tests.

All patients were given 1 g ceftriaxone intravenously preoperative.

A routine diagnostic arthroscopy was performed to confirm the partial ACL tear diagnosis, to pinpoint the torn bundle, and to assess any other pathological disorders that may have

been present. Meniscal injuries were addressed before going to reconstruct the torn bundle. Debridement of torn bundle was done leaving intact bundle.

1. Arthroscopic portals [Figure 1]
2. Probing of the intact bundle [Figure 2]
3. Harvesting of the tendon graft [Figure 3]
4. Graft preparation [Figure 4]
5. Guide pin insertion in the anatomical footprint [Figure 5]
6. Measuring femoral tunnel [Figure 6]
7. The lateral femoral cortex is left at least 6–7 mm intact after the femoral tunnel is drilled according to the diameter of the graft and its length
8. Vicryl suture was inserted into the guide pin's slotted end, and the free ends were then threaded through the lateral soft tissue to leave a looped end in the femoral tunnel [Figure 7]
9. A C-guide aimer with a 55° angle is used to drill the tibial tunnel into the material of the ACL remnant just anterior to the PCL tibial insertion, 4–5 mm just lateral to the tibial tuberosity. The drill bit diameter used is the same as the diameter of the graft [Figure 8]
10. The suture loop that had been left in the ACL femoral tunnel was removed through the tibial tunnel using an arthroscopy probe or grasper
11. The graft is inserted into the knee through the tibial tunnel, then through the femoral tunnel until the loop is flipped [Figure 9]
12. To verify that the graft is tightened, 20 cycles of knee flexion and extension are performed [Figure 10]
13. Interference screw graft fixation in the tibial tunnel [Figure 11]
14. Arthroscopic probing of the graft after reconstruction to ensure its tension [Figure 12].

Rehabilitation

Postoperatively, all patients followed the accelerated rehabilitation program of Shelbourne and Nitz.

Follow-up

Visits were made every 2 weeks, 1½ months, 3 months, 6 months, a year, and every year after that. Patients were evaluated clinically and utilizing Lysholm[4] at each visit.

Statistical analysis

The data were processed and statistically analyzed using the SPSS (Statistical Package for Social Science) version 25.0 (IBM company, Chicago, USA) application. Frequencies and relative percentages were used to represent the qualitative data. The quantitative results were presented in the form of mean standard deviation. A paired sample *t*-test was used to calculate the difference between quantitative variables in the same group before and after therapy in normally distributed

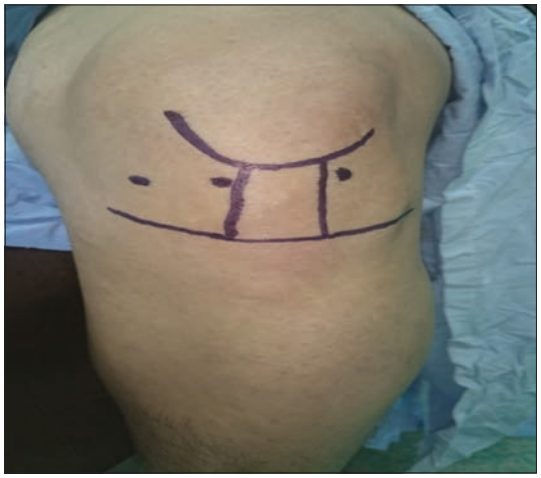


Figure 1: Arthroscopic portals

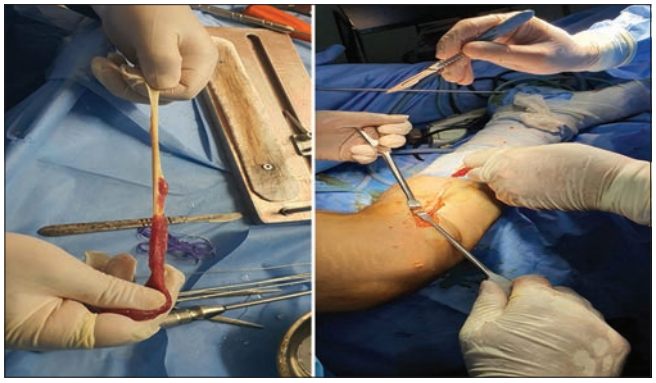


Figure 3: Graft harvest

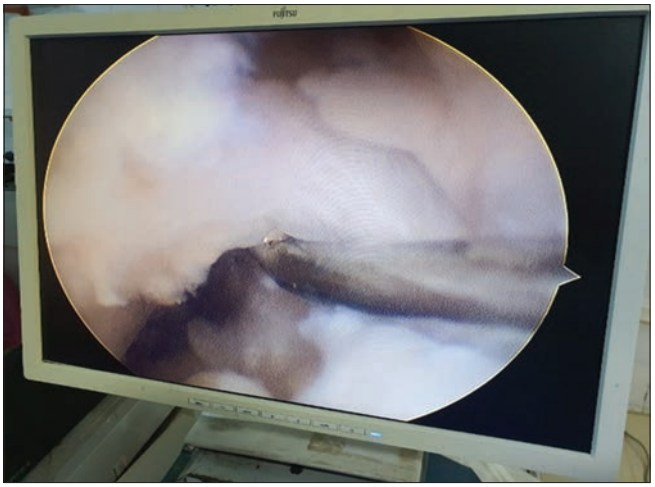


Figure 2: Probing of the intact bundle

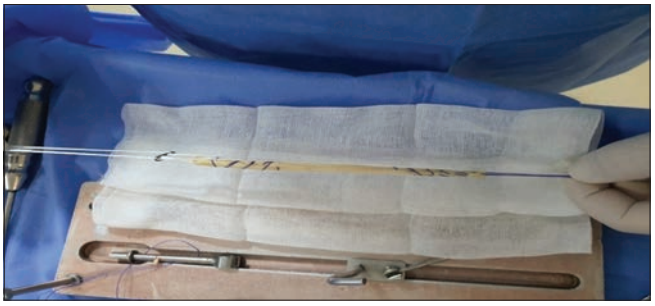


Figure 4: Graft preparation

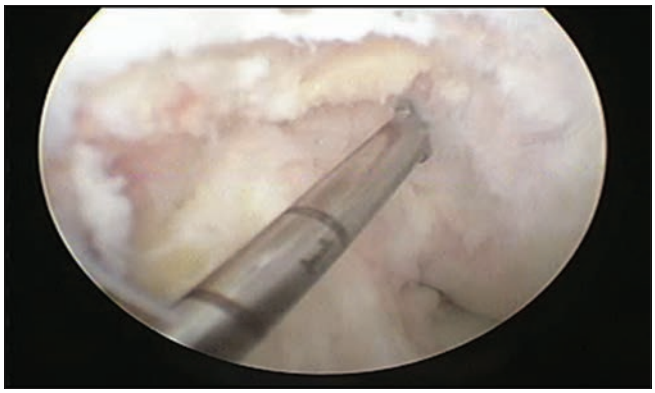


Figure 5: Guide pin insertion

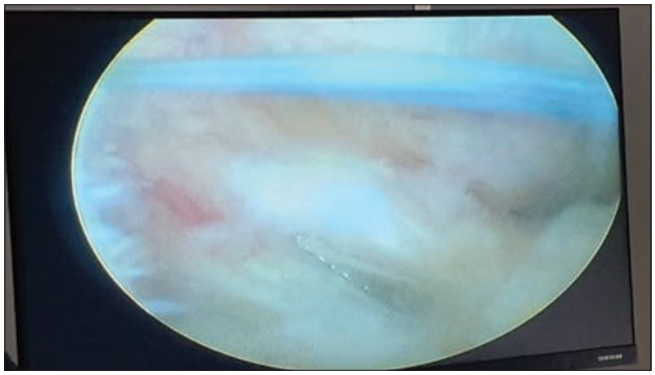


Figure 7: Vicryl suture passed through the femoral tunnel

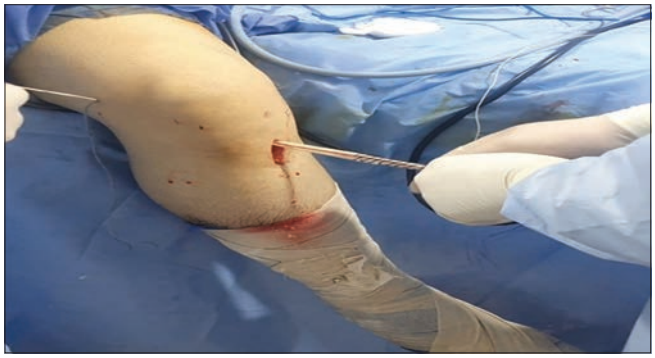


Figure 9: Graft passage

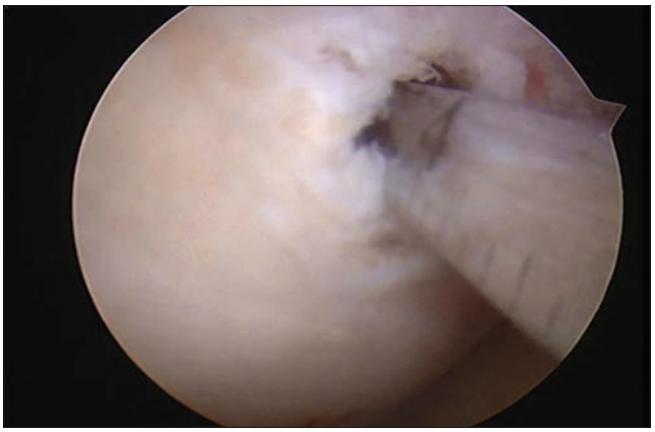


Figure 6: Measuring femoral tunnel with depth gauge

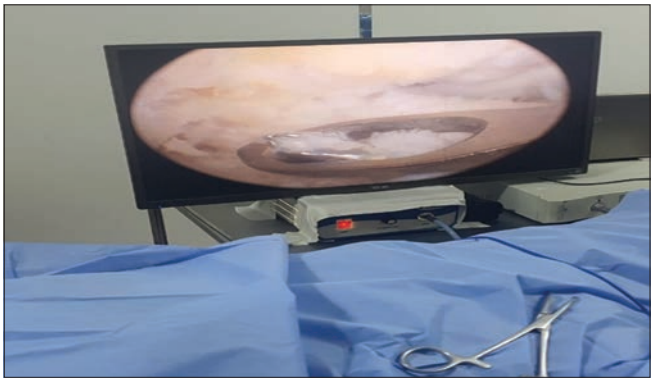


Figure 8: Tibial tunnel drilling

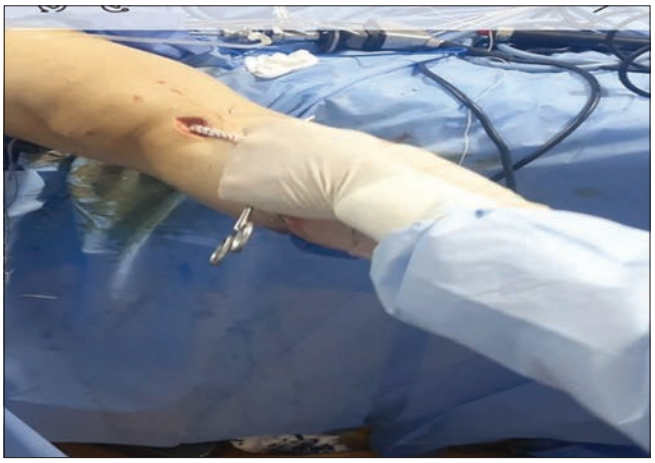


Figure 10: Tightening of the graft

data. The paired Wilcoxon test was used to calculate the difference between quantitative variables in the same group before and after therapy in nonnormally distributed data. The level of significance for all of the abovementioned statistical tests. The level of significance (*P* value) is set at 5%.

1. **P* > 0.05 implies that the results are not statistically significant
2. **P* = 0.05 implies that the results are significant
3. **P* < 0.01 implies highly significant results.

Results

Table 1 revealed the basic characters of the studied cases. There were 9 females and 21 males with age limits between 18 and 38 years with a mean of 25.64 ± 7.05 years, weight range was 55–97 kg with a mean of 79.13 ± 16.19 kg. The right side was reported in 19 patients, whereas the left side was in 11 patients. The mean duration of symptoms preoperatively averaged 3 months–1.5 years with a mean of 0.78 ± 0.23 years.

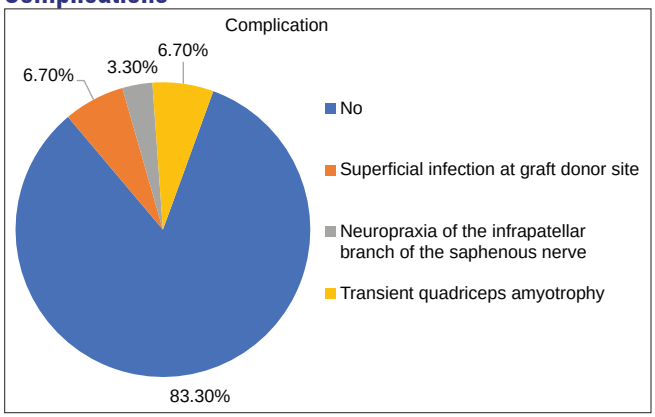
Assessment by Lysholm score

Regarding the overall result of all 30 patients in our investigation, the preoperative score had a mean value of 66.17 ± 10.39. At

2 years, the postoperative score was 96.1 ± 6.71, indicating a highly statistically significant improvement ($P = 0.001$). Except for support and stair climbing, all subscale scores increased significantly [Table 2].

Regarding the correlation between the percentage of change in Lysholm score[4] and different parameters among the studied cases, it was found that there was a statistically negative significant correlation between the percentage of change in score and age and duration of symptoms among the studied cases; whereas weight had no relation with change in score.

Complications



Discussion

In this study, 30 patients had partial ACL tear, 18 (60%) cases were undergone reconstruction of AM bundle preserving the PL bundle, whereas 12 (40%) cases were undergone reconstruction of the PL bundle preserving the AM bundle. This was near to those of Abat *et al*.[1] who had 28 cases of ACL insufficiency, 18 of them were of AM bundle tears (64.2%), whereas only 10 patients had PL bundle tear (35.8%). Sabat and Kumar[6] also operated 38 cases with partial ACL tear, 26 of them had AM bundle tear (68.4%), whereas 12 patients underwent PL bundle reconstruction (42.8%). This signifies that the incidence of AM bundle tear is higher than that of PM bundle [Table 3].

The age of our patients is ranging between 18-38 years with a mean (25.64 ± 7.05) which is near to that of Buda[2], whose patients was with a mean of age (23.3). It is also near to mean age of the pateints involved in the study of Sonnery cottet[7] which was of a mean of 28 years, while the mean of age of the cases included in the study of Pujol[8] was 32 years.

Table 1: Basic characters

Age (years)	
Mean±SD	25.64±7.05
Range	18–38
Sex, *n* (%)	
Male	27 (90)
Female	3 (10)
Weight (kg)	
Mean±SD	79.13±16.19
Range	55–97
Side, *n* (%)	
Right	19 (63.3)
Left	11 (36.7)
Type, *n* (%)	
AM bundle	18 (60)
PL bundle	12 (40)
Duration of pain till operation (years)	
Mean±SD	0.78±0.23
Range	0.25–1.5

SD: Standard deviation, PL: Posterolateral, AM: Anteromedial

Table 2: Lysholm score pre- and postoperative

Variable	Mean±SD		Percentage of change	*P*
	Pre	Post		
Limp	4.38±1.08	4.87±0.79	11.19	**0.04***
Support	5±0	5±0	0	1 (NS)
Locking	10.13±3.46	15.19±1.9	49.9	**<0.001****
Instability	15.37±3.08	22.84±2.64	48.6	**<0.001****
Pain	13.67±4.13	24.39±4.18	78.42	**<0.001****
Swelling	5.06±1.59	9.12±2.96	80.2	**<0.001****
Stair climbing	9.35±2.46	9.54±2.34	2.03	0.76 (NS)
Squatting	3.21±1.06	5.15±1.96	60.44	**<0.001****
Total	66.17±10.39	96.10±6.71	45.23	**<0.001****

**Highly significant ($P<0.001$). Paired *t*-test. SD: Standard deviation, NS: Not significant

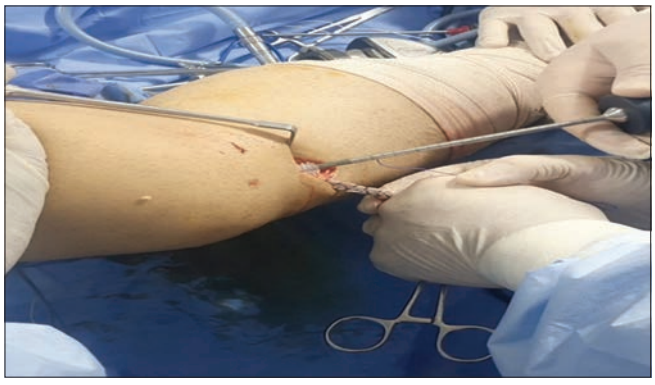


Figure 11: Fixation of the graft by interference screw

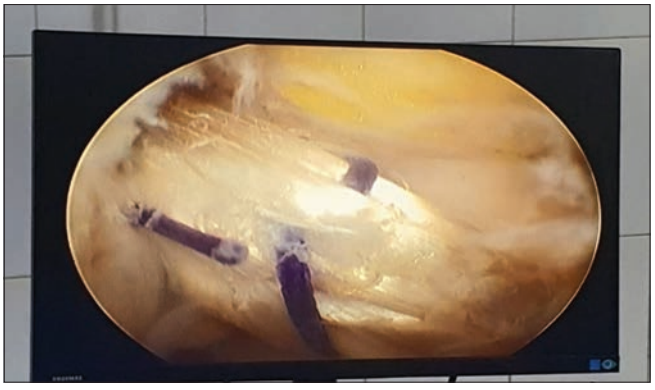


Figure 12: Arthroscopic probing of the graft

Table 3: Summary of comparison between our results and other's results mentioned in discussion section

	Our study	Other studies	Significance
AM bundle versus PL bundle	Our study: 30–18 cases, (60%) were undergone reconstruction of AM bundle preserving the PL bundle, while 12 cases (40%) were undergone reconstruction of PL bundle preserving the AM bundle	Abat who had 28 cases of ACL insufficiency, 18 of them was of AM bundle tears (64.2%) while only 10 patients had PL bundle tea (35.8%) Sabat operated 38 cases with partial ACL tear, 26 of them had AM bundle tear (68.4%), while 12 patients undergone PL bundle reconstruction (42.8%). This signifies that the incidence of AM bundle tear is higher than that of PM bundle	
Age of the patient	Our study: Is ranging between 18–38 years with a mean (7.05±25.64)	Buda: Patients was with a mean of age (23.3) Sonnery-Cottet: Patients who had a mean age 28 years, while the mean of age the study of Pujol was 32 years	It is a limitation in our study
Gender of the patient	Our study: Sex distribution was 27 males (90%) and 3 females (10%)	Abat: Sex distribution was 21 male (75%) and 7 female (25%) Buda: 32 male (68%) and 15 female (32%) Pujol: 16 male (55.1%) and 13 female (44.9%)	Significant improvement
Lysholm score	Our study: The total mean score showed highly significant improvement from (66.17±9.07) preoperatively to (96.10±3.4) postoperayively	Abat: The the total mean score of Lysholm score is increased from 65.4 points preoperative to 95.8 points postoperative In the study of Sonnery Cottet, the total mean score of Lysholm score is improved from 60.8 points preoperatively to 94.2 points postoperatively	This may be due to the young patients are having young healthy knees with minimal probability of developing degenerative changes
Variables *age	Our study: We found that there was a statistical –ve significant correlating between the percentage of change in score and the age among the studied cases which means the younger the patient, the better the prognosis of the patient	Osti performed 40 arthroscopic ACL surgeries on 20 middle-aged patients (12 men and 8 women) and 20 subjects younger than 30 years (control group) over a 24-month period and discovered that all variables improved significantly in both groups compared to preoperative values (*P* 0.05), with no significant intergroup difference. In his work Wierer operated 59 patients with ACL deficit. Group A comprised 39 patients (14 women and 25 men, with a median age of 27 years), while Group B had 20 patients (12 women and 8 men, with a median age of 45 years). During the final follow-up, there was no significant difference in the Lysholm score between groups A (median 90; range 68–100) and B (median 94.5; range 63–100)	This may be because the long duration may cause damaging effect to the structures of the knee such as articular cartilage and menisci due to the micro-instability caused by the partial ACL injury, also, partial ACL injury may progress into complete ACL which is found by other authors
Duration of symptoms*	Our study: We have found statistical negative significant correlating between the percentage of change in score and the duration of the onset of symptoms which means the shorter the duration between the onset of symptoms and the time of the procedure, the better the results	Fayard: Managed 30 cases of partial ACL tears conservatively over a mean of 43 months and discovered that the partial ACL damage escalated to total ACL tear in 16 patients (39%) Rai: Managed 351 partial ACL tear patients conservatively, with 166 (47.3%) patients progressing to a complete tear after a mean of 17.5 months, whereas the rupture in 185 (52.7%) patients remained stable and did not advance to a total tear	
Complications	Our study: We found only two individuals with superficial wound infection at the graft donor site which is managed by parentral antibiotics for one week and daily dressing, one patient with quadriceps amyotrophy due to unique neuropaxia, and two patients with neuropraxia of the infrapatellar branch of the saphenous nerve, they were managed by physiotherapy, rehabilitation and medical treatment. In our study, the complication rate was 16.67%	Abat noticed two cases exhibited a chronic extension deficit caused by Cyclops-like lesions in each. They were treated satisfactorily with arthroscopic shaving. Septic arthritis developed in one patient. For 6 weeks, the patient was treated with arthroscopic debridement and specialized antimicrobial therapy Sabat got complications in five patient. Two patients had persistent limited extension, one patient showed infection at graft site and two patient had neuropraxia of infrapatellar branch of saphenous nerve	

PL: Posterolateral, AM: Anteromedial, ACL: Anterior cruciate ligament

In our study, sex distribution was 27 (90%) males and 3 (10%) females, which is a limitation in our study in comparison with the sex distribution of the cases included in the study of Abat *et al*.[1] which was 21 (75%) males and 7 (25%) females. Buda *et al*.[2] had a sex distribution of 32 (68%) males and 15 (32%) females, Whereas Pujol *et al*.[8] had 16 (55.1%) males and 13 (44.9%) females. The generalization in our study is limited by gender of the patients as only 3 females participating in our study.

Lysholm knee scoring system was used to evaluate the results of this work. The total mean score showed a highly significant improvement from (66.17 ± 9.07) preoperatively to (96.10 ± 3.4) postoperatively.

Our results were near to those obtained by Abat *et al*.[1] in their study, the total mean score of Lysholm score is increased from 65.4 points preoperative to 95.8 points postoperative. In the study of Sonnery Cottet and Colombet[7] the total mean score of

Table 4: Correlation between percent of change in Lysholm score[4] and different parameters among the studied cases

Variable	Lysholm score	
	r	*P*
Age	−0.41	0.006*
Weight	0.06	0.84 (NS)
Duration	−0.52	<0.001**

*Significant (P<0.05), **Highly significant (P<0.001). *r*: Pearson's correlation coefficient, NS: Nonsignificant (P>0.05)

Lysholm score[4] is improved from 60.8 points preoperatively to 94.2 points postoperatively.

We have studied different variables which may affect the results. We found that there was a statistically negative significant correlation between the percentage of change in score and the age among the studied cases which means the younger the patient, the better the prognosis of the patient this may be due to the young patients are having young healthy knees with minimal probability of developing degenerative changes. These findings contrast with those of Osti *et al*.[9] performed 40 arthroscopic ACL surgeries on 20 middle-aged patients (12 men and 8 women) and 20 subjects younger than 30 years (control group) for 24 months and discovered that all variables improved significantly in both groups compared to preoperative values (P = 0.05), with no significant intergroup difference. In his work, Wierer *et al*.[10] also operated on 59 patients with ACL deficits. Group A comprised 39 patients (14 women and 25 men, with a median age of 27 years), whereas Group B had 20 patients (12 women and 8 men, with a median age of 45 years). During the final follow-up, there was no significant difference in the Lysholm score[4] between groups A (median 90; range 68–100) and B (median 94.5; range 63–100).

We have found a statistically negative significant correlation between the percentage of change in score and the duration of the onset of symptoms which means the shorter the duration between the onset of symptoms and the time of the procedure, the better the results. This may be because the long duration may cause damaging effects to the structures of the knee such as articular cartilage and menisci due to the microinstability caused by the partial ACL injury. Furthermore, the partial tear of the ACL may progress into a complete ACL tear in active patients. These results are similar to those obtained by Fayard *et al*.[11] They managed 30 cases of partial ACL tears conservatively over a mean of 43 months and discovered that the partial ACL damage escalated to total ACL tear in 16 (39%) patients. Similar results were achieved by Rai *et al*.[12] who managed 351 partial ACL tear patients conservatively, with 166 (47.3%) patients progressing to a complete tear after a mean of 17.5 months, whereas the rupture in 185 (52.7%) patients remained stable and did not advance to a total tear.

In our study the weight of the patient was insignificant. This may be because most of our patients were of average BMI [Table 4].

In our investigation, we found only two individuals with superficial wound infection at the graft donor site which is managed by parenteral antibiotics for 1 week and daily dressing, one patient with quadriceps amyotrophy due to unique neuropraxia, and two patients with neuropraxia of the infrapatellar branch of the saphenous nerve, they were managed by physiotherapy, rehabilitation, and medical treatment. In our study, the complication rate was 16.67%.

Complications have been described by several authors. Abat *et al*.[1] noticed two cases exhibited a chronic extension deficit caused by cyclops-like lesions in each. They were treated satisfactorily with arthroscopic shaving. Septic arthritis developed in one patient. For 6 weeks, the patient was treated with arthroscopic debridement and specialized antimicrobial therapy.

Sabat and Kumar[6] got complications in five patients. Two patients had persistent limited extension, one patient showed infection at the graft site and two patients had neuropraxia of the infrapatellar branch of the saphenous nerve.

Limitations

The generalization in our study is limited by the gender of the patients as only three females were participating in our study.

Conclusion

When you meet a case with recurrent knee pain and swelling related to effort, do a thorough clinical examination and radiological investigations, if the investigations were not conclusive of definite diagnosis, i.e. no osteochondral problems, no synovial pathology, no meniscal or ligamentous injury, partial ACL tear should be suspected. Partial ACL tear is a hidden cause of chronic knee pain and recurrent swelling, especially after exerting an effort in young adult and middle-aged people. It is called "hidden" as no definite sure diagnosis unless diagnostic knee arthroscopy and probing are done. MRI is not conclusive in all cases as the diagnosis of partial ACL tear is mainly confirmed by arthroscopic probing intraoperatively. The cause of pain and swelling is mainly referred to as the microinstability caused by the partial ACL injury. Postoperative results after ACL selective bundle reconstruction were very encour aging and significant. Partial ACL tear is a common hidden cause of chronic knee pain and swelling after exertion. Further researches should be done on a wider scale to search for other hidden causes, especially in the female gender.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Original Article

Is Arthroscopic Management of Synovial Chondromatosis of the Hip Enough?

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Abstract

Study Design: The design of the study was a retrospective case series. **Objective:** This study evaluated the clinical and radiological manifestations of synovial chondromatosis (SC) of the hip, along with the role of hip arthroscopy in the diagnosis and treatment of this pathologic condition and its postoperative curative effect. **Patients and Methods:** With a minimum 1-year follow-up, 13 hips with SC received arthroscopic surgery. Preoperatively and postoperatively, patients were assessed for hip pain using the modified Harris Hip Score and Nonarthritic Hip Score. **Results:** Considerable reduction in postoperative hip pain was observed in all cases, along with sufficient improvement in hip range of motion. **Conclusion:** Hip arthroscopy is a trusted and adequate treatment option for hip SC.

Keywords: Hip arthroscopy, hip pain, loose bodies of the hip, synovial chondromatosis

Introduction

Management of hip pathologies is a challenge, especially those that affect the articular cartilage and synovium.[1] Hip arthroscopy is a proper technique that has greatly aided in the identification and management of these pathological disorders. Synovial abnormalities like synovial chondromatosis (SC) are among the major indications of the arthroscopy of the hip.[1]

A feature of SC is intrasynovial metaplasia, which can lead to the development of many intracapsular cartilaginous loose bodies. Synovial hypertrophy and the development of numerous loose bodies were seen during arthroscopy. They can be either floating inside the joint capsule or adhering to the synovium. Usually, only one joint is affected by the illness. Following the knee, the hip joint is the one that is most usually impacted.[2-4]

Since the symptoms of the condition are nonspecific and develop gradually, it may take longer than 2 years to confirm the diagnosis because early imaging modalities are inconclusive. The patient usually complains of persistent hip pain, limited range of motion, limping, and catching. Investigations are usually plain radiograph, computed tomography (CT), and magnetic resonance imaging (MRI). Delayed treatment may cause complications like degenerative arthritis of the hip (osteoarthritis [OA]).[2-4]

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Hip arthroscopy is used as a tool not only for proper diagnosis but also for definitive management with a minimal complication rate and a minor recurrence rate (7%). It also provides a limited period to stay at the hospital and early rehabilitation with full weight bearing. However, hip arthroscopy is a technically difficult treatment due to the hip's complex construction and the bulky muscular wrap around it.[2]

The extraction of all dispersed loose bodies and diseased synovium will determine the disease's prognosis.[2]

Arthroscopically, the hip is formed of two compartments, the central compartment which is situated between the head's and the acetabulum's articular surfaces, as well as the peripheral extra-articular compartment. Distraction is mandatory to approach the central compartment arthroscopically, while flexion of the hip is preferred by us to approach the peripheral compartment. On the traction table, we preferred the supine position of the patient's decubitus during the procedure.[2]

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Hip arthroscopy is contraindicated in the presence of open wounds; debilitating disease, fibrous ankylosis, and morbid obesity.[3]

Patients and Methods

Between 2012 and 2018, 13 patients were the subject of this investigation. 1.5 years was the bare minimum follow-up length (mean, 3.25 years; range, 1.5–5 years). The modified Harris Hip Score (mHHS) and Nonarthritic Hip Score (NAHS)[2-4] were used to assess patients for hip pain. A thorough clinical assessment was conducted to the hip range of motion, an impingement test was done for all cases, and exclusion of referred pain from nearby regions such as the spine and knee was done.

For all patients, standard posteroanterior and lateral hip X-rays were taken. CT and MRI were done for all patients. CT is mainly to evaluate the joint condition to exclude degenerative changes and also to localize the site of the loose bodies. The classic MRI finding of SC is marked thickening and proliferation of the synovium. Calcified loose bodies are evident in plain X-rays, CT, and MRI. All 13 patients had hip arthroscopies.

Exclusion criteria

1. Hip degenerative disorders
2. Lower limb malalignment
3. Infection.

Surgical technique

In our study, we started our hip arthroscopic procedure by approaching the peripheral compartment, using general anesthesia on the fracture table [Figures 1-3], through the standard proximal and distal anterolateral portals [Figure 4] with a flexed hip to perform intracapsular synovectomy [Figure 5]; most of the loose bodies are removed during the procedure either by picking it up using grasper, if it is incarcerated, or by saline wash done throughout the procedure [Figures 5 and 6].

To complete our arthroscopic procedure, we approach the central compartment using traction against a thick perineal post, through the standard anterolateral and the anterior portals to get access to evaluate the articular surface and to extract loose bodies in the fovea within the acetabular cavity.

For the staging of the disease's pathological phase, we adopted Milgram's[5] staging approach. Stage I consists of synovial cartilaginous metaplasia without loose bodies, stage II of synovial cartilaginous metaplasia with production of loose bodies, and stage III of loose bodies without active synovial cartilaginous metaplasia.

Follow-up

Visits were made at intervals of 2 weeks, 1 month, 3 months, 6 months, and 1 year. Patients were evaluated clinically using mHHS and NAHS at each visit.

Statistical analysis

The SPSS program (Statistical Package for the Social Sciences), version 25.0 (IBM company, Chicago, USA), was used to computerize and statistically analyze the obtained data. Frequencies and relative percentages were used to depict qualitative data. Standard deviation (SD) was used to express quantitative data as mean. The difference between quantitative variables in the same group before and after therapy was calculated using the paired sample *t*-test on normally distributed data. The level of significance for the completed statistical tests is indicated above. Results with $P > 0.05$ are considered nonsignificant, whereas those with $P = 0.05$ are considered significant. Results with $P = 0.001$ are considered very significant. Following are the calculations for the percent of change: ([postvalue-prevalue]/prevalue) × 100 = % of change. The basic characters of the studied cases are listed in Table 1.

Assessment by the Nonarthritic Hip Score [Table 2]

Preoperative scores had a mean value of 36.62 with 8.37 SD when it came to total results. The postoperative score at 6 months, 1 year, and the last follow-up was of the mean value 66.77, 62.54, and 62.38, respectively. The average improvement was 26 points (percentage of improvement 77.32%). With $P < 0.001$, the NAHS improvement postoperatively at 6 months, 1 year, and the last follow-up was statistically highly significant when compared to the preoperative values.

Assessment by the modified Harris Hip Score [Table 3]

The preoperative score had a mean value of 37 and an SD of 6.32 when it came to the overall outcome of all the study participants. The postoperative score was 75.69, 69.46, and 69.46 at 6 months, 1 year, and the final follow-up, respectively; the mean improvement was 32 points (improvement percentage: 86.33%). The improvement of the mHHs at 6 months, 1 year, and the last follow-up postoperatively was statistically highly significant versus preoperative with $P < 0.001$.

Regarding the relation between the percent of change in the mHHs and NAHS score and different parameters [Table 4] among the studied cases, it was found that there was a statistically negative significant correlation between % of the change in both score and age and duration of symptoms among the studied cases, while weight and Milgram[5] stage had no relation with change in scores.

Complications

Only a single patient in our clinical trial had femoral nerve neurapraxia which spontaneously improved within 2 months later with a complication rate in our study (7.69%). Three patients (23.1%) showed recurrence of the pathology, two of them have been recommended for another arthroscopy or open surgery, and one of them with degenerative changes in the hip joint and has been recommended for total hip arthroplasty. In all other cases, the postoperative rehabilitation regimen revealed total recovery.

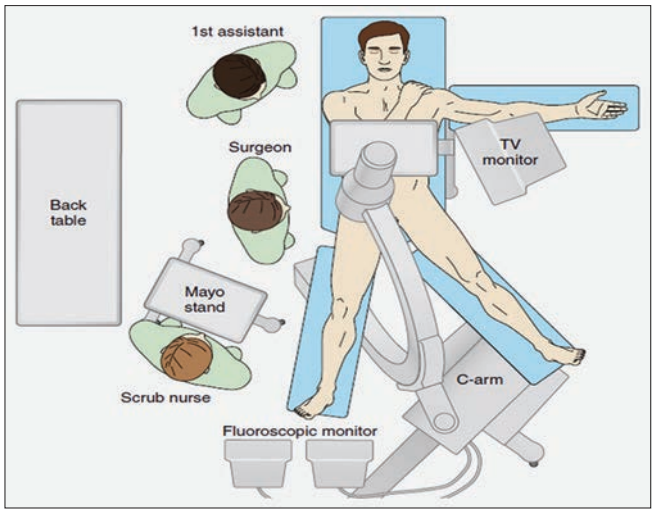

Figure 1: The operative theater

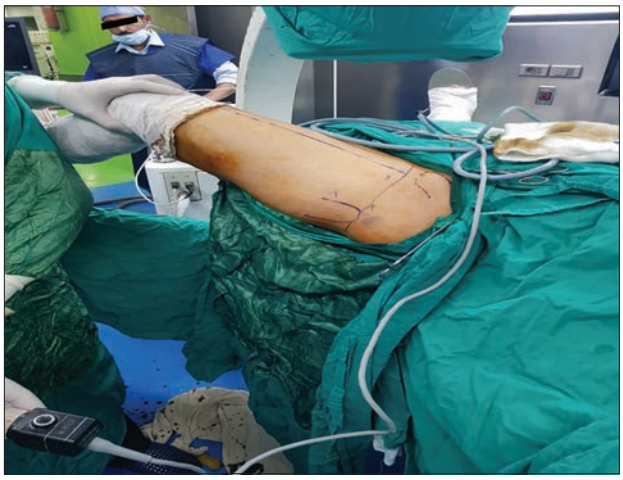

Figure 3: Anatomical landmarks and safe zone

Discussion

Regarding the patients' overall results in the trial, the mean NAHS scores increased from 36.62 ± 8.37 before surgery to 62.38 ± 11.23 2 years later (mean improvement = 25.76), while the mean mHHS scores increased from 37 ± 6.32 before surgery to 69.46 ± 16.39 2 years afterward (mean improvement = 32.46). That is supported by the results of Boyer and Dorfmann[6] who performed 116 cases of subtotal synovectomy and loose bodies extraction using the hip scope, among which 51 cases of single arthroscopy was enough, while 23 cases needed more than one arthroscopy and 42 cases required open surgery.

In our study, the disease activity as assessed by Milgram[5] staging did not appear to influence either the prognosis of the disease or the postoperative improvement or the recurrence rate. This finding is similar to that got by Boyer and Dorfmann[6] who also found no significant link between Milgram[6] classification and the prognosis of the disease after arthroscopic management.

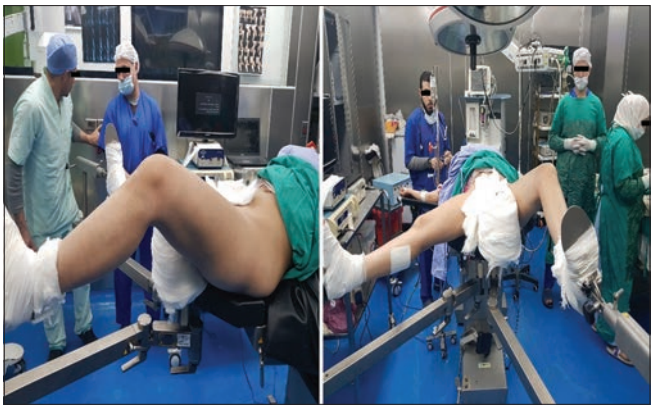

Figure 2: Patient positioning and the wide perineal post

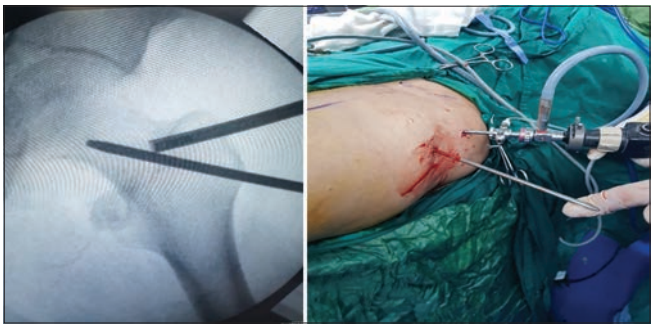

Figure 4: Access to the peripheral compartment

Table 1: Basic characters of the studied cases

Variable	*n*=13, *n* (%)
Age (years), mean±SD	26.69±7.13
Sex	
Male	7 (53.8)
Female	6 (46.2)
Weight (kg), mean±SD	81±15.47
Side	
Right	10 (76.9)
Left	3 (23.1)
Duration (years), mean±SD	2.47±1.01
Symptoms	
Groin pain	13 (100)
Limited range of motion	13 (100)
Catching sensations	9 (69.2)
Surgical history	
Positive	11 (84.6)
Negative	2 (15.4)
Milgram staging	
Stage 1	4 (30.7)
Stage 2	6 (46.2)
Stage 3	3 (23.1)

SD: Standard deviation

The age of the patient was of significant relationship with the prognosis of the disease. The older the patient, the poorer the prognosis; this may be related to the unhealthy articular cartilage of the joint with the aging process. This result is near

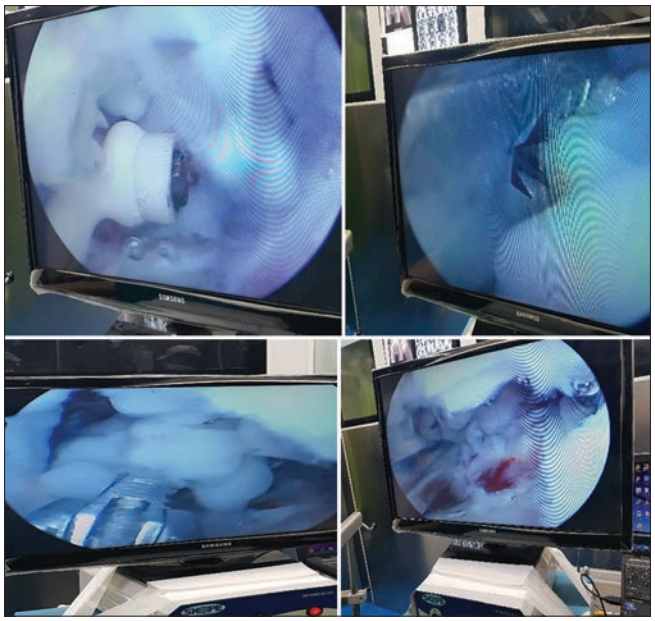

Figure 5: Arthroscopic synovectomy and loose bodies removal

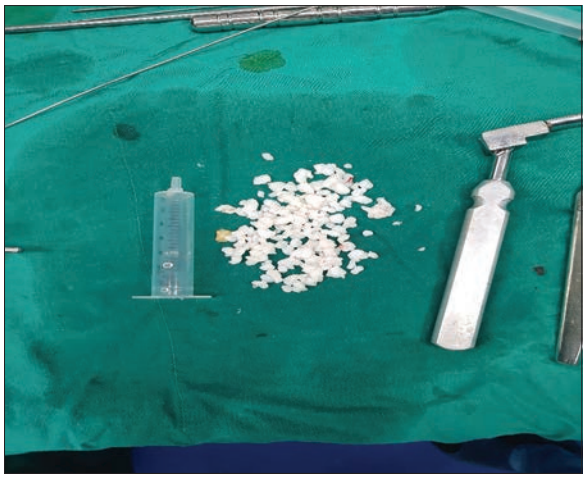

Figure 6: Loose bodies after extraction and lavage

Table 2: The Nonarthritic Hip Score pre- and postoperative

Variable	Mean±SD	Range	*P* (vs. pre)
Pre-NAHS	36.62±8.37	21–48	-
6-month NAHS	66.77±7.08	56–84	<0.001**
1-year NAHS	62.54±11.35	45–85	<0.001**
Last follow-up	62.38±11.23	45–84	<0.001**

**Highly significant (*P*<0.001), paired *t*-test. SD: Standard deviation, NAHS: Nonarthritic Hip Score

Table 3: The modified Harris Hip Score pre- and postoperative

Variable	Mean±SD	Range	*P* (vs. pre)
Pre-NAHS	37±6.32	26–44	-
6-month NAHS	75.69±12.35	44–89	<0.001**
1-year NAHS	69.46±16.48	35–89	<0.001**
Last follow-up	69.46±16.39	35–84	<0.001**

**Highly significant (*P*<0.001), paired *t*-test. SD: Standard deviation, NAHS: Nonarthritic Hip Score

Table 4: Correlation between the percentage of change in the modified Harris Hip Score and Nonarthritic Hip Score and different parameters among the studied cases

Variable	mHHs		NAHS	
	r	*P*	*r*	*P*
Age	−0.34	0.02*	0.36	0.01*
Weight	0.12	0.78 (NS)	0.03	0.93 (NS)
Duration	−0.40	<0.001**	−0.46	<0.001**
Milgram	0.23	0.28 (NS)	0.19	0.63 (NS)

*Significant (*P*<0.05), **Highly significant (*P*<0.001), Pearson's correlation coefficient (*P*>0.05). NS: Nonsignificant, mHHs: Modified Harris Hip Score, NAHS: Nonarthritic Hip Score

to that found by Lim *et al*.[7] who operated 21 hips with SC and found a significant link between the age of the patient of SC and the possibility to develop hip severe OA after surgical management.

We found in our study that the duration of symptoms before the operative procedure is of negative correlation with the prognosis of the patient; this may be due to the occurrence of degenerative changes in the hip with the long-standing pathology. This finding is supported by the data collected by Iyengar *et al*.[8] in his retrospective cohort analysis of primary SC.

Only one patient in our study's 13 cases had femoral nerve neurapraxia, and three other patients had recurrence, but no other major problems, including infections or thrombosis, were present.

We suggest that neuropraxia may occur mainly due to the high magnitude of the force of the traction. Furthermore, the longer the duration of traction time, the higher the incidence of neuropraxia. This complication is inhibited by avoiding the high force of traction and by admitting the protocol of intermittent traction when we operate on the central compartment, limiting the traction time by approaching the peripheral compartment, adequate positioning of the patients, and adequate padding of the perineal post.

Many authors have discovered problems with traction. In 60 cases of hip arthroscopy, Glick[9] described eight individuals with transient neurapraxia. Sciatic neuropraxia is found in four cases and the others had pudendal nerve affection, but all recovered fully. Brumback *et al*.[10] described that the main cause of pudendal nerve neuropraxia is connected to the amplitude of the intraoperative traction force. Sampson[11] discovered a 5.5% complication rate in 530 hip arthroscopy procedures. 0.5% of them were long-term, and 5% have completely recovered. The transient neuropraxia of the femoral, sciatic, pudendal, and lateral cutaneous nerves of the thigh was the most frequent consequence.

Our recurrence rate is 23%, which is an accepted rate in comparison to that estimated by Boyer and Dorfmann[6] who performed 116 cases of subtotal synovectomy and loose bodies extraction using the hip scope, among which 51 cases of single arthroscopy were enough, while 23 cases needed more than one arthroscopy and 42 cases required open surgery, with recurrence rate about 56%. Lee *et al*.[12] have arthroscopically operated on 24 cases of hip SC, with recurrence in four patients (16.7%). Recurrence mainly is due to inadequate synovectomy of the hip. Little amount of residual loose bodies in the hip is also a common finding after arthroscopies with most surgeons, but it is of little significance because they rarely become incarcerated in between the articular surfaces.

Although open hip arthroplasties in cases of SC have received favorable reviews and have a low recurrence incidence, they come with a significant risk of AVN of the femoral head, a longer hospital stay, and the potential for surgical wound complications. Schoeniger *et al*.[13] performed open synovectomy on eight patients with SC after at least 4 years of follow-up with no recurrence; however, THA was later done on two cases. With an open synovectomy, Lim *et al*.[7] also had successful results in 21 instances with SC with a mean follow-up of 4.4 years and a low recurrence rate. Four cases with SC of the hip were operated on by McIvor[14] using open synovectomy and loose bodies excision with good clinical prognosis and no recurrence; however, still, the arthroscopic procedure, although it requires a lot of technical skills and has a steep learning curve, is of a great benefit over open arthrotomy as it avoids the complications of open surgery and no need for a long time of hospital stay or long rehabilitation program and with results as good as of those of open arthrotomy. The limited recurrence rate of arthroscopy mainly depends on how much synovium is removed and how much is still there.

Conclusion

The treatment of hip SC with arthroscopic loose body removal and subtotal synovectomy is relatively successful, and patients recover quickly, making it an effective treatment with good postsurgical outcomes.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Original Article

Arthroscopically Assisted Technique in the Treatment of Ankle Fractures with Posterior Malleolus Fragment in Adults

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Abstract

Introduction: Ankle fractures constitute a challenging condition due to its high impact on the long term. Thus, advancements in management have been proposed to ensure the best possible outcome. Hence, we aimed to assess the role of arthroscopy in the treatment of ankle fractures that involve posterior malleolus fragments in adults. **Patients and Methods:** In a quasi-experimental, interventional, prospective, nonrandomized study, we included 16 adult patients with acute ankle fracture with posterior malleolus fragment. They underwent arthroscopically assisted technique for their fracture treatment. A standard systematic arthroscopic ankle examination, their fracture grade, and classification were assessed, and subsequent management was conducted. The patients were followed up for 6 months using the American Orthopedic Foot and Ankle Society (AOFAS) score and radiographic monitoring with standard X-ray. **Results:** The mean AOFAS score improved significantly after 6 months of follow-up (from 84.81 in the 3rd month to 92.81 in the 6th month). Ankle dorsiflexion angle and ankle plantar-flexion angle showed a gradual increase during follow-up, reaching 17.31° ± 3.25° and 45° ± 5°, respectively. Only two patients developed complications. Age, body mass index, and grade of the osteochondral lesion were negatively correlated statistically significantly with the AOFAS score. This proves the effective role of arthroscopically assisted technique in the treatment of ankle fractures with posterior malleolus fragment. **Conclusion:** Arthroscopically assisted technique in the treatment of ankle fractures with posterior malleolus fragment in adults resulted in good functional outcomes with less complications and it allows the assessment of associated intra-articular injuries. Further studies with longer follow-up periods are needed for the assessment of outcomes and complications for comparison.

Keywords: American Orthopedic Foot and Ankle Society, ankle fracture, arthroscopy, posterior malleolus

Introduction

Ankle fracture is a common injury with potentially significant morbidity. The affected age groups most commonly include young, active patients who have suffered high-energy trauma and older patients with comorbidities. Ankle fractures account for 9% of all fractures and 36% of all lower-extremity fractures. Complex ankle fractures may be associated with fracture dislocation or the appearance of a posterior malleolus fragment, and they result in poorer long-term outcomes.[1]

Ankle fracture with posterior malleolar fragment occurs in 7% of all ankle fractures. However, isolated posterior ankle fractures are rare.[2] It is usually associated with intra-articular cartilage and soft-tissue injuries. In addition, inadequate ankle fracture reduction leads to poor outcomes and persistent chronic pain, stiffness, recurrent swelling, and instability.[3] Surgical treatment with open reduction and internal fixation is the standard of care for unstable or displaced ankle fractures, with the primary goal of anatomical realignment of the joint and restoration of ankle stability.[1] However, even a successful anatomical reduction does not automatically lead to a favorable clinical outcome, as associated intra-articular injuries are overlooked.[4]

Today, arthroscopy is considered the gold standard method for diagnosing intra-articular injuries and is increasingly used as a visual aid in the reduction and fixation of intra-articular

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fractures, as it offers a direct way to visualize intra-articular structures and proper diagnosis and treatment.[5] For ankle fractures, arthroscopically assisted open reduction and internal fixation allows confirmation of anatomical reduction, and careful examination of the cartilage and intra-articular ligaments.[6] In this study, we aimed to assess the role of arthroscopy in the treatment of ankle fractures with posterior malleolus fragments in adults. The primary objective of this study is to evaluate the clinical functional and radiological outcomes following arthroscopic assisted reduction and fixation of ankle fractures with posterior malleolus fragment and assessment of this technique's efficacy.

Patients and Methods

In a quasi-experimental, interventional, prospective nonrandomized study that received approval from the institutional research board (approval # 4354), inclusion criteria were: 16 adult patients aged between 19 and 60 years with acute ankle fracture associated with posterior malleolus fragment who were admitted to orthopedic surgery emergency department. Patients with signs of infection around the ankle, plafond or pilon injury, Charcot joint arthropathy, diabetic foot, or malunited or delayed union fractures around the ankle were excluded from the study.

Written informed consent was obtained from all patients. Preoperative evaluation included thorough history taking of personal data, medical history, and general and local examination of the ankle. Investigations included standard X-ray ankle (antroposterior, lateral, and mortise views) plus computed tomography scanning to classify and define the fracture pattern.

Operative technique

under spinal or general anesthesia (2 patients under general anesthesia due to a history of spinal fixation and 14 patients under spinal anesthesia), a thigh tourniquet was inflated, the patient was positioned in the floppy lateral position, a standard systematic arthroscopic ankle examination was performed through the standard anteromedial and anterolateral portals for hematoma evacuation and loose body removal using a 4 mm or 2.7 mm, 30° arthroscopy after inflation of joint by 10 ml saline. The pattern of each fragment of the fracture determined the method of fixation. Posterolateral approach [Figure 1] to the ankle was used to manage both posterior and lateral malleolus fracture. The lateral malleolus fracture was fixed by one-third tubular plate and screws, and the posterior fragment was fixed by plate and screws or lag screws only from posterior to anterior according to fragment size. The medial malleolus fracture was fixed by two cannulated screws or tension bands according to fragment size through separate direct medial incisions. Syndesmotic stability was assessed by external rotation, hook test, and direct arthroscopic visualization. If syndesmotic instability was confirmed, a syndesmotic tricortical fully threaded 3.5 mm cortical screw was inserted 30° from posterior to anterior parallel to the tibial plafond

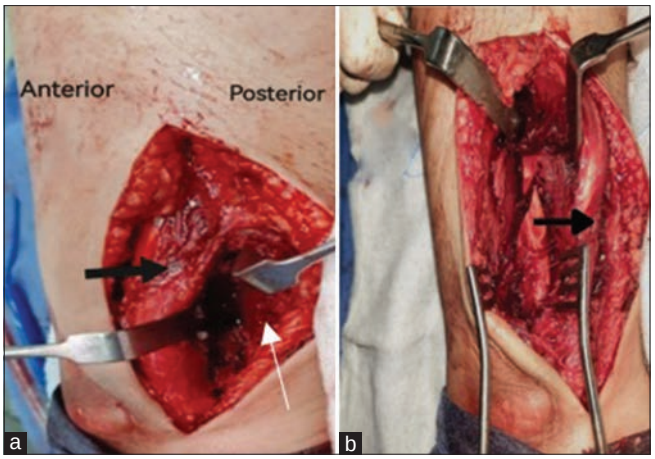

Figure 1: Ankle posterolateral approach. Black arrows refer to peroneal muscles white arrow refer to flexor hallucis longus. (a) Exposure of posterior malleolus through interval between peroneal and flexor hallucis longus muscles, (b) exposure of lateral malleolus

and 2–3 cm above the ankle joint while the ankle was in a neutral position. After reaching optimal reduction and fixation radiologically, a second look with an arthroscope was done to confirm accurate direct visual anatomical reduction [Figure 2] and syndesmotic reduction.

Debridement and micro drilling of the associated osteochondral lesion were done if needed. Grade and locations of any intra-articular lesions, such as chondral lesions, ligamentous damage, course of wound healing, and posttraumatic activity level, were evaluated and documented. Lesions of the articular cartilage were graded according to the depth and localization. The classification system postulated by the International Cartilage Repair Society (ICRS) focusing on lesion depth (grades 0–4) was applied.[7]

Postoperative measures

Routine immobilization of the ankle in a slab for 4 weeks. Assisted passive ankle movement was tried 1 week later as the patient could tolerate it. Removal of sutures was done by 14 days postoperative. Partial weight bearing was allowed for 6 weeks postoperatively, followed by progressive weight bearing to tolerance. The syndesmotic screw was removed after 8–12 weeks. Follow-up visits were at 2 weeks for suture removal, and then at 1 month, 3rd month, and then 6th month. The American Orthopedic Foot and Ankle Society (AOFAS) score was used for the evaluation after 3 and 6 months, in addition to radiographic analyses X-ray with antroposterior, lateral radiographs, and mortise view at each follow-up visit [Figure 3] to evaluate for syndesmotic reduction, loss of fixation, and hardware failure.

Data analysis was performed using the SPSS (Statistical Package for the Social Sciences) (version 25.0, SPSS Inc. (IBM Corp., Armonk, NY)). Shapiro–Wilk test of normality was carried out to all the data, including demographic data, and then, appropriate statistical analysis was applied to assess the improvement of function, foot alignment as well as ankle

pain in everyday-life activities expressed as scores, where Student's *t*-test was used for the normally distributed variables, while Wilcoxon signed-rank test was used for the variables not following the normal distribution.

$P < 0.05$ is statistically significant in all analyses.

Results

Sixteen patients with acute ankle fracture with posterior malleolar fragment underwent arthroscopic-assisted reduction and fixation technique; details of their characteristics are shown in Table 1. Fourteen had a B3 fracture based on AO classification (two remaining type one A3 and C, 10 patients had type I posterior malleolus fracture pattern according to Haraguchi classification (type II four patients and type III two patients). Posterior fragment size ranged from 15% to 35% of tibial plafond with a mean of 29.9% ± 7.8%; however, fragment size had no statistical influence on the functional outcome. Eleven patients underwent posterior malleolus fixation, of whom seven by plate and screws and four patients by screws only. Osteochondral lesions were found at variable sites but mostly on the talus. Five patients had grade III osteochondral ulcers [Table 2]. A syndesmotic screw was used in seven patients after confirmation of syndesmotic instability intraoperatively radiologically and arthroscopic.

The mean AOFAS score improved significantly after 6 months of follow-up (from 84.81 to 92.81) [Figure 4]. By the end of the follow-up period, 12 (75%) patients achieved excellent AOFAS scores [Figure 5] and one patient had poor outcomes (most probably due to obesity and old age). Ankle dorsiflexion angle and ankle planter-flexion angle showed a gradual increase during follow-up, reaching 17.31° ± 3.25° and 45° ± 5°, respectively [Figures 6 and 7]. Only two patients developed complications (one superficial infection and one delayed union).

Among the studied parameters, age, body mass index (BMI), and grade of osteochondral ulcer were negatively correlated with the AOFAS score, and it was statistically significant $P \leq 0.05$ [Table 3].

Discussion

This quasi-experimental prospective interventional study included 16 patients and showed improvement in functional

Table 1: Characteristics and risk factors of participants

Variables	*n*=16, *n* (%)
Age, mean±SD	35.3±11.8
BMI, mean±SD	26.3±3.1
Gender	
Male	11 (68.7)
Female	5 (31.3)
Smoking	6 (37.5)
Diabetes	2 (12.5)
Hypertension	3 (18.8)

SD: Standard deviation, BMI: Body mass index

Table 2: Characteristics of fracture

	n=16, *n* (%)
Affected site	
Right	7 (43.8)
Left	9 (56.2)
AO fracture classification	
A3	1 (6.3)
B3	14 (87.5)
C	1 (6.3)
Haraguchi classification	
Type 1	10 (62.5)
Type 2	4 (25)
Type 3	2 (12.5)
Site of osteochondral lesion	
Multifocal lesion (talar and tibial)	3 (18.7)
Talar lesions	6 (37.5)
Medial	5 (31.2)
Lateral	1 (6.3)
Osteochondral ulcer grading	
I	1 (6.3)
II	2 (12.5)
III	5 (31.2)
IV	1 (6.3)

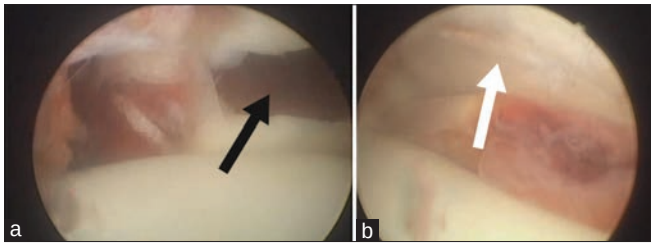

Figure 2: Arthroscopic assessment of posterior malleolus fracture reduction. (a) Black arrow displaced fracture posterior malleolus, (b) White arrow show well-reduced fracture fragment

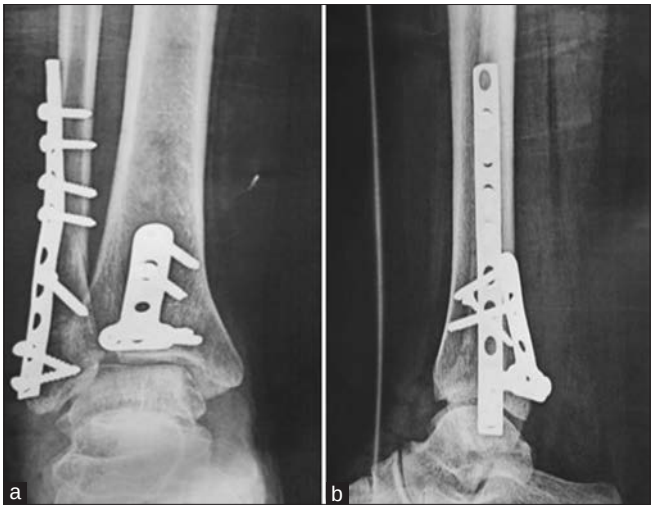

Figure 3: Follow-up after 6 months shows fully united fracture as shown in (a) anteroposterior, (b) lateral view

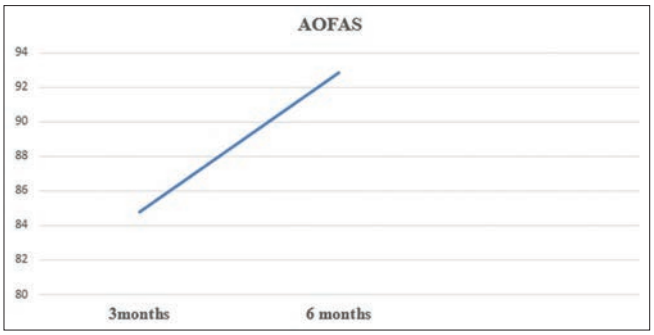

Figure 4: American Orthopedic Foot and Ankle Society scores during follow-up period shows increase follow score at 3 and 6 months follow-up. AOFAS: American Orthopedic Foot and Ankle Society

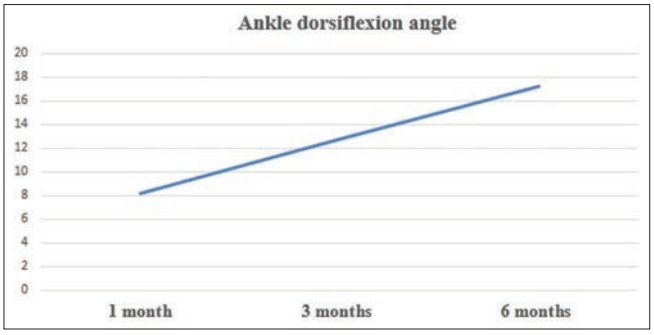

Figure 6: Ankle dorsiflexion angle assessment during follow-up period show gradual increase in range at 1, 3, and 6 months follow up

Table 3: Correlation between age, body mass index, and osteochondral ulcer grade and final American Orthopedic Foot and Ankle Society score

	R	*P*
Age	−0.649	0.006
BMI	−0.829	<0.001
Ulcer grade	−0.535	0.03

BMI: Body mass index

outcomes of all patients at the end of the follow-up period. Most cases showed excellent and good outcomes according to the AOFAS assessment. Age, BMI, and grade of associated osteochondral injuries showed a statistically significant negative correlation with outcome. Majority of cases show a B3 fracture pattern according to the AO/OTA classification of ankle fractures. Furthermore, most of the cases presented with type I pattern of posterior malleolus according to Haraguchi classification. Most associated osteochondral lesions were talar lesions with different grades but mainly grade III.

Baumbach *et al*. reported significantly higher functional improvement with arthroscopic reduction internal fixation (ARIF).[8] While Fuchs *et al*. reported no significant difference in the clinical outcomes of patients with ankle fractures who underwent ankle ORIF and ARIF.[9]

In the current study, according to the AOFAS assessment, there was a gradual increase in scoring during the follow-up period.

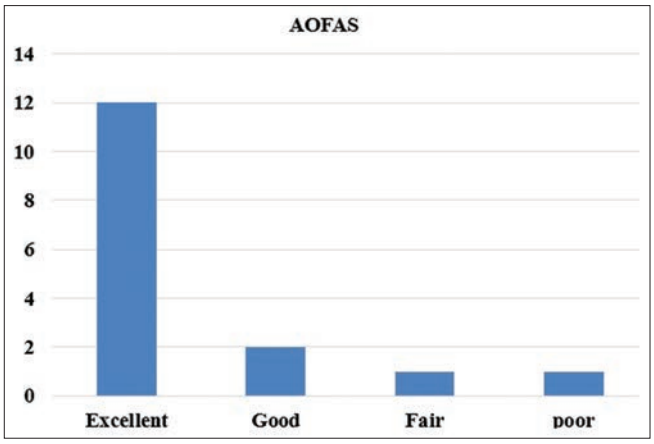

Figure 5: Grades of final American Orthopedic Foot and Ankle Society scores shows that outcome was excellent for 12 patients good for two patients, fair for one and poor for one patient. AOFAS: American Orthopedic Foot and Ankle Society

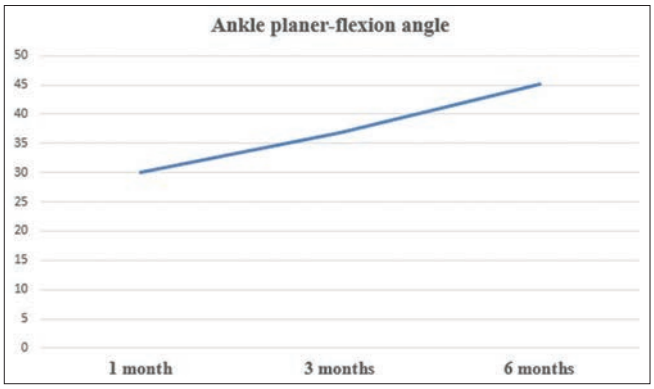

Figure 7: Ankle planter flexion angle assessment during follow-up period show gradual increase in range at 1, 3, and 6 months follow-up

This is in line with Braunstein *et al*., the median AOFAS was 94 for all patients.[10] Similarly, Weigelt *et al*. reported a median AOFAS score of 96 at the final follow-up.[11] This agrees with, but to a lesser extent, Drijfhout van Hooff *et al*., who found long-term outcomes of medium to large posterior malleolus fractures with AOFAS scores are 88.[12] A lower score was found in a study by Martin *et al*., as postoperative AOFAS was 85 among patients who underwent arthroscopic reduction and internal fixation.[13]

Using arthroscopic-assisted posterior malleolar fracture, a study by Diab shows all patients had successful reductions. All patients were back to their preinjury activity levels and satisfied with the results.[14] This is confirmed by our findings as around 75% excellent AOFAS scores, yet this was after only 6 months of follow-up. Further follow-up could have revealed much better outcomes. Ono *et al*. performed fixation of 105 malleolar fractures using arthroscopy to verify anatomic reduction and treat intra-articular abnormalities.[15] Patients reported overall favorable outcomes after a 3.8-year average follow-up period. In disagreement with our results, Stufkens *et al*. reported that only 58.1% of 1822 patients who were followed for more than

4 years postoperatively had outstanding or excellent outcomes regardless of the kind of surgical care they underwent.[16] Possible explanations for these varying outcomes and levels of satisfaction include injury to the cartilage that went undetected either because of poor vision or the inflammatory causes.

Our results show that most patients (87.5%) had a B3 fracture pattern. According to De Vries *et al*., after AO categorization, most patients with posterior malleolar fragment ankle fractures were assigned to the type B category (75.6%) as well.[17] In line with our results, Hintermann *et al*. found, based on radiographs, fractures were categorized according to the AO classification; the highest percentage was recorded in type B then type C and A.[18]

According to the classification developed in 2006 by Haraguchi *et al*. which classified posterior malleolus fracture into three distinct types.[19] Our study shows 62.5% of the cases were categorized as type I; 25% as type II; and 12.5% as type III. Concomitantly, Fidan *et al*. found that the posterior malleolus fractures were classified as Haraguchi type I in 69.2%, Haraguchi type II in 18.5%, and Haraguchi type III in eight patients 12.3%.[20] In contrast to our results, Martin *et al*., 2021 found that 46.4% of posterior malleolus fragment are classified by Haraguchi type I, and the vast majority (50%) are type II, and 3.5% type III.[13] Again, Taki and Hio, 2022 found that 36.4% had type I and 63.6% had type II as well.[21]

In our study, 44% of patients had syndesmotic injury which was confirmed both radiologically and arthroscopic. Takao *et al*. conducted a study on 38 patients with distal fibular fractures of Denis-Weber type B. Anteroposterior radiography revealed tibiofibular syndesmosis disturbances in 42% of patients, mortise radiography in 55% of patients, and ankle arthroscopy in 87% of patients, according to the study's findings.[22]

In addition, Lui *et al*. observed that 66.0% of their patients had positive arthroscopic findings of syndesmosis diastasis, while only 30.2% had positive intraoperative stress radiographs.[23] A higher proportion was detected by Martin *et al.*, who found 75% syndesmosis incongruity among patients with trimalleolar ankle fractures.[13]

In the present study, osteochondral lesion represents 56.2%, 3 of them had multifocal lesions (talar and tibial), 6 patients had solely talar lesions, 5 of them had medial talar lesions, and one had lateral lesions. According to ICRS, 9 patients were identified as suffering from osteochondral lesions, 1 patient was Grade I, 2 patients were Grade II, 5 patients were Grade III, and 1 patient was Grade IV.

The frequency of osteochondral lesions in acute ankle fracture, which have been demonstrated to be an independent predictor of the development of posttraumatic osteoarthritis, ranged from 20.0% to 88.9%, with a mean incidence of 63.3%, based on a systematic review by Chen *et al*.[24] Furthermore, Loren and Ferkel agreed that osteochondral lesions measuring >5 mm in diameter, were identified in 30 of the 48 ankles (63%), with 11 lesions localized to the tibia and 19 noted on the talus.[25]

A study by Hintermann *et al*. showed a higher prevalence of osteochondral lesions than in our study as 228 out of 288 patients (79.2%) had acute ankle fractures together with chondral lesions.[18] The same as a study by Leontaritis *et al*., 61 out of 84 individuals were found to have chondral lesions (73%).[26]

Similarly, Utsugi *et al*. reported a greater incidence of osteochondral injury identified by arthroscopy in patients with worse functional outcomes after open treatment of ankle fractures.[27] A possible explanation of the osteochondral lesions is that the likelihood of a chondral lesion would occur with a more unstable fracture. Furthermore, osteochondral defect increases with the severity of the fracture which may explain the variations between the studies.

In the current study, only two patients developed complications during follow-up, one developed signs of superficial infection and one had delayed union, superficial infection responds well to daily dressing and antibiotics.

Delayed union followed by serial radiographs and infection profile till developed union at 8 months. Similar studies stated minimal postoperative complications after arthroscopy in the treatment of ankle fractures. Martin *et al*. agreed that there was one case of persistent sural nerve numbness and one case of cellulitis, which resolved with oral antibiotics.[13] In consistency, Braunstein *et al*. found that complications were observed in three patients, two with superficial skin necrosis at the posterolateral incision, and one with nonunion.[10] Ono *et al*. discovered no postoperative complications when using arthroscopy to treat intra-articular lesions during the fixation of malleolar fractures.[15]

Conclusion

Arthroscopically assisted technique in the treatment of ankle fractures with posterior malleolus fragment in adults resulted in good functional outcomes with less complications and it allows the assessment of associated intra-articular injuries. Further studies with longer follow-up periods are needed for the assessment of outcomes and complications for comparison.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Original Article

Functional and Radiological Outcomes Following Arthroscopic-Assisted Reduction and Fixation of Intra-Articular Distal Radius Fractures

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Abstract

Background: Intra-articular distal radius fractures (DRFs) are prevalent injuries that are usually difficult to treat and rehabilitate. These injuries may be associated with ligamentous injuries or intra-articular loose fragments. This study aims to assess the functional and radiological results of using arthroscopic-assisted reduction and fixation, which offers direct visualization of the joint surface, evaluation of intra-articular ligaments, and removal of loose fragments, potentially enhancing recovery outcomes. **Patients and Methods:** This quasi-experimental interventional study evaluated the functional and radiological outcomes of arthroscopic-assisted reduction and fixation for intra-articular DRFs. The study included 26 patients who met specific inclusion criteria, and data collection involved preoperative assessment, patient preparation, operative measures, postoperative care, and follow-up evaluations using various scoring systems. **Results:** The range of motion showed a significant ($P < 0.001$) improvement over the study duration: flexion increased from 42.81° ± 11.81° at 6 weeks to 54.23° ± 14.95° at 12 months, and extension improved from 56.88° ± 13.28° to 68.38° ± 13.43°. In addition, there was a significant reduction in disability and wrist-related symptoms, as indicated by improvements in the Disabilities of the Arm, Shoulder, and Hand (DASH) scores (6 weeks: 25.80 ± 15.85 vs. 12 months: 5.27 ± 8.61; $P < 0.01$) and Patient-Rated Wrist Evaluation (PRWE) scores at the same follow-up intervals (6 weeks: 46.04 ± 22.49 vs. 12 months: 9.54 ± 12.03; $P < 0.001$). Chronic illness and injuries like triangular fibrocartilage complex tears affected outcomes negatively. Age, ulnar variance, and palmar tilt were significantly correlated with DASH and PRWE scores. **Conclusion:** Arthroscopic-assisted reduction and fixation for intra-articular DRFs resulted in favorable outcomes regarding the range of motion, disability, and wrist-related symptoms. Further research and long-term follow-up studies are recommended to validate the positive outcomes of arthroscopic-assisted reduction and fixation for intra-articular DRFs, compare it with other surgical approaches, and assess its economic implications.

Keywords: Arthroscopic-assisted reduction and fixation, distal radius fractures, intra-articular distal radius fractures

Introduction

Intra-articular distal radius fractures (DRFs) are common injuries that can significantly impact a patient's wrist function and overall quality of life.[1] These fractures involve the joint surface and require precise anatomical reduction and rigid stable fixation to optimize functional recovery.[2,3] The most common causes of intra-articular DRFs are falling onto an outstretched hand and high-energy trauma.[3,4] Over the years, various surgical techniques have been developed to address these fractures and achieve satisfactory outcomes in terms of function and radiological parameters. The primary goal of surgical intervention for intra-articular DRFs is to restore articular congruity, provide stable fixation, and enable early mobilization of the wrist joint.[5,6]

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Traditional open reduction and internal fixation techniques have long been considered the gold standard for managing these fractures.[7,8] However, they are associated with drawbacks such as extensive soft-tissue dissection, periosteal stripping, and an increased risk of complications, including tendon injury, infection, and stiffness.[9,10]

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One technique that is gaining popularity is arthroscopic-assisted reduction and fixation. Arthroscopic-assisted reduction and fixation have emerged as a less invasive alternative to open techniques.[11] It combines the advantages of direct visualization of the joint surface with the ability to achieve stable fixation using minimally invasive approaches. This technique utilizes an arthroscope, to visualize the fracture fragments and guide reduction while minimizing soft-tissue trauma.[12] Depending on the fracture pattern and surgeon preference, fixation can be achieved with various implants, such as screws, Kirschner wires, and volar or dorsal locking plates.[13,14]

The primary objective of this study is to evaluate the functional and radiological outcomes following arthroscopic-assisted reduction and fixation of intra-articular DRFs. By examining the postoperative results, we aim to determine this technique's efficacy and potential advantages compared to traditional open approaches.

Patients and Methods

This was a quasi-experimental interventional study that received approval from the institutional research board (approval #4848). The study was conducted on 26 patients with isolated intra-articular DRFs presented to the emergency department who met the criteria of inclusion. Inclusion criteria of the study were: adult patients, between (18 and 60) year old, with intra-articular fractures of the distal end of the radius, both genders (male and female). The exclusion criteria included peripheral neuropathy, Charcot joints, pathological fractures, associated ipsilateral fractures, open fractures, mal-united or delayed union DRFs, advanced osteoarthritis of the wrist joint, and loss of follow-up within 6 months post operation. According to computed tomography (CT) AO classification for distal radius was used in the study, to define fracture pattern, chosen approach, and types of plating. Best pattern for arthroscopic-assisted reduction is the simple intra-articular fractures.

Sample size calculation

The sample size was determined using $n = (Z\_[1-\alpha/2]^2 \times SD^2)/d^2$.[15] In this equation, n represents the sample size, $Z\_(1-\alpha/2)$ is the confidence interval (1.96 for 5% types 1 error), SD is the standard deviation of the functional Disabilities of the Arm, Shoulder, and Hand (DASH) score among patients who underwent arthroscopic-assisted fixation of intra-articular DRFs (estimated as 0.25 based on previous literature), and d is the desired absolute error or precision (usually set at 10%). Plugging in the values, the sample size was calculated to be 24 patients. An additional 10% was added to account for potential dropouts, resulting in a final sample size of 26 individuals.

Data collection

The data collected in this study involved a comprehensive assessment of patients with intra-articular DRFs. The study followed ethical standards and obtained informed consent from all participants before any procedures were performed. The data collection process included preoperative assessment, patient preparation, operative measures, postoperative care, and follow-up evaluations.

Preoperative assessment

The preoperative assessment involved gathering a full history of the patients, including personal history and history of the present illness. The patients underwent a thorough examination, which included the ABCDE approach for polytrauma patients, a general examination, and a local examination focusing on skin condition, swelling, distal vascularity, and neurological assessment of peripheral nerves. X-ray imaging, including anteroposterior, lateral, and scaphoid views, and CT wrist scans with three-dimensional reconstructions were conducted as part of the investigation.

Preparation of the patient

All patients received general anesthesia or regional anesthesia (19 patients for general anesthesia and 7 received supraclavicular brachial plexus block). The patients were supine on the operating table, with the operative upper extremity extended onto an arm board. An intravenous antibiotic (third-generation cephalosporin) was given 30 min before tourniquet inflation, and a tourniquet was applied at a pressure 100 mmHg above systolic arterial pressure. Radio-fluoroscopic imaging and traction using sterile finger traps were utilized during the procedure.

Operative measures

A standard Flexor carpi radialis (FCR) volar approach was utilized, and a standard per-articular plate was used initially as a buttress to restore length. The dorsal approach and dorsal plating were utilized according to fracture needs. Then, arthroscopic portals are utilized. A 3–4 portal is used as a viewing portal, a 4–5 portal as a working portal, and a 6U portal as an outflow portal. The pattern of the fracture guided the operative measures. Arthroscopic-assisted reduction and evaluation of ligaments were performed, with the use of specific portals for visualization [Figure 1]. Arthroscopic lenses with a 30° field of vision were used, and saline was used for joint washing. The joint space is then washed to remove any blood clots. The depressed or floating segments are reduced and maintained with K-wires under both arthroscopic and fluoroscopic guidance. Then, the distal fragments are secured to the plate with locking screws.

Once satisfied with the reduction and the fixation, the triangular fibrocartilage complex (TFCC) [Figure 2], triangular fibrocartilage, and S-L and L-T ligaments were assessed, and the joint was evaluated for loose fragments [Figure 3]. After application of plate by open approach, the wound was washed and closed in layers.

Postoperative care and follow-up

Patients were put in a bulky dressing for 48 h and then in a splint for 4 weeks. The wound was reviewed, and sutures were removed on day 14. Patients were instructed to start active-assisted range of motion by day 7. Postoperative care

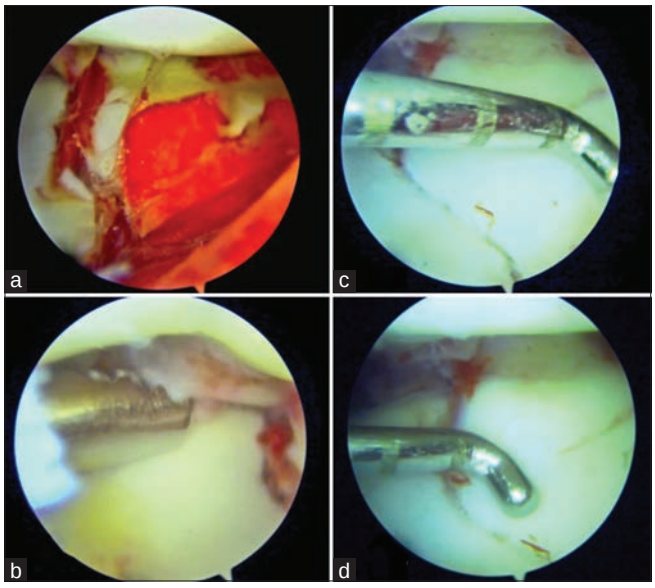

Figure 1: The arthroscopic management of the intra-articular distal radius fracture (a) showing the fracture hematoma, (b) using a shaver to remove the intra-articular hematoma and view the fracture, (c and d) using a probe to reduce the fracture and maintain reduction by temporal K-wires

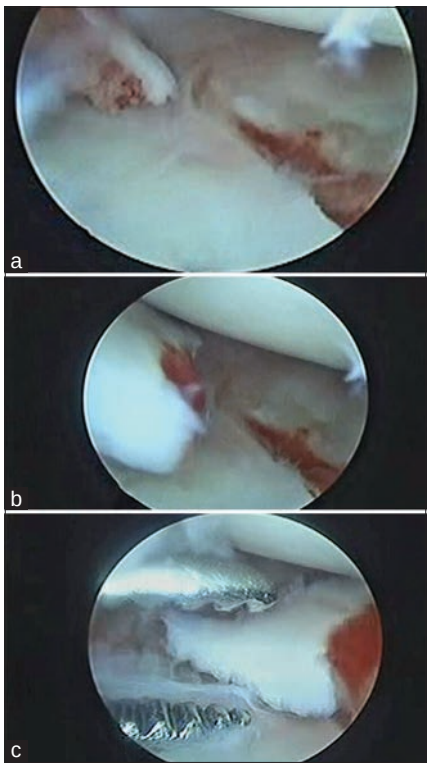

Figure 3: (a and b) Loose body (black arrow) separated from the fracture found by scope after maintaining reduction by K-wires and then removed by a grasper (c)

and follow-up included monitoring the patients with X-ray to evaluate reduction and fixation [Figure 4]. Follow-up evaluations with X-rays were conducted at 2 weeks, 6 weeks, and 12 weeks to assess union [Figure 5]. Scoring systems such as the DASH Disabilities of the Arm, Shoulder, and Hand

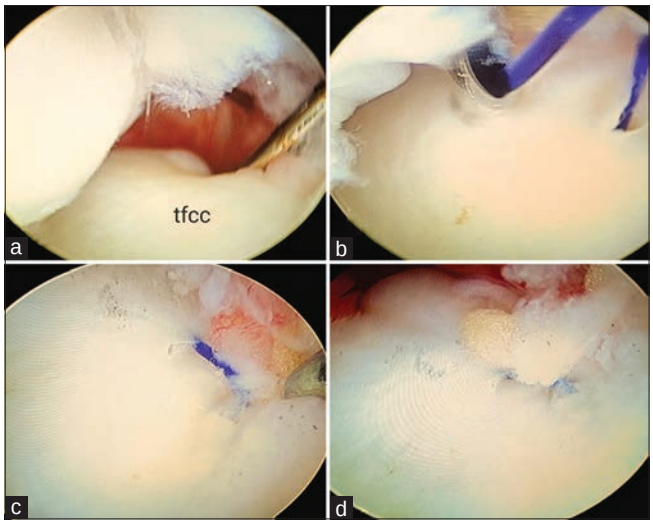

Figure 2: (a) Assessment of triangular fibrocartilage complex (TFCC) ligament using a probe showing peripheral TFCC tear (black arrow), (b-d) Repair of TFCC tear using non-absorbable suture (green arrow)

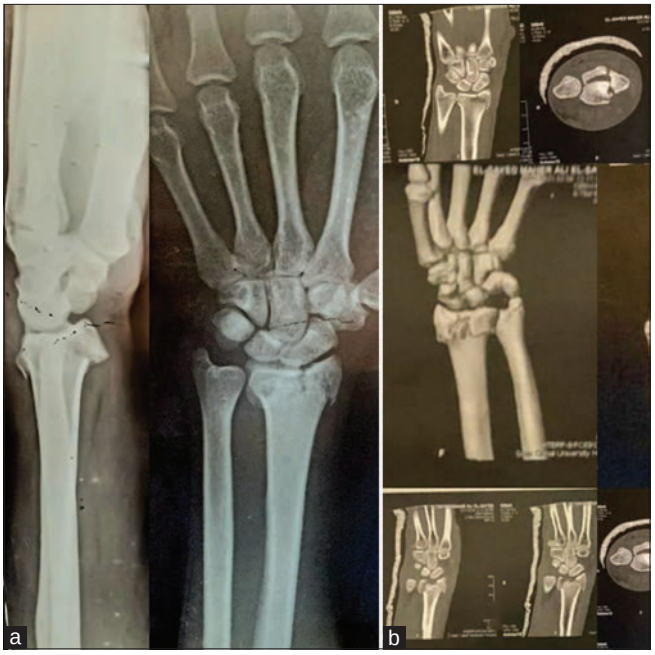

Figure 4: (a) X-ray (anteroposterior, lateral views), (b) computed tomography of intra-articular distal radius fracture

(DASH) score and the rated wrist evaluation questionnaire were used to evaluate patient outcomes at 6 weeks, 6 months, and 1 year.

Statistical analysis

The data collected for the study underwent various processes, including data entry, visualization, manipulation, and statistical analysis. The Statistical Package for the Social Sciences IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. (Armonk, NY: IBM Corp) captured and analyzed the data. The mean and standard deviation were estimated for continuous variables, such as numerical measurements. Categorical variables,

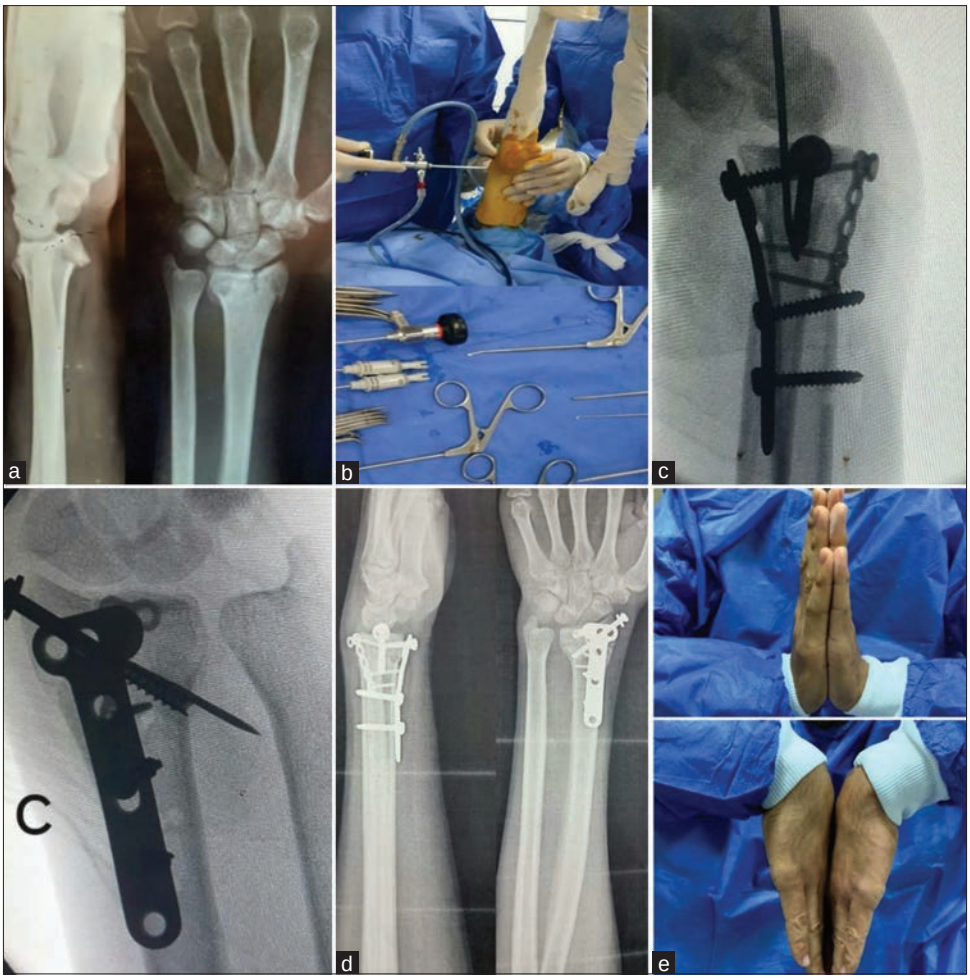

Figure 5: (a) Anteroposterior (AP)-lateral preoperative views, (b) operative preparation of the patient, (c) post fixation AP and lateral views, (d) AP-lateral views 1 year post operation, (e) clinical outcome 1 year post operation

on the other hand, were analyzed by calculating frequencies and proportions. Statistical tests such as the student *t*-test and Chi-square were employed to assess the statistical differences between variables based on their type. We employed Mann–Whitney and Spearman's correlation coefficient tests to assess the correlation and association between the baseline data and outcomes.

Results

Demographic characteristics and clinical characteristics of the study patients

The study included 26 participants with distal radial fractures, with a mean age of 34.85 ± 12.13 years. The majority of patients were male (57.7%), and the remaining were female (42.3%). Most participants did not have any chronic illnesses (76.9%), while a minority had conditions such as hypertension (23.1%) and diabetes mellitus (11.5%). Fractures were more common on the right side (65.4%), and the dominant hand was affected in the majority of cases (69.5%). Falls on an outstretched hand were the most frequent mechanism of injury (92.3%), with motor car accidents accounting for a small portion (7.7%). The average time between injury and operation was 3.08 days (early recovery and function are facilitated by early surgical fixation and delayed fixation may contribute to stiffness and loss of function). Volar plate fixation was performed in all patients. The operation duration averaged 83.46 min, and the healing process took approximately 6.77 weeks. Measurements such as ulnar variance (0.731), radial inclination (19.23°), and palmar tilt (7.91°) provided further insights into the fractures. Associated injuries were observed in 61.5% of patients, with the most common combination being TFCC tear and scapholunate ligament injury (18.7%), as shown in Table 1.

Outcomes

Comparison of postoperative range of motion at 6 weeks, 6 months, and 12 months

Arthroscopic-assisted reduction and fixation on intra-articular DRFs showed a significant improvement in the postoperative range of motion as follows: at 6 weeks, the mean flexion angle was 42.81° ± 11.81°. Furthermore, at 6 and 12 months, the mean flexion angles increased to 50.27 ± 13.83 and 54.23° ±14.95° ($P < 0.001$). Similarly, in terms of extension, the mean angle at 6 weeks was 56.88° ± 13.28°, which increased to 63.65° ± 13.04° at 6 months and further to 68.38° ± 13.43° at 12 months ($P < 0.001$). For

Table 1: Demographic characteristics and clinical characteristics of the study patients

Variables	*n*=26
Age (years)	
Mean±SD	34.85±12.13
Median (range)	31 (18–58)
Gender, *n* (%)	
Male	15 (57.7)
Female	11 (42.3)
Chronic illness, *n* (%)	
Absent	20 (76.9)
Present	6 (23.1)
Hypertension	6 (23.1)
Diabetes mellitus	3 (11.5)
Site of fracture, *n* (%)	
Left	9 (34.6)
Right	17 (65.4)
Dominance, *n* (%)	
Dominant	16 (69.5)
Nondominant	10 (30.5)
Mechanism of injury, *n* (%)	
Fall on outstretched hand	24 (92.3)
MCA	2 (7.7)
Time between injury and operation (day), mean±SD	3.08±1.01
Difference between volar and ulnar plate, *n* (%)	
No difference	21 (80.8)
Depression	1 (3.8)
Step off	4 (15.4)
Operation duration (min)	83.46±13.91
Method of fixation	
Volar plate	25
Dorsal plate, cannulated screw, and volar plate	1
Time to union (weeks), mean±SD	6.77±0.99
Ulnar variance, mean±SD	0.731±0.65
Radial inclination, mean±SD	19.23±1.98
Palmar tilt, mean±SD	7.91±1.83
Associated injuries, *n* (%)	16 (61.5)
TFCC+scapholunate ligament tear	3 (18.7)
TFCC+loose bodies	1 (6.25)
TFCC	8 (30.7)
Scapholunate ligament tear	1 (6.25)
Loose bodies	3 (18.7)

TFCC: Triangular fibrocartilage complex, SD: Standard deviation, MCA: Motor car accident

supination, the mean angle at 6 weeks was 68.38° ± 8.35°, which improved to 72.50° ± 7.89° at 6 months and 74.77° ± 8.26° at 12 months ($P < 0.001$). Regarding pronation, the mean angle was 67.77° ± 8.11° at 6 weeks, which increased over time to be 72.35° ± 7.60° at 6 months, and 75.04° ± 8.28° at 12 months ($P < 0.001$), as shown in Table 2.

Comparison of postoperative Disabilities of the Arm, Shoulder, and Hand score at 6 weeks, 6 months, and 12 months

At 6 weeks postoperatively, the mean DASH score was 25.80 ± 15.85. After 6 months, the mean score significantly improved to 10.42 ± 9.86, and similarly, this improvement persisted at the 12-month mark, with the mean DASH score reducing to 5.27 ± 8.61 ($P < 0.001$), as shown in Figure 6.

Table 2: Comparison of postoperative range of motion at 6 weeks, 6 months, and 12 months

Variables	Mean±SD			*P*[a]
	6 weeks	6 months	12 months	
Flexion	42.81±11.81	50.27±13.83	54.23±14.95	<0.001*
Extension	56.88±13.28	63.65±13.04	68.38±13.43	<0.001*
Supination	68.38±8.35	72.50±7.89	74.77±8.26	<0.001*
Pronation	67.77±8.11	72.35±7.60	75.04±8.28	<0.001*

*Statistically significant *P*-value, [a]Repeated measures ANOVA. SD: Standard deviation

Comparison of postoperative Patient-Rated Wrist Evaluation at 6 weeks, 6 months, and 12 months

At 6 weeks postoperatively, the mean Patient-Rated Wrist Evaluation (PRWE) score was 46.04 ± 22.49. Significant improvement was observed at 6 months, with the mean score decreasing to 20.63 ± 11.39. Further improvement was present after 12 months, where the mean PRWE score reduced to 9.54 ± 12.03 ($P < 0.001$).

Association of baseline characteristics of patients with Disabilities of the Arm, Shoulder, and Hand score and Patient-Rated Wrist Evaluation

Patients without chronic illness had a higher mean ΔDASH score (−17.72 ± 7.17) compared to those with chronic illness (−29.86 ± 12.4) ($P = 0.001$). Similarly, patients without chronic illness had higher mean ΔPRWE (−31.72 ± 12.05) compared to those with chronic illness (−25.41 ± 6.71) ($P < 0.001$). Patients without loose bodies had a higher mean ΔDASH score (−18.30 ± 7.19) compared to those with loose bodies (−32.72 ± 14.66) ($P = 0.005$). Similarly, patients without loose bodies had a higher mean ΔPRWE (−34.04 ± 13.7) compared to those with loose bodies (−50.00 ± 6.96) ($P = 0.034$); in conclusion, both chronic illness and loose bodies affect DASH score and RRWE score, as shown in Table 3.

Correlation between Δ Disabilities of the Arm, Shoulder, and Hand score and Δ Patient-Rated Wrist Evaluation with different clinical variables

Age exhibited a significant negative correlation with both ΔDASH score ($r = −0.420$, $P = 0.033$) and ΔPRWE ($r = −0.518$, $P = 0.007$). On the other hand, the time between injury and operation did not display a significant correlation with ΔDASH score ($r = −0.275$, $P = 0.174$) or ΔPRWE ($r = −0.328$, $P = 0.102$). Furthermore, operation duration did not show a significant correlation with ΔDASH score ($r = −0.126$, $P = 0.538$) or ΔPRWE ($r = −0.099$, $P = 0.629$). Similarly, no significant correlation was found between the duration of union and ΔPRWE ($r = −0.132$, $P = 0.522$), but it did demonstrate a significant negative correlation with ΔDASH score ($r = −0.412$, $P = 0.037$). Ulnar variance exhibited a significant positive correlation with both ΔDASH score ($r = 0.710$, $P < 0.001$)

and ΔPRWE (r = 0.517, P = 0.007). Conversely, no significant correlations were observed between radial inclination and ΔDASH score (r = 0.259, P = 0.201) or ΔPRWE (r = −0.069, P = 0.736). Finally, palmar tilt demonstrated a significant positive correlation with both ΔDASH score (r = 0.436, P = 0.026) and ΔPRWE (r = 0.438, P = 0.025), as shown in Table 4.

Complications

Out of 26 patients, only one (3.84%) experienced a superficial infection as a postoperative complication, while no other complications, including chronic pain, nerve injury, device failure, stiffness, compartmental syndrome, complex regional pain syndrome, tendon injury, tourniquet pain, tourniquet palsy, malunion, or nonunion, were reported.

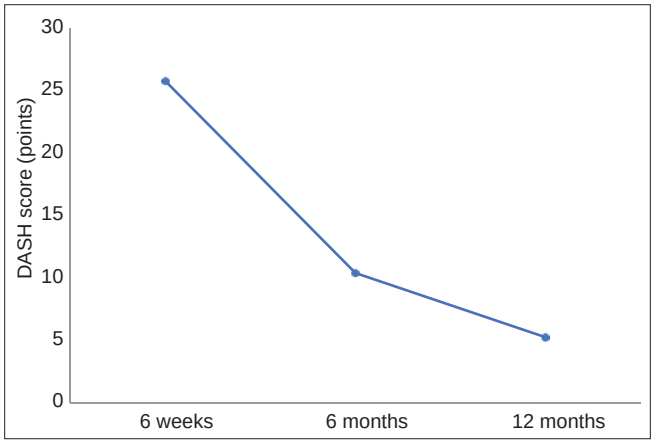

Figure 6: Disabilities of the Arm, Shoulder, and Hand score at 6-week, 6-month, and 12-month follow-up

Table 3: Association of baseline characteristics of patients with Disabilities of the Arm, Shoulder, and Hand score and Patient-Rated Wrist Evaluation

Variables	ΔDASH score, mean±SD	P^a	ΔPRWE, mean±SD	P^a
Gender				
Male	−18.87±8.82	0.328	−35.30±14.77	0.622
Female	−22.78±11.16		−38.13±13.6	
Chronic illness, *n* (%)				
Absent	−17.72±7.17	0.001*	−31.72±12.05	<0.001*
Present	−29.86±12.4		−25.41±6.71	
Site of fracture, *n* (%)				
Left	−19.30±12.42	0.654	−38.88±13.59	0.540
Right	−21.1±8.58		−35.23±14.58	
TFCC injury				
Absent	−22.29±10.88	0.256	−38.96±15.23	0.267
Present	−17.70±7.65		−32.55±11.67	
Scapholunate ligament tear				
Absent	−20.61±10.37	0.919	−38.65±14.04	0.066*
Present	−20.05±7.58		−24.62±7.08	
Loose bodies				
Absent	−18.30±7.19	0.005*	−34.04±13.7	0.034*
Present	−32.72±14.66		−50.00±6.96	

*Significant below 0.05; [a]Values are based on the Mann–Whitney test. DASH: Disabilities of the Arm, Shoulder, and Hand, TFCC: Triangular fibrocartilage complex, PRWE: Patient-Rated Wrist Evaluation

Discussion

This quasi-experimental study included 26 participants with distal radial fractures, with (57.7%) being males and an average age of 34.85 years.

In our study, the TFCC injury rate was 30.7%. This finding aligns with the rates reported by Mathoulin (25.9%), Varitimidis *et al*. (30%), Klempka *et al*. (23.6%), and Christians (30%).[16-19] However, it differs from the rates reported by Ruch *et al*. (66.7%), Mehta *et al*. (83.9%), and Kasapinova and Kamiloski (10%).[20-22]

Our study results indicate that arthroscopic-assisted reduction and fixation of intra-articular DRFs positively impact postoperative outcomes, specifically in terms of the range of motion and functional evaluation. Significant improvements were observed in all measured ranges of motion (flexion, extension, supination, and pronation) over 6–12 months. At 6 weeks, patients exhibited a limited range of motion, which improved significantly by 6 months and continued to show further enhancement after 12 months. The DASH and PRWE scores were used to assess functional outcomes and subjective evaluation, respectively. Both scores demonstrated significant improvements over time. At 6 weeks postoperatively, patients reported limitations in functionality and higher levels of disability and impairment, as indicated by higher DASH and PRWE scores. However, substantial improvements were observed at 6 months and further enhancements at 12 months, with significantly lower scores in both assessments.

This finding is consistent with previous studies. Regarding improvement in the range of motion, Yamazaki *et al*.[23] reported an improved range of motion from 6 weeks to 48 weeks after arthroscopy in flexion, extension, supination, and pronation. Similarly, Krustins *et al*.[24] found that the range of motion improved over a 12-month follow-up period in supination,

Table 4: Correlation between Δ Disabilities of the Arm, Shoulder, and Hand score and Δ Patient-Rated Wrist Evaluation with different clinical variables

Variables	ΔDASH score		ΔPRWE	
	r	P^a	r	P^a
Age	−0.420	0.033*	−0.518	0.007*
Time between injury and operation	−0.275	0.174	−0.328	0.102
Operation duration	−0.126	0.538	−0.099	0.629
Duration of union	−0.412	0.037*	−0.132	0.522
Ulnar variance	0.710	<0.001*	0.517	0.007*
Radial inclination	0.259	0.201	−0.069	0.736
Palmar tilt	0.436	0.026*	0.438	0.025*

*Significant below 0.05; [a]Values are based on Spearman's correlation coefficient. DASH: Disabilities of the Arm, Shoulder, and Hand, PRWE: Patient-Rated Wrist Evaluation

radial deviation, and extension. Koo *et al*.[25] also reported a better range of motion improvement in the arthroscopic group at the final follow-up. Selles *et al*.[26] also observed range of motion improvement following arthroscopy-assisted treatment for intra-articular DRFs. Finally, Huang *et al*.[27] classified patient-reported range of motion into five categories based on the percentage of uninjured wrists: 0%–24%, 25%–49%, 50%–74%, 75%–99%, and 100%. The range of motion of the injured wrist was compared to that of the uninjured wrist during a clinical review conducted 2 years after the operation.

Regarding improvement in the DASH score, Selles *et al*. also observed a positive change in DASH scores following arthroscopy treatment for intra-articular DRFs, with scores decreasing from 34 to 8 after 12 months.[26] Furthermore, Yamazaki *et al*.[23] reported a significant reduction in DASH from 28 to 8 after 4 8 weeks. Similarly, Saab *et al*.[28] reported a decrease in DASH after 1 year to 9.7.

Regarding the PRWE score, similar findings were reported by Selles *et al*.,[26] with PRWE scores decreasing from 48 to 7 after 12 months. In addition, Krustiņš *et al*.[24] found slightly lower PRWE scores for patients treated with arthroscopy in the long term. Furthermore, Huang *et al*. and Sabb *et al*. reported a significant decrease in the Mayo Clinic Scale.[27,28]

Furthermore, a meta-analysis conducted by Shihab *et al*. included six eligible studies, comprising a total of 280 patients, were included in the final analysis. The meta-analysis revealed a significant statistical difference in postoperative step-off, indicating that arthroscopic-assisted Volar locked plate (VLP) was more favorable. Furthermore, arthroscopic-assisted VLP led to improved detection of associated soft-tissue injuries, increased wrist extension, and longer operative duration. However, no notable distinctions existed in other postoperative radiographic complications or functional outcomes.[29]

In our study, 25 patients went for fixation with volar plate only one patient went for fixation with volar plates, dorsal plates and cannulated screw due to dorsal comminution of the fracture and instability after fixation with volar plate only.

The study found no gender difference in ΔDASH and ΔPRWE scores. Patients without chronic illness scored higher in ΔDASH and ΔPRWE compared to those with chronic illnesses. Fracture site and TFCC injury did not significantly impact these scores, but patients without loose bodies scored higher. Age, duration of union, and ulnar variance were significantly correlated with ΔDASH and ΔPRWE. In addition, gender and fracture site had no significant influence, but chronic illness, TFCC injury, scapholunate ligament tear, and loose bodies negatively impacted recovery and function outcomes. These findings suggest that these factors could guide the development of more personalized therapeutic interventions, potentially improving patient recovery and overall quality of life.

Regarding complications, one patient (3.84%) had a superficial postoperative infection; no other complications were reported. compared to other studies. Wrist arthroscopy complications varied across studies, ranging from 3% to 24%.[12,16,18,19,21,26,27] The variability in the complication rate could be attributed to the patient's medical history, the severity of the injury, and the surgeon's experience.

Conclusion

Wrist arthroscopy is a useful adjunct procedure in the surgical management of DRFs. Compared to traditional techniques, arthroscopy shows the advantage of allowing direct visualization of the articular surface to assess and guide fracture reduction; in addition, it has the advantage of allowing assessment and management of concomitant soft-tissue injuries such as intercarpal ligament injuries, TFCC injuries, and chondral pathology, so we found arthroscopic-assisted reduction and fixation of intra-articular DRFs a valuable treatment tool with a consistent and progressive increase in ROM over the follow-up period. Moreover, patients reported improvement of the functional outcomes over the follow-up period as reported by both the DASH score[30] and the PRWE score.[31] In addition, the procedure had a low complication rate. We recommend careful patient selection and evaluation as well as proper fracture evaluation before surgery.

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Conflicts of interest

There are no conflicts of interest.

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Original Article

Comparative Study Between Latarjet Procedure Versus Free Iliac Graft in the Management of Recurrent Shoulder Dislocation

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Abstract

Background: The most common form of shoulder dislocation is the recurrent anterior traumatic type. Latarjet and Eden Hybinette are the two competing techniques in reconstructing significant bone loss accompanying this type. **Aim of the Work:** The aim is to evaluate the functional results in the management of recurrent shoulder dislocation with bone loss by comparing Latarjet and Eden Hybinette techniques. **Patients and Methods:** A prospective, randomized controlled trial was performed on forty adult patients suffering from recurrent shoulder dislocations. Two groups (a total of forty patients; twenty iliac graft cases and twenty Latarjet controls) were performed in a randomized method. We compared the two groups; clinical evaluation was completed before surgery and at least 1 year postoperatively, by using the modified Rowe score which consists of pain level, stability, motion loss, and limitation of function. Satisfactory results included excellent and good results, while unsatisfactory results included fair and poor results. Adverse events were prospectively recorded. CT studies were performed to assess the radiographic result preoperatively, immediately-postoperatively, and at final follow-up visits. **Results:** Both groups did not differ significantly in either the clinical or the radiological aspects ($P > 0.05$) except for more limited range of motion (ROM) (external and internal rotation) in the Latarjet group at the final follow-up ($P < 0.05$). One case in the Latarjet group had recurrent dislocation due to tramadol fits. Two cases in each group had anterior apprehension only. Donor-site sensory disturbances were reported in 10% of the iliac group patients. Computed tomography revealed a larger graft size in the iliac group. **Conclusion:** Both Latarjet and Eden Hybinette can be used as reconstructive surgeries in restoring critical bone loss accompanying shoulder dislocations; they did not show significant differences except for the more limited external and internal rotation motions in the Latarjet group.

Keywords: Bone augmenting techniques, Eden Hybinette procedure, Latarjet procedure, significant bone loss either unipolar or bipolar

Introduction

As 50% of all joint instabilities are recurrent anterior shoulder dislocation, it is considered the most common form.[1] A high rate of recurrence occurs in younger populations; it may reach 92% in patients aged <30 years.[2] Lack of care for significant bone loss either unipolar or bipolar is the main cause of failure after Bankart surgeries in up to 67% of cases.[3,4] Diminished congruency of the shoulder due to bone loss may lead to a high recurrence rate that may reach 90% [Figure 1].[4,5] In the Latarjet procedure, the vertical coracoid after being osteotomized with the attached conjoint tendon is passed along the subscapularis muscle which was incised horizontally. The triple blocking effects are the main stabilizing advantages of the Latarjet procedure; bony, muscular, and ligamentous effects.[6] However, possible postsurgical complications are the limitation of shoulder motion, dyskinesia of the shoulder, possible neurovascular injuries, difficult revision after failure, and possible arthritis. The main indications for autogenous iliac graft as reconstructive shoulder surgeries are either significant glenoid loss of more than 50%, failure of previous Latarjet, or uncontrolled epileptic patients. Highly contoured, unlimited,

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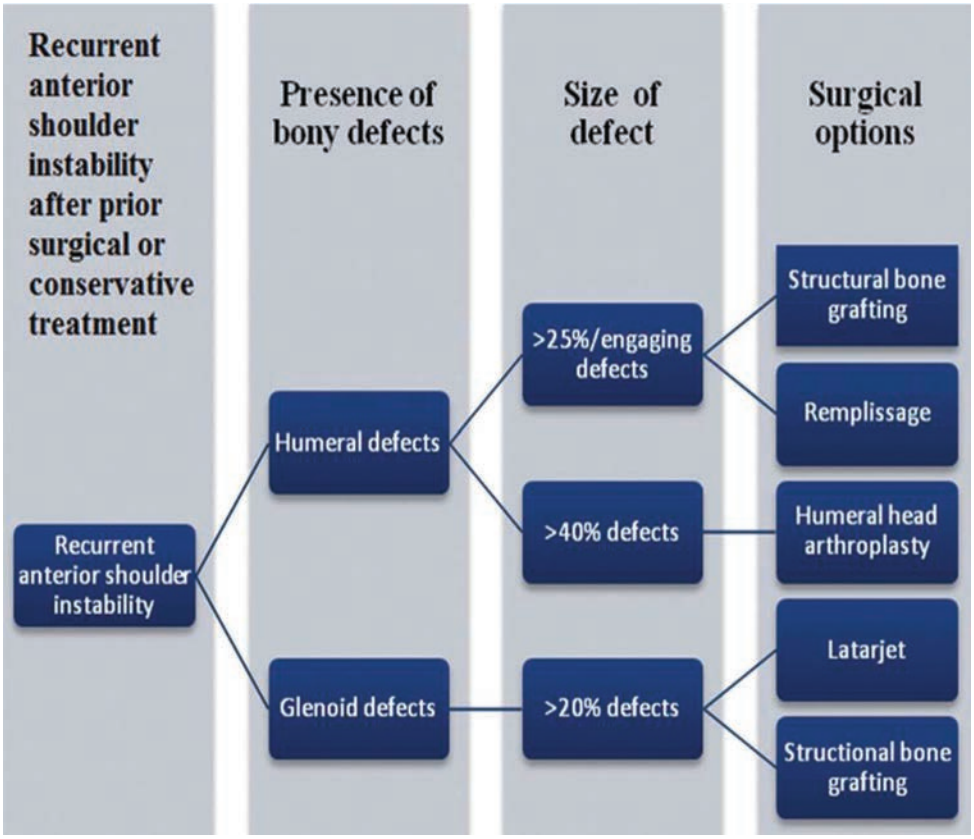

Figure 1: Options in the management of patients with anterior recurrent shoulder instability associated with bony defects[5]

nonimmunogenic grafts in addition to providing both osteoinductive and osteoconductive properties are the main advantages of autogenous iliac grafts.[7] Eden[8] and Hybinette[9] are the first who use autografts in shoulder instabilities. Due to some limitations seen with Latrarjet, Warner *et al*. described his technique by implanting an intraarticular autologous tricortical iliac graft in recurrent instability of the shoulder joint.[7] Although possible postsurgical complications of Latarjet procedures may occur such as (nonanatomical nature, limited ROM, shoulder dyskinesia, decrease in concerning the triple effect, and more graft that can be taken in iliac grafting), no second incision, complications associated with iliac graft harvesting and field exposure are better. Comparing both the clinical and radiological functions between them was done for the long decades to report both the advantages and disadvantages of each technique.[10]

The aim of this work

To compare the functional results between Latarjet and autologous free tricortical iliac graft in cases of recurrent shoulder dislocation with critical glenoid bone loss, Hill Sachs, or combined bipolar lesions

Patients and Methods

This study is a randomized controlled trial performed on forty adult patients suffering from a recurrent shoulder dislocation with glenoid bone loss of more than 20% loss, off-track Hill-Sachs lesions, or combined bipolar lesions. Randomization was achieved by using the parallel group design on selected patients of multiple sites using computer-generated randomization; two groups were created in our study as follows: One patient was operated by using the tricortical iliac grafting technique, and the other was operated by using the Latarjet technique, respectively, until we completed both groups; 20 patients were for each group. We considered the iliac grafting technique as a (case group) and the other group treated with the Latarjet technique as a (control group). The patients were collected with a randomized selection from December 2020 and May 2023, from the OPD of Benha University Hospital (Benha City, Egypt) and East Jeddah Hospital (Jeddah, Saudi Arabia). For each patient, a detailed sheet and written consent were taken. A Plain X-ray, CT using the Pico method [Figures 2 and 3] and MRI were done for all the patients.[11-13]

Inclusion criteria

It was as follows: (1) Recurrent traumatic anterior shoulder dislocation, (2) Unilateral cases, (3) age group from 18 to 35 years, (4) antero-inferior glenoid bony defect of more than 20% of the anteroposterior diameter or large engaging Hill Sachs lesion of more than 25% of the humeral articular surface, and (5) failed previous stability operation (e.g., failed Bankart repair).

Exclusion criteria

The exclusion criteria were as follows: (1) Patients with multidirectional instability, (2) Patients with glenohumeral

dysplasia, (3) Patients with associated rotator cuff tear, (4) Patients who underwent previous shoulder operations rather than stability procedures, (5) Patients with associated fractures of the greater tuberosity or the proximal humerus, (6) Patients with uncontrolled neurologic disease (e.g., epilepsy), (7) Paralytic dislocation, and (8) Patients ≤6 points according to the Instability Severity Score Index score.[14]

Ethical approval and surgical consent were done for each patient.

Open Latarjet techniques were performed as described by Young and Walch[15] and open ICBGT was performed as described by Warner *et al*.[16] The deltopectoral approach was the incision in both groups, while the anterior iliac crest incision was added for graft harvesting in Eden Hybinette techniques.

The operative position was low beach chair in both groups [Figures 4 and 5]. The Latarjet procedure is operated by the release of the pectoralis minor tendon, osteotomy of the coracoid close to the base with the conjoined tendon and parts of the coracoacromial ligament left attached [Figures 6 and 7], a permanent horizontal split of the subscapularis, a vertical split of the capsule, transposition of the coracoid with the attached conjoint tendon to be flushed with the articular surface of the glenoid, 2 partially threaded screws were used for fixation, and suturing the 1 cm of the coracoacromial ligaments (attached to coracoid) to the lateral aspect of shoulder capsule. While in Eden Hybinette, after measuring the glenoid defect, a tricortical iliac graft was harvested (measured 3 cm × 2 cm × 1 cm) [Figures 8 and 9], the graft is implanted intra-articularly with the inner table faced laterally, fixation with two screws [Figure 10], and horizontal split of the subscapularis was completely closed (side by side). Patients were followed up clinically for at least one year according to the modified Rowe scale which consists of (pain, stability, motion, and function).[17] The cases are also followed up radiologically by doing X-rays and computed tomography (CT) for graft healing assessment at the end of follow-up at least 1 year. Finally, we compared Latarjet and Eden Hybinette patients regarding our results. The collected data were statistically analyzed using the SPSS software (Statistical Package for the Social Sciences-version 28.0.1.1 (IBM, Armonk, Newyork, USA), February 8, 2022).

Clinical outcome assessment

preoperative assessment included the following: A pathology-specific medical history (dislocation numbers, age of first dislocation, cause of dislocation, previous Bankart repairs, and bilateral affection); instability testing including the apprehension test and relocation test;[18] and hyperlaxity assessment using the Beighton score (six patients in Latarjet group and three in iliac group).[14] Dynamometer is used for shoulder strength assessment. A goniometer was used for measuring ROM. The highest vertebral level that could be reached by the hand of the affected side was used for assessing

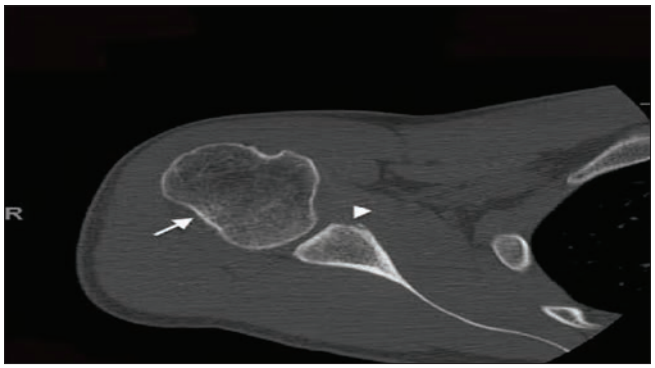

Figure 2: Preoperative axial computed tomography shows glenoid bone loss (Wite Arrow Head) and Hill Sachs lesions (White Arrow)

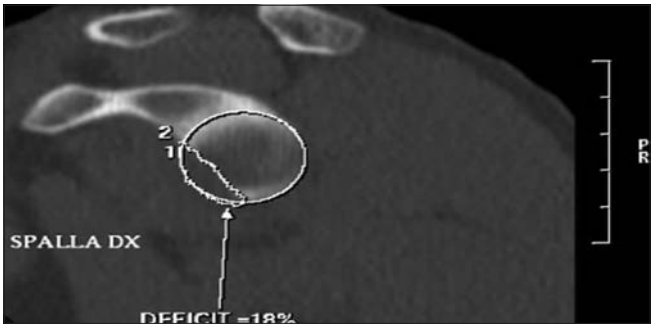

Figure 3: Glenoid defect measurement using the Pico method

Figure 4: Low beach chair in Latarjet procedure

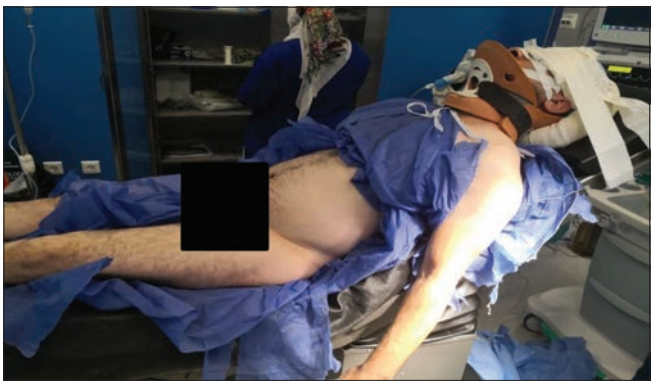

Figure 5: Exposing both the affected shoulder and iliac regions in iliac grafting patient

internal rotation capacity. Furthermore, the recurrence of instability recorded after being assessed might be dislocation, subluxation, apprehension positive, and apprehension negative.

Results

Both groups showed no significant differences regarding their preoperative characteristics [Table 1]. Our results are described in the following tables.

Clinical outcome

The difference between the means of postoperative total modified Rowe scores in both groups was statistically insignificant at the

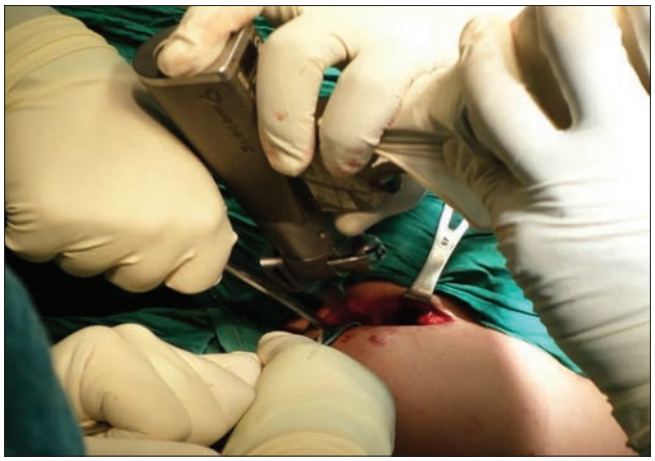

Figure 6: Coracoid osteotomy with attached conjoint tendon using an oscillating saw

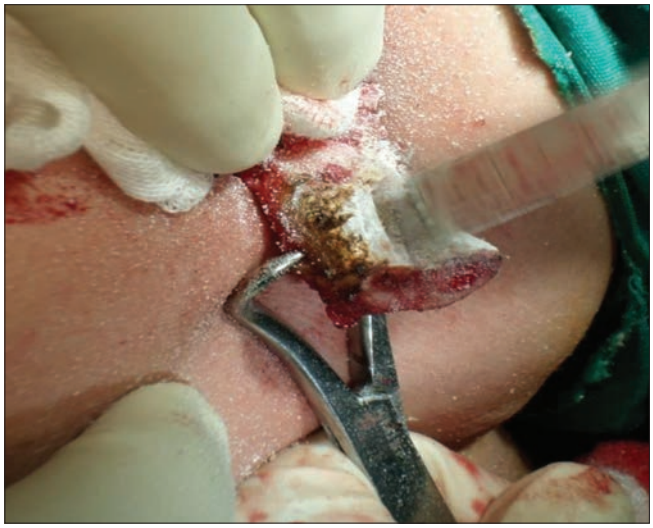

Figure 7: Preparation of the inferior surface of the coracoid for enhancing graft healing with cancellous bone

Table 1: Comparison of preoperative group characteristics and radiologic assessment

Parameters	Eden Hybinette group	Lattarget group	χ^2, FE, *Z* (Mann–Whitney *U*-test) or *G*-test (likelihood ratio)	*P*
Age distribution (years) (18–≤25–18–25)	13/7	11/9	0.417	0.519
Age (years), mean±SD	25.05±4.57	26.5±5.68	0.692	0.495
Gender distribution (male/female)	19/1	16/4	0.151	0.342
Dominance of the affected shoulder (dominant/non)	18/2	14/6	0.114	0.235
Occupation (unemployed/student/manual worker/office worker/driver)	1/2/10/4/3	2/1/9/3/5	1.381	0.848
Mechanism of trauma (direct/indirect)	5/15	8/12	1.026	0.311
Hyperlaxity (positive/negative)	3/17	6/14	0.256	0.451
Age at first dislocation (<20/21–27/28–34)	7/7/6	3/13/4	3.8	0.150
Number of dislocation (≤10/>10 episodes)	4/16	6/14	0.533	0.456
Previous failed Bankart repair (no/yes)	16/4	18/2	0.376	0.661
Nonoperative treatment (none/immobilization <4 weeks/ immobilization 4 weeks + physiotherapy)	5/9/6	4/13/3	1.862	0.394
Time of surgery (<12/≥12 months)	11/9	7/13	0.533	0.465
Preoperative, mean±SD (modified Rowe score)	6.75±17.86	37.75±17.51	0.628	0.779
Preoperative glenoid bone loss (<20/20–33/30–45)	3/12/5	4/13/3	0.689	0.709
Preoperative hill-saches (<20/20–33/30–45)	6/9/5	8/7/5	0.537	0.746

Preoperative period, duration from injury to surgery. χ^2: Chi-square test, $P>0.05$: Insignificant difference, *Z*: Mann–Whitney *U*-test likehood ratio: *G*-test, FE: Fisher's exact test, SD: Standard deviation

Table 2: Comparison of both groups postoperative means Rowe scores and motion loss

Parameters	Eden Hybinette group	Latarjet group	*Z* or (*G*-test)	*P*
Postoperative, mean±SD (modified Rowe score)	85.75±13.5	86.25±12.55	0.387	0.699
Mean±SD of postoperative motion	8.25±2.94	6.5±2.86	2.038	0.042*
Degree of internal rotation loss in 90° abduction (0°/≤10°/>10°)	13/6/1	5/13/2	6.66	0.036*
Degree of external rotation loss in 90° abduction (0°/≤10°/>10°)	12/7/1	4/15/1	7.163	0.028*

*Statistically significant at $P\leq0.05$. *Z* value for Mann–Whitney test, *G*-test (likehood ratio)

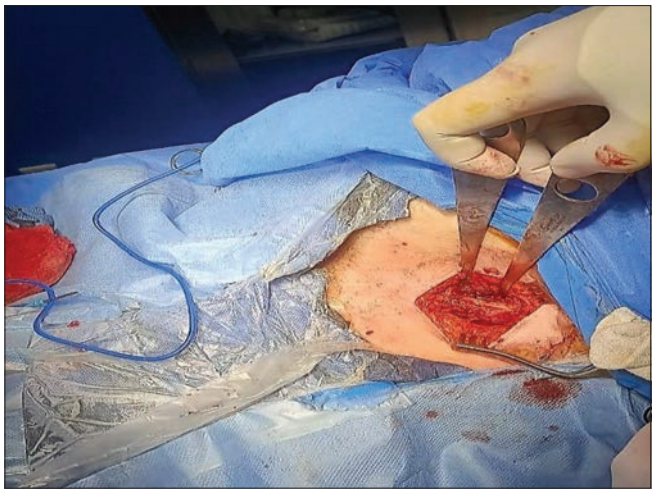

Figure 8: Iliac graft incision

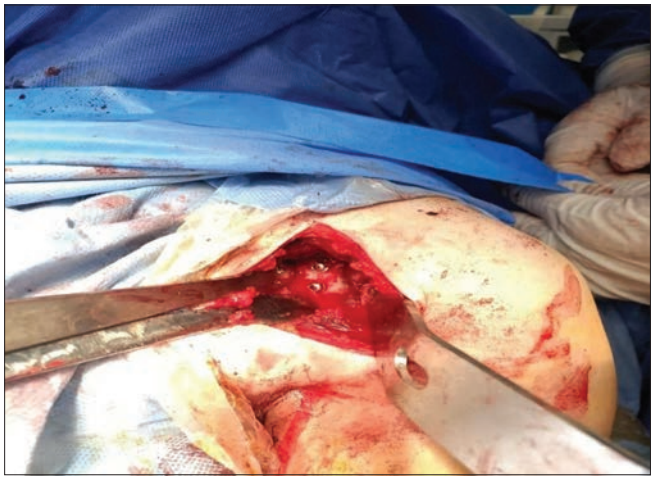

Figure 10: Fixation of the iliac graft with 2 cannulated screws flushed with the glenoid

final follow-up which was at least one year ($P = 0.699$) [Table 2 and Figure 11]. Satisfactory results were in 17 patients (85%) of the Latarjet group, while 18 patients (90%) were of the iliac group ($P = 1$). Although the motion component is statistically better in the iliac group than the Latarjet group especially limited (both external and internal rotation motion in 90° abduction), most of them were ≤10° [Figures 12-14]. Regarding the Latarjet group, only one case had recurrent dislocation (5%) due to returning into tramadol addiction with a recurrence of seizures during which screw bending occurred, he had undergone revision with a free iliac graft. The two cases in each group (10%) suffered from positive apprehension tests only postoperatively due to new minor traumatic events in patients who suffered from hyperlaxity. Graft harvesting-related complications; in the Latarjet group, one patient had a superficial surgical site infection, treated with irrigation, debridement, and antibiotic therapy. Two patients had surgical site hematoma, and both of them improved with dressing and medical treatment. One patient had graft nonunion without any clinical consequence, for further follow-up. Hardware failure was encountered in one case, and revision with a free iliac graft was

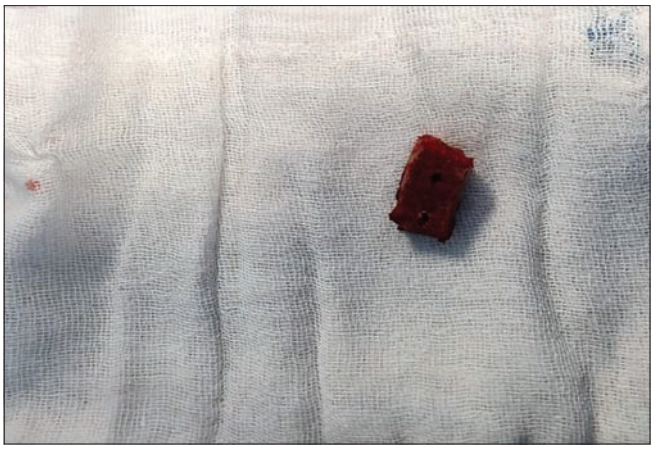

Figure 9: Iliac graft harvested and two holes were drilled 1 cm apart

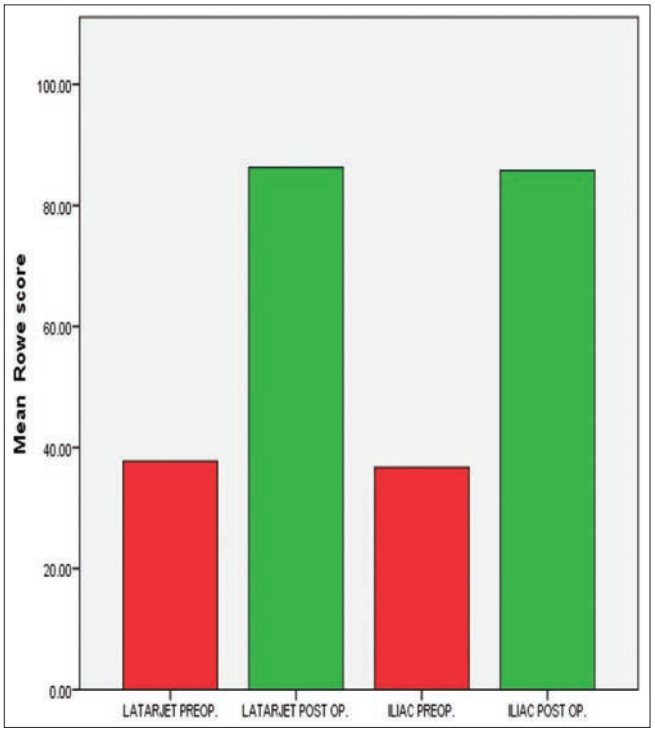

Figure 11: Comparison between preoperative. and postoperative modified Rowe scores' means in both groups

done. Regarding the iliac graft group; three patients had donor site pain, pain is improved after physiotherapy and medication. Two patients had sensory disturbances around the donor-site scar (numbness on the upper lateral part of the thigh and both of them improved at the 6-month visit). Three had a superficial wound infection at the donor site, all of them are eradicated with wound debridement, daily dressings, and antibiotic therapy.

Radiologic outcome

postoperative glenoid augmentation by iliac graft had significantly increased surface area ($P = 0.02$), reduced defect area ($P = 0.003$), increased diameter ($P = 0.009$), increased depth ($P = 0.034$), and more retroversion ($P = 0.002$) in comparison with the Latarjet technique. Before surgery, off-track Hill-Sachs lesions were

found in 83% of patients in the ICBGT group and 68% of those in the Latarjet group ($P = 0.206$). After surgery, the percentage of patients with off-track defects was reduced to 14% in the ICBGT group and 28% in the Latarjet group ($P = 0.310$).

Discussion

Among these bone grafting techniques are two competing types of procedures: Coracoid transfer techniques and iliac grafting techniques.

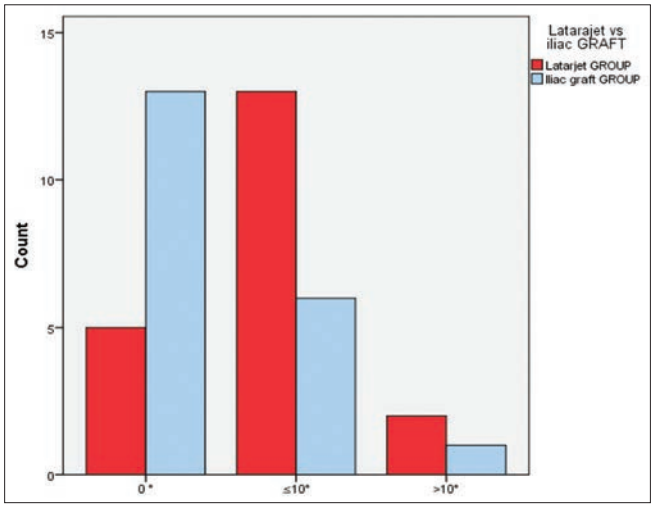

Figure 12: Degree of internal rotation loss with 90° abduction in both groups

Figure 14: (a) preoperative Range of Motion (ROM) of one patient in the Latarjet group, and (b) post-operative ROM shows excellent improvement

Ideal graft position

In our study, we tried to avoid the lateral placement of the coracoid graft; therefore, we aimed to place it flush with the glenoid. Hence, in the Latarjet group, 16 grafts (80%) were flush with the glenoid [Figure 15], while regarding the iliac graft group, 18 grafts (90%) were flushed with the glenoid [Figure 16]. This result was similar to other studies that reported; that the placement of the coracoid graft is very critical in determining results over time. The optimum position is difficult to define, but it is recognized that it should be neither too medial nor too lateral (<10 mm from the cartilage for some, <2 mm for others). Some authors stated that the bone blocks should be flush to increase the articular surface of the glenoid.[19] Similarly, normalization of shoulder pressures is fulfilled by flushing of graft with the glenoid as described by Ghodadra *et al*. Lateralization of the graft even by 2 mm or more may increase the joint reaction forces.[20] Both groups' grafts

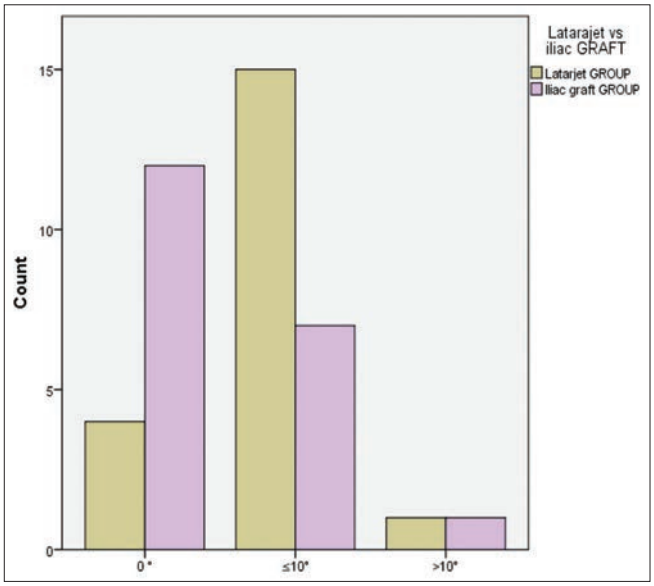

Figure 13: Degree of external rotation loss with 90°abduction in both groups

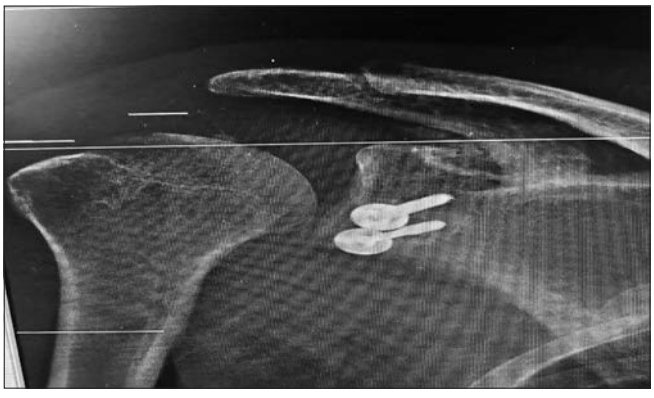

Figure 15: Latarjet graft flushed with the glenoid in post-operative X-ray

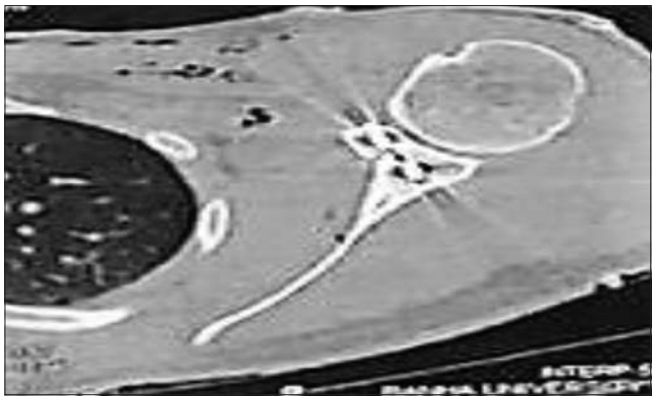

Figure 16: Iliac graft flushed with the glenoid in postoperative axial computed tomography

are at the equator or below (no grafts above the equator), also Saito *et al*. suggested placing the graft between 2:30 and 4:30 based on the location of the average glenoid fracture on a right scapula.[21] Similarly, high failure rates with grafts implanted above the equator were also described by Hovelius *et al*. study.[22] Interestingly, Nourissat *et al*. reported a difference between the radiographic and postoperative CT assessments.[23]

There was no statistically significant difference between both clinical (postoperative modified Rowe scores groups' means) and radiological outcomes. This result is more or less similar to the published studies; Moroder *et al*. (Neer Award 2019) performed a prospective randomized trial of 60 patients and found comparable clinical (WOSI and Rowe scores) and radiological outcomes between an open Latarjet and iliac crest graft for at least 2 years of follow-up. The functional differences, strength, and range of motion were insignificant between both groups; except for diminished internal rotation in the Latarjet group.[7,24] Furthermore, two recent systematic reviews (Longo *et al*. and Beran *et al*.) on different glenoid reconstructing techniques for recurrent anterior glenohumeral instabilities confirmed that both techniques had similar clinical results, with lower neurological injuries in the Eden-Hybinette procedure.[10,25] The iliac group had a better range of motion, especially regarding both external and internal rotation in 90° abduction (statistically significant difference) than the Latarjet group, a possible explanation of internal rotation loss is the permanent split of the subscapularis by the conjoint tendon. Moreover, the loaded conjoint tendon might cause limited external rotation, especially if it was at 90° of abduction position.

The outcomes in both groups were not affected by the age of the patients, sex, side, dominance of the affected shoulders, occupation, generalized hyperlaxity, time interval before surgery, number of dislocations, sports participation, the period of follow-up, and post-operative physiotherapy. Furthermore, the development of arthropathy could not be judged properly in our study because of the short follow-up period unlike long-term studies.[26] The difference between postoperative stability was statistically insignificant. This reflects the results of former case series reports that showed the high rate of stabilization success of both procedures even in the long term.[27,28]

Although the shoulder-related adverse event rate was very low in the ICBGT group, 15% had donor site pain, 10% had sensory disturbances around the donor site, 5% had superficial wound infection at the donor site, and also the additional pelvic scar.[29]

Immediate postoperative CT reported a larger boost of the glenoid in the iliac graft group than the Latarjet which is limited by coracoid dimensions.[30] However, due to the short time of our study, we could not detect further osteolysis and resorption of the iliac graft.[31] The limitations of our study that might affect our result are a short follow-up period and small sample size, so our recommendation for further studies are larger number of patients and a longer follow-up period.

Conclusion

No statistically significant difference between both groups clinically and radiologically except for limited ROM (external and internal rotation) in the Latarjet group. Although the results were encouraging with (85% and 90%, respectively) success rates, the follow-up period was relatively short. A longer follow-up of these cases is recommended to determine whether the results will remain consistent over time. Future work with a larger study group is needed for the absolute determination of factors affecting the outcome.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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