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Guest Editors:
Prof. Mohamed Elashhab
Prof. Gamal Hosny

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Bridging Continents: Egyptian Perspectives in Joint Surgery – The Egypt Issue and Its Guest Editors

Dear Readers,

It is with great pride and excitement that we introduce to you a special issue of our journal, aptly titled "Bridging continents: Egyptian perspectives in joint surgery – The Egypt issue and its guest editors." This issue marks a significant milestone, as it is entirely dedicated to the remarkable contributions of Egyptian orthopedic surgeons in the fields of arthroscopy, arthroplasty, and joint disorders as major orthopedic education collaborative efforts are underway by Egypt with India and other countries.

In this issue, we have the honor of collaborating with two guest editors who are distinguished surgeons from Egypt, whose expertise and leadership in orthopedics have been instrumental in shaping the landscape of the field in Egypt and abroad. We welcome Professor Mohammed Elashhab, the revered Dean of Benha University and Secretary of the Egyptian Orthopedic Association (EOA), whose academic and clinical leadership has significantly advanced orthopedic education and practice in Egypt and online. Alongside him, we have Professor Gamal Hosny, the esteemed Past President of the EOA, whose contributions to orthopedics have been very inspiring.

Prof. Elashhab is a professor of Orthopedic Surgery at Benha University, an Ex-president of the Department of Orthopedic Surgery, and presently, the Dean of Benha Faculty of Medicine. He is a member of the administrative board and a member of the scientific committee of the Egyptian Orthopedic Fellowship program of EOA. He is also a member of the committee for the Egyptian Orthopedic Guidelines and has prepared guidelines for arthroplasty for Egyptian surgeons. He has created a rapidly expanding online repository of lectures from national and international experts in all subspecialties of orthopedics through EOA.

Professor Gamal Ahmed Hosny is a trailblazer in the field of orthopedic surgery, earning recognition as the pioneer of bone lengthening and deformity correction through the Ilizarov technique in Egypt and the Middle East since 1984. His impact is evident through the establishment and leadership of the Bone Lengthening and Deformity Correction Center at El-Haram Hospital, where he has successfully overseen over 3500 Ilizarov cases. He has played a crucial role as Head of the Orthopedic Surgery, Department at Benha University Hospital. He has served as the President of the Egyptian Orthopedic Association, contributing to the advancement of orthopedic practices in the country. Internationally, he held the position of President of the International ASAMI and Bone Reconstruction Society, showcasing his dedication to shaping the global landscape of orthopedic care. With a career marked by innovation, leadership, and a relentless pursuit of excellence, Professor Hosny continues to leave an indelible mark on the field of orthopedic surgery.

This issue is more than a collection of articles; it is a testament to the rich history and ongoing advancements in joint surgery in Egypt. The authors, many of them prominent Egyptian orthopedic surgeons, present their insights, experiences, and research findings, offering our readers a window into the innovative, modern, and effective approaches being employed in one of the world's oldest civilizations. The leading article is a summary of the evolution of orthopedic practices in Egypt along thousands of years. The Egyptian articles will be spread over two issues interspersed with regular articles.

Our aim with the Egypt issue is not only to highlight the significant contributions of Egyptian surgeons but also to foster a global dialogue in the orthopedic community. By sharing knowledge and experiences across borders, we believe we can collectively enhance patient care, surgical techniques, and overall outcomes in joint health.

We trust that this issue will be a valuable resource for our readers from Egypt and abroad, providing fresh perspectives and inspiring new ideas. As you delve into the articles, we hope you will appreciate the depth and diversity of arthroscopic and arthroplasty surgery in Egypt and recognize the universal passion that drives all of us in this field – the commitment to improving the lives of those we serve.

Thank you for joining us on this journey.

Srinivas B. S. Kambhampati[1,2], Hemant Pandit[1,3], Amol Tambe[1,4]

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Orthopedics in Ancient Egypt

Introduction

Upper and lower Egypt was politically united around 3150 BC along the Nile River in northern Africa, establishing the ancient Egyptian civilization. It lasted for over 3000 years from 3150 BC to 30 BC.[1] Ancient Egypt was the cradle of the first dawn of modern medical care, including bone setting and simple surgery.[2]

The current orthopedic practice depends on evidence-based medicine. The history of orthopedics in ancient Egypt is based on the following evidence found in mummified bodies, wall paintings, and hieroglyphics.

The most thorough knowledge of ancient Egyptian medicine comes from two papyri (papyrus is an ancient writing material that was used extensively in ancient Egypt and other Mediterranean societies.): G. Ebers' massive medical papyrus and E. Smith's surgery papyrus. Smith's papyrus is interesting since it discusses ancient Egyptian surgery. In the Middle Kingdom, 1800–300 BCE, more than 40 papyri documenting medicinal methods for various ailments were found.[3,4]

There was even exceptional specialization for that period. Only one ailment was treated by each doctor. Doctors were everywhere. Some physicians treated the eyes, others the head, teeth, belly, and hidden diseases. Ancient Egyptians valued orthopedic surgeons. Broken bones and dislocations were prevalent in agrarian societies due to wars and accidents.[5]

Treatment of Fractures in Ancient Egypt

Edwin Smith's papyrus documented 48 occurrences of vertebral injuries and fractures of the clavicle, humerus, and sternum and includes thorough anatomical, clinical, and therapeutic information.

This papyrus instructs the doctor how to examine the patient and look for signs of injuries. Each case was chosen whether to treat, contend, or not treat owing to a dismal prognosis.

Case 31 was cervical dislocation with unconsciousness of his legs and arms (paralysis or quadriplegia) with dribbling of urine, a condition not to be treated.[6,7]

The frequency of long bone fractures, healing, and malalignment was investigated by visually inspecting 2287 long bones of 204 adult skeletons (112 males and 92 females) and taking anteroposterior and lateral radiographs. Of 2287 long bones tested, 45 had fractures (1.97%). Three fractures were malaligned, but most healed with good alignment due to effective treatment. However, 80% of fractures were in the radius and ulna, which were treated easily with hanging and splints. Finally, long bone fractures healed well, proving that therapy was effective.[8,9] The lack of evidence of joint dislocation in ancient Egypt is surprising given the amount of fracture documentation. Only a famous artwork by a funereal artist showed a physician treating a dislocated shoulder, utilizing Kocher's 1870 technique. The earliest shoulder dislocation and reduction attempts are shown here.[10] The Egyptian Orthopaedic Association's symbol depicts a shoulder reduction.[11] Dislocated joint reductions are not well documented, according to other writers. The finding of an intramedullary fixation with an iron nail in a mummy's right knee in 1996 clarified surgical fracture management. On forensic medical evaluation, evidence of the right knee surgery was found. Investigations found that the device was implanted around the time of death.[12]

Congenital Deformities and Skeletal Dysplasia

Mummies, the time travelers of ancient Egypt, provide early evidence of congenital diseases. Genetics has improved our understanding of how inbreeding causes hereditary illnesses. The frequency of congenital illnesses may have grown due to consanguineous marriages at that time. The half-brother–sister marriage of Thothmus and Aahmes produced Queen Hatshepsut (18th Dynasty) (158–1350 BC). Her mother was the result of marriages in two successive generations between full brothers and sisters.[13,14] The two stillborn children of King Tutankhamun were embalmed and placed in small coffins in his tomb. Both were females, 5–8 months of gestational age. Radiographs revealed scoliosis, spina bifida, and Sprengel deformity.[15] Achondroplasia is one of the most well-known genetic abnormalities, however, the medical papyri did not include dwarfism since the ancient Egyptians did not consider it a sickness or illness. The "Badarian period" (4500 BCE) included the first biological evidence of dwarfism in Egypt. At the Museum of the Royal College of Surgeons in England, the almost complete skeleton was extensively researched.[16] Dwarfs were employed as personal servants, linen overseers, animal tenders, jewelers, dancers, and entertainers, according to artistic evidence. In the Old Kingdom (2686–2190 BCE), numerous high-ranking dwarfs had exquisite tombs near the pyramids. Several Old Kingdom dwarfs were buried at the royal cemetery near the pyramids in spectacular fashion. Funerary sculptures or reliefs inscribed their names and titles. They were Seneb, Pereniankh, Khnumhotep, and Djeder. The father, the Seneb statue, was likely achondroplastic. His wife and kids are average sized. On a rectangular seat, Seneb sits as a scribe close to his wife. Two of their three children, a boy, and a girl, are under Seneb, placing their fingers to their mouths as was typical in ancient Egypt. Dwarfs were gods in ancient Egypt. The best-known dwarf gods, Ptah and Bes, used magic to protect the living and the dead.[17]

Poliomyelitis occurred in ancient Egypt. The late 19th dynasty mummy of Siptah (1342–1197 BCE) has a severely malformed Pes equinovarus-like left foot and shortened left leg, a polio deformity. The doorkeeper Ruma had a leg deformity that required a cane. Wasted and shortened limbs with foot equinus deformity were depicted. Pictures showed knee recurvatum, which can result from Polio and resultant muscular weakening.[18,19]

Egyptologists and academics agree that short persons were seen positively in ancient Egypt.[20] Ancient Egyptian art offers a rich record of physical disability's role in daily life, particularly in the Old Kingdom. All physical infirmities were likely respected and publicly recognized in ancient Egypt. In addition, their disease was not physically limiting. Moral and wisdom teachings show ancient Egyptians' acceptance of physically disfigured people. Many old kingdom dwarfs received extravagant burials near the royal cemetery. Their hieroglyphic statues and expensive tombs demonstrate their exalted status.[19] Ancient Egyptian teachings on morals and wisdom show their good view of the dwarfs. The New Kingdom Instructions of Amenemope, who reigned under Amenhotep III, describe ancient Egyptian principles. Amenemope advised respecting dwarfs and other handicapped people. The following was some of the instructions: do not jeer at a blind man nor tease a dwarf, neither interfere with a cripple, do not insult a man in God's hand, nor scowl at him if he errs.[16,21,22]

The Orthopedic Diseases of Ancient Egypt

Early Egyptians had few arthritic disorders. Only mummified corpses of pharaohs, viziers, high priests, and nobility, who lived longer than the rest of the populace, show Osteoarthritis (OA).[23] Medical-like whole-body computed tomography scanning was done on 52 ancient Egyptian mummies. A comprehensive examination of all major joints and the spine documented Osteoarthritis (OA) changes. Six (12%) of 52 mummies exhibited pathologic spine curvature. Modern society has substantially lower scoliosis rates. Twenty-five (48%) of our 52 mummies revealed spine degeneration with osteophytes and other anomalies indicative of current spinal osteoarthritis. Given the young predicted death age (mean 38.1 years), this incidence is greater than expected in a modern population. There were 13 mummies with acromioclavicular OA. Osteoarthritis alterations were less prevalent in the major joints of the hip (one case, 2%), elbow (one case, 2%), knees (four cases, 8%), and ankles (five cases, 10%), and ankle damage was not found.[24] Several predynastic instances of spine tuberculosis were documented. Nesparehan, an Amun priest, recounted the most authentic example. A classic dorsal vertebral collapse with angular kyphosis and a large right iliac fossa psoas abscess.[25]

The human bones were inspected at the Deir el-Medina settlement, known to have been established to house the families of the Valley of the Kings tomb cutters and decorators. OA was detected in these too. OA frequency found by joint and sex in Deir el-Medina were: hip osteoarthritis was the most frequent in men and women (39% and 30%, respectively), followed by the knee (35% and 17%), and the ankle (31% and 8%).

The proportion of components with OA at Deir El-Medina shows that males had higher knee and ankle joint strain than women or comparable populations of middle-class and elite Egyptians.[26] Thus, workmen's treks may cause knee and ankle OA at higher rates than women from the village or other working areas. OA rates at Deir el-Medina are between those of other Egyptian working and elite populations, showing how the craftspeople there had good social access yet hard labor.[27-29]

Conclusion

The ancient Egyptian civilization lasted for 3000 years and ended in 30 BCE. Orthopedics as a specialty was documented in ancient Egypt by the human remains the drawings, and the medical papyri. Fracture management was evident by the significant number of healed fractures. The old Egyptian tolerance for people with physical disabilities whether hereditary such as skeletal dysplasia, congenital deformities, or diseases such as polio was an example of respect for human rights.

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Total Knee Replacement in Nonambulant Patients: Osteoporosis, Severe Fixed Flexion Deformity, and Weak Extensor Mechanism "the Terrible Triad"

Radwan G. Metwaly, Zeiad M. Zakaria

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Abstract

Background: Knee osteoarthritis is among the most disabling disorders in elderly. With delay in proper management, muscular weakness, progressive flexion deformity (FD), and disuse osteoporosis "the terrible triad" are serious consequences, which could be major obstacles for the planned total knee replacements (TKRs). High risk for iatrogenic fractures, difficult gap balancing and failure to promote the patient activity are common expectations. **Materials and Methods:** A retrospective analysis of all TKRs that were done in a university specialized unit between January 2015 and January 2021 searching for nonambulant-patients was done. Twenty-two replacements for 15 patients who were unable to walk at least 3 months before surgery were found. The median fixed FD (FFD) before anesthesia was 45°. Osteopenia was evident on X-rays and bone thickness intraoperatively. Quadriceps muscle strength was not more than grade four. The median preoperative functional KSS was 0°. The median preoperative WOMAC score was 90.63. **Results:** Twelve knees had remaining FFD 1 year after surgery with a median of 5°. Ten had iatrogenic fractures mostly affected the medial femoral condyle. One patient could not regain walking capability and 11 patients could not walk without assistance. The median postoperative functional KSS and WOMAC scores were 61 and 21.36, respectively. **Conclusion:** TKRs in nonambulant patients with evident terrible triad (muscle weakness, osteoporosis, and FFD) is a risky procedure. Common complications include iatrogenic fractures and inability to regain normal physical capabilities. Despite the magnificent improvement in function, we do not recommend performing TKRs in such patients without strict patient counseling with possible drawbacks.

Keywords: Flexion deformity, muscle weakness, nonambulant, osteoporosis, total kneein elderly

Introduction

Osteoarthritis is the most common articular cartilage disease. It is considered to be among the most disabling comorbidities in elderly especially when affecting lower limb weight-bearing joints. As population is aging, the incidence of osteoarthritis has been doubled since the mid-12th century.[1,2] Knee osteoarthritis is responsible for more than 80% of joint injury and disease burden.[3] After the failure of conservative measures, total knee replacements (TKRs) surgery is always considered the treatment of choice.[4-7]

With the advancement of the disease, pain impedes normal physical activity and impedes performing the activities of daily living. Standing from sitting position, walking for even a short distance and going up or downstairs become a major concern for patients and so they may prefer to reduce their ambulation to the minimal requirement and become more confined to chairs.[8,9]

Nonfavored consequences are evidenced with limitation in elderly physical activities. A strong association was found between cardiovascular comorbidities and osteoarthritis, with three times higher risk of having a heart failure or myocardial infarction.[10,11] Psychological disturbances with increased risk of anxiety, depression, and other mental disorders were found in one-fifth of osteoarthritic patients.[12,13]

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Locally, as a result of limited ambulation, muscular integrity is reduced with weakness of pelvic stabilizers and quadriceps muscles leading to imbalanced gait and increased difficulty in walking.[14,15] With disease progression, disuse osteoporosis in bone is found which poses a superadded problem when surgical treatment is considered.[16,17]

Prolonged periods of sitting, pain, and muscle spasm lead to progressive fixed flexion deformity (FFD) with loss of ability to fully extend the knee. This leads to more articular damage, increased pain, and muscle spasm. Thus patients enter into a viscous circle of difficult ambulation due to pain and progressive FD. The delay in properly timed surgery either due to patient fears or due to late waiting list dating prolongs the nonambulant situation on which severe degrees of FFD expected.[18-20]

Accompanied muscle weakness, bone osteoporosis, and severe FFD presume huge challenges for TKRs, and when present together, surgeons must be aware of the increased risk for the expected complications in the form of iatrogenic fractures, failure to fix the implant promptly with nonconstrained prostheses and residual FD with imbalance of flexion and extension gaps. Postoperatively, patients may not regain their capabilities of walking and performing their activities of daily living that poses a high patient dissatisfaction.

This study aimed to estimate the pros and cons for performing TKR in osteoarthritic patients who were nonambulant for more than 3 months before surgery with consequent muscle weakness, osteoporosis, and FFD to help surgeons in decision-making and patient counseling.

Materials and Methods

A retrospective analysis of all TKRs performed in a specialized adult knee reconstructive unit in a university hospital through a 6-year period between January 2015 and January 2021 searching for knee osteoarthritic patients who were nonambulant before surgery was done. Only TKRs for primary osteoarthritis were included. Patients with neuromuscular diseases limiting the physical capabilities, Charcot joints, revision TKRs, and patients with advanced hip and spine diseases were excluded.

Among those who had TKRs, 15 patients (four males and eleven females) were recorded as unable to walk for at least 3 months before surgery (average 4.8 months), and their average age at the time of surgery was 67.7 years old. The main cause of delay was surgical dating problem (eleven surgeries) followed by patients' fear from surgery (five surgeries) and the rest of delayed surgeries were due to control of comorbid conditions (two patients) or local condition (four patients).

The main pathology for surgery was primary osteoarthritis for all the 15 patients although four patients were recorded as having postlocal injection with steroids or hyaluronic acid septic arthritis, and surgical debridement was done before surgery. However, in these patients, septic arthritis was not the primary cause of osteoarthritis.

Patients' data were reviewed for the preoperative clinical examination including FFD, coronal plane deformity, range of motion (ROM), functional scores (KSS and WOMAC scores), involvement in any preoperative physiotherapy or rehabilitation programs, and preoperative X-ray searching for evident osteopenia. Postoperative data for the same parameters at 3 weeks and 1 year after surgery were retrieved but a comparison was done between the preoperative and the 1-year follow-up measures.

Four patients had body mass index (BMI) >40, and the most common comorbidity found was diabetes mellitus (eight patients). Other recorded comorbidities were hypertension, cardiac problems, hepatic problems, and a single case of ITP, which had repeated attacks of bilateral knees intra-articular hemorrhage. Only two patients were free of comorbid medical conditions at the time of surgery.

FFD (which was recorded to the nearest 5°) measurement differs before and after induction of anesthesia due to muscle spasm and so degrees of FFD measured at the outpatient clinic (OPC) and postinduction were searched. The median OPC measure was 45° and postinduction FFD was 25° (ranging from 15° to 75°) with 13 patients had improved FFD to < 30° after induction. Comparison with postoperative measures was done with the postinduction records.

Extensor mechanism muscle strength was recorded according to medical research council (MRC) grading system[21] [Table 1] and a maximum record of grade four was found (14 knees with quadriceps muscle strength grade 4 and 8 with grade 3 with an average of 3.6 and a median of 4). Osteoporosis was evident in a qualitative manner in the form of a wide medullary canal, narrow cortices, reduced radiological opacity and was confirmed from the intraoperative data where severe thinning of the cortices was documented.

Although performance-based physical function tests (as 30s chair stand test, stair climb test, and 6-min walk test) are done in the preoperative clinical package for patients undergoing to have TKRs, these functional tests were recorded as inapplicable

Table 1: Medical Research Council muscle strength grading scale

Muscle strength grade	Description
0	No movement is observed
1	Only a trace or flicker of movement is seen or felt in the muscle or fasciculations are observed in the muscle
2	Muscle can move the joint only if the resistance of gravity is removed
3	Muscle can move the joint only against gravity with the examiner's resistance completely removed
4	Muscle strength is reduced but muscle contraction can still move joint against resistance
5	Muscle contracts normally against full resistance

and physical activity was retrieved from functional KSS, which was recorded in all the 22 knees as zero as the results were with minus values. The median objective KSS was also recorded as zero. The median preoperative satisfaction and expectation parts of the KSS were 8 and 6.5 respectively.

The WOMAC score is used as a patient-reported outcome measure and reflects the patient satisfaction ranging from 0 to 100 with the highest value reflects patient dissatisfaction. The median preoperative WOMAC score was 90.63 (ranging from 70.04 to 100).

ROM as well as the FD degree was recorded in degrees for the nearest five using a digital goniometer in a mobile phone application and the median preoperative ROM was 45° (ranging from 15° to 80°).

As regard the coronal mal-alignment, three patients had valgus knees with four TKRs done, and 12 had the more common varus deformity with eighteen TKRs done.

Results

The analysis was done using the Statistical Package for the Social Sciences (SPSS software version 19, SPSS Inc., Chicago, IL, USA). Using the Nonparametric test Kruskal–Wallis Chi-square test, the mean rank and medians of the different studied parameters were estimated. $P < 0.01$ was considered statistically highly significant. Results are shown in Table 2.

TKRs were done for the 15 patients. Seventeen knees with constrained condylar knee implants and four with PS implants with tibial stem insertion) with failed implant fixation in one patient who had intraoperative iatrogenic comminuted fracture of the whole medial femoral condyle (MFC) due to severe osteoporosis that could not be fixed or reconstructed at the time of surgery. Knee arthrodesis was planned later on for this patient.

Ten intraoperative iatrogenic fractures were recorded most commonly in the form of MFC fracture (4 cases) followed by three cases with avulsion of the medial epicondyle and another three cases with anterior tibial plateau fracture. Most of the fractures recorded were during full trial or plastic insertion [Figure 1].

Only three knees could have full extension with no FD immediatly after surgery, the median immediate postoperative FFD was 10° (range from 0° to 20°). These three TKRs had preoperative postinduction FFD of 15°.

Following rehabilitation, seven other TKRs could gain full extension which had immediate postoperative FFD of 5°. Twelve patients had remaining FD 1 year after surgery with a median of 5° (range from 0° to 15°). Comparing the immediate postoperative FFD with the 1-year follow-up revealed that physiotherapy could improve only 5° of FFD in this patient group.

Table 2: Comparison of the preoperative and 1 year follow-up results

Parameter	Preoperative	Postoperative (at 1 year follow-up)	χ^2	P
FFD				
Median	25.00	5.00	31.318	0.000**
Mean rank	33.23	11.77		
Range	15–75	0–15		
KSS objective				
Median	0.00	62.00	33.702	0.000**
Mean rank	11.59	33.41		
Range	0–28	25–75		
KSS functional				
Median	0.00	61.00	34.297	0.000**
Mean rank	12.00	33.00		
Range	0–0	0–88		
KSS satisfaction				
Median	8.00	29.00	26.871	0.000**
Mean rank	12.50	32.50		
Range	4–16	0–38		
KSS expectation				
Median	6.50	12.00	13.761	0.000**
Mean rank	15.36	29.64		
Range	4–11	3–14		
WOMAC				
Median	90.63	21.36	28.694	0.000**
Mean rank	32.86	12.14		
Range	76.04–100	4.17–94.79		
ROM				
Median	45.00	75.00	8.116	0.004**
Mean rank	17.00	28.00		
Range	15–80	0–110		
Muscle				
Median	4.00	5.00	16.088	0.000**
Mean rank	15.23	29.77		
Range	3–4	3–5		

**P<0.01: is highly significant. FFD: Fixed flexion deformity, ROM: Range of motion

Comparing the preoperative postinduction FFD with the 1 year follow-up results showed highly statistically significant improvement in the FD.

As regard muscle strength, preoperative median MRC was recorded as grade 4 (range from 3 to 4). Postoperative median MRC was grade 5 (range from 3 to 5). Physiotherapy could not improve the muscle strength in five knees of five patients (two of these patients had bilateral TKRs, the other two knees had improved MRC grade from 3 to 4). One of these patients had not gained the walking capability (failed TKR) and the other four patients could walk 6 months after surgery only with the assistance of a walking frame. Again the muscle strength grade comparison with the 1 year follow-up showed highly statistically significant improvement.

For the ROM, a median of 75° (range from 0° to 110°) was gained at the end of rehabilitation for 1-year after surgery.

Figure 1: Case presentation for a male patient 78 years old with (a) bilateral fixed flexion deformity of 45°. (b and c) ROM of right knee (45°–55°–115°) with extension lag of 10° due to weak extensor mechanism. (d and e) Preoperative X-rays showing varus alignment. (f and g) Postoperative X-rays of left side with fracture of the medial femoral epicondyle fixed with locked plate. (h) 3 weeks after bilateral TKRs showing patient started regaining walking capability supported with a frame. TKR: Total knee replacement, ROM: Range of motion

When compared with the preoperative median ROM, a highly statistically significant improvement was found.

Comparing the preoperative KSS parts with the 1 year KSS showed a highly statistically significant improvements in all parts with the median postoperative objective, functional, satisfaction, and expectation results were 62, 61, 29, and 12. The same highly significant improvement was found in the 1-year postoperative median WOMAC score (21.36 ranging from 4.17 to 94.79).

Discussion

Ambulation in the elderly is very crucial. With decreased activity levels, serious consequences are inevitable.[22] Cardiovascular diseases are common comorbidity among osteoarthritis patients, whether as a result of decreased activity or a mere coincidence. Their effect on the general health status worsens the physical capabilities and vice versa.[10,11] In this study five of the 15 patients had associated cardiac comorbidities in the form of low ejection fraction %, coronary heart disease and previous myocardial infarction. High BMI also affects the general health condition as well as the physical capabilities. Morbid obesity with BMI > 40 was recorded in four patients out of the 15 patients included. The cumulative burden of osteoarthritis and comorbidities increases patients' suffering affecting the health-related quality of life (QoL) scores.

The delay of proper surgical timing was attributed to busy waiting list schedules due to increasing number of patients in need of joint replacements and patients' constrain against surgery. Hudak *et al*.[23] explained various assumptions for the patients-side delay. Some patients consider osteoarthritis not as a disease but as a part of their normal aging, others presumed that their surgical candidacy requires more severe symptoms than they do have while others do not believe that surgery could improve their QoL. In this retrospective study, three patients were the cause of delay while seven were delayed due to dating. The other five patients were delayed due to associated local (infection) or medical condition.

With advancement of knee osteoarthritis, pain, muscle spasm, and decreased ambulation leads to progressive FD, muscle weakness, and osteoporosis "the terrible triad." This triad was recorded in osteoarthritic knees in patients with connective tissue diseases mainly rheumatoid arthritis. In this retrospective study, the authors reviewed primary osteoarthritis as the main articular cartilage disease with the exclusion of other pathological conditions like rheumatoid arthritis, neuromuscular diseases, Charcot joints, and revision cases.

To the best of our knowledge, this is the first time to link primary osteoarthritis with the inability to walk due to delayed surgery to grasp the attention to the possible occurrence of such triad in delayed proper timing of TKR in primary osteoarthritis patients. Although only 15 patients were found in this retrospective 5 years study period, this rare situation should be highlighted to increase the awareness of the possible complications that might occur with unsatisfactory outcomes.

The assessment of the extensor mechanism integrity before TKRs is very important. At least quadriceps muscle strength of grade three of five on the MRC score was suggested for the success of the procedure.[24] A recent systematic review by Vasta *et al.*,[25] showed that preoperative rehabilitation programs in the form of isometric quadriceps strengthening, antagonists stretching, and neuromuscular balancing exercises could improve QoL for osteoarthritis patients and decrease the postoperative hospital stay but there is no clear evidence on their effect on improved function in the postoperative period.

Preoperative rehabilitation was not routine in the study group and weak muscle strength (median of 4) was recorded. Improvement in muscle strength was found after TKRs (median of 5), which suggests that TKRs facilitates rehabilitation due to decreased pain and so improving the physical capabilities and the QoL for elderly patients. A similar improvement could be found as regard the ROM that was improved from a median of 45° preoperatively to 75° after 1 year of follow-up.

Osteoporosis is a silent disease. The relationship between osteoporosis and osteoarthritis had been studied as two different age-related diseases with shared incidence and pathological mechanisms. Physical activity improves the function capabilities of arthritic joints as well as bone quality. To follow osteogenetic rehabilitation programs that involve low-impact activities such as brisk walking or jogging, cooperative patients with painless joints are needed.[16,17] TKRs in osteoporotic bone carry a higher risk of iatrogenic intraoperative fractures. Surgeons fall into debate when trying to improve the physical capabilities for patients with arthroplasty surgeries due to the fear of complications.[26-29]

Alden *et al.*,[29] found that iatrogenic fractures during TKRs were most commonly affecting the MFC with bone thinning diseases (such as osteoporosis and rheumatoid arthritis), component design, component position, and excessive bone cuts are of among the predisposing risk factors. Ten intraoperative fractures out of twenty-two TKRs (45.4%) were recorded most commonly affecting the MFC (four cases), the medial femoral epicondyle (three cases), and the anterior tibial plateau cortex (three cases). Lombardi *et al.* reported a 4.4% risk of intraoperative fractures in TKRs from a cohort of 898 surgeries.[30] Patients with the presence of the terrible triad (bone thinning, FFD, and muscle weakness) are at ten times higher risk to suffer from intraoperative fractures. A special relationship between the preoperative coronal mal-alignment and the location of the fracture could not be statistically proven due to the limited case number.

Flexion contracture is a well-known cause of low functional scores due to higher muscle energy expenditure required causing increased tiredness from activities like standing from sitting position, walking, and climbing stairs.[18] Campbell and Trudel,[31] found that severe single FFD affects the contralateral knee and spine worsening the functional ability of patients. FFD impede full-foot ground bearing making normal standing and walking impossible.

The presence of FFD increases the risk of residual postoperative flexion.[32] Many authors had recommended incomplete intraoperative correction of severe degrees of FD as part of such contracture could be corrected with serial postoperative casting and physiotherapy.[33] Scott,[34] predisposed a "rule of one-third" in the management of FFD > 40° when correction should be limited to one-third of that recorded after induction of anesthesia. A residual FD of more than 15° after TKRs was found incompatible with normal gait cycle and velocity due to increased quadriceps contraction force demands to 22% of those with fully extended knees. This contraction forces demands increase to 50% with 30° of flexion contracture.[19] Hence, primarily every surgeon do his best to gain a full extension to improve the quadriceps biomechanics after surgery. With the presence of severe flexion contractures and to avoid massive bone resection from distal femoral cuts, a compromise could be accepted according to the rule of one-third. In our opinion, this rule was unacceptable for all patients as in cases of more than 45° of FD after induction of anesthesia, an expected > 15° of residual deformity would be in need for aggressive rehabilitation protocols that may lead to periprosthetic fractures with such osteopenic thin bone. If such residual FD could not be corrected, failure to walk again would be the result with unsatisfactory PROMs.

In our unit, the philosophy was to fully correct any FD if possible with the maximum allowed distal femoral bone cuts and not to accept a residual FD of > 15° that could be improve with physiotherapy. Six knees were found to have FD of > 45° after induction of anesthesia, five of them had residual deformity of 15° immediately after surgery and one knee had a residual FD of 20°. The improvement after 1 year of follow-up was of only 5° in four patients confirming our hypothesis.

The median preoperative FFD was 45° and that improved to 25° after induction of anesthesia, this was significantly improved to 5° 1 year after surgery. However, actually four knees had a residual FD of 15° (18.1%), three with 10° (13.6%), and five with 5° (22.7%). This means that although a significant improvement was achieved in the FD, only 45.4% could have full knee extension and this goes with that preoperative FFD is one of the most common causes of persistent flexion contracture.

The semi-constrained condylar prosthesis was used in most of the cases (17 patients 77.2%) due to the need of stemmed femoral component to strengthen the bone or the independable state of ligaments stability. The cases where a nonconstrained prosthesis was used, a tibial stem was inserted to support load sharing on diaphyseal bone.

The most important finding of this study was the marvelous improvement in the knee functional scores and WOMAC score indicating high patient satisfaction after surgery upon which the risk-benefit of such a procedure should be highlighted. One patient failed to regain walking ability (due to MFC fracture), 11 patients could walk with assistance and three could regain their walking capability 1 year after surgery without assistance.

With such results, we do recommend TKRs in nonambulant primary osteoarthritic patients with the terrible triad of muscle weakness, bone thinning, and FFD but only after strict patient counseling of possible complications.

We are aware of the study limitations due to the small sample size but this is explained by the rarity of the condition as it is a debatable issue whether to proceed for surgery or not as it carries a high risk of complications. Another limitation is due to the heterogenous technique for managing FD we cannot set up a protocol to guide which technique should be followed for such cases and management of FD in such patient groups should be individualized following the acceptable techniques of bone cuts and soft tissue release.

Conclusion

Delayed proper timing for TKRs in primary osteoarthritis may lead to serious consequences in the form of muscle weakness, bone thinning, and flexion contracture "terrible triad." With the advancement of the disease, the physical activities of the patients are markedly affected with possible progression to nonambulant status and patients prefer to be confined to wheelchairs. Although we had found a magnificent improvement in the functional objective scores and patient-reported outcomes, higher than usual risk of possible complications in the form of residual deformity, intraoperative fractures, and failure of surgery were recorded. Surgeons must be aware of the possible complications and weigh the cost-benefit on an individual basis. Patient education as regard the pros and cons of surgery is mandatory.

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Conflicts of interest

There are no conflicts of interest.

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The Clinicoradiological Outcome of Arthroscopic-assisted Reduction and Internal Fixation of Tibial Plateau Fractures

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Abstract

Background: The fractures of the tibial plateau are intraarticular fractures accounting for 1% of all fractures. Surgical management of such fractures is often challenging because they require anatomical reduction and stable fixation, which will allow for early rehabilitation. Arthroscopy has evolved nowadays and arthroscopically assisted reduction and fixation is a good option among the available surgical options. **Materials and Methods:** This prospective study included 50 cases of tibial plateau fractures managed surgically by arthroscopic-assisted reduction and fixation starting from August 2019 to December 2022. **Results:** The patients were 39 years old on average and were mostly men (58%). The right knee was the most usually injured (53%), and the most common cause of injury (41.5%) was a fall from a height. The majority of these fractures (44.5%) belonged to Schatzker type 2, followed by type 1 (37%) and type 3 (18.5%). The average time to complete weight-bearing for a Schatzker type I fracture was 10 weeks, 11.5 weeks for a type II fracture, and 13.5 weeks for a type III fracture. The average time to union for Schatzker type I was 13 weeks, 15.5 weeks for type II, and 16 weeks for type III. The mean clinical and radiological scores using the modified Rasmussen criteria were 26.3 and 7.3, respectively. **Conclusions:** A good surgical outcome of tibial plateau fracture is acquired when anatomic articular surface reconstruction with the elevation of depressed bone fragment is combined with rigid stable fixation, which permits early rehabilitation. Arthroscopy helps in achieving these goals by providing a good visualization of the articular surfaces, adequate fracture reduction, and anatomical restoration of the joint surface and aids in thorough joint lavage to remove the intraarticular debris.

Keywords: Arthroscopic assisted, articular surface, Rasmussen criteria, Schatzker type, tibial plateau fractures

Introduction

The fractures of tibial plateau fractures are a type of intraarticular fracture, representing nearly about 1% of all fractures.[1] These fractures pose considerable surgical challenges because they require precise anatomical reduction and secure fixation to allow for early rehabilitation and improved functional results. The major therapeutic aims for intraarticular fractures are always to reconstruct the articular surface and ensure stable fixation to allow for early mobility. The treatment of tibial plateau fractures adheres to two fundamental principles. First, it involves achieving an anatomical reduction of the joint surface and reconstructing the mechanical axis of the limb. Second, it entails restoring the stability of the knee joint.[2] Schatzker type I to III fractures are relatively low-energy injuries, sustained in the lateral tibia plateau, whereas type IV to VI are high-energy trauma injuries.[3-5] Displaced tibial plateau fractures have conventionally been managed using a surgical technique known as open reduction internal fixation (ORIF).[6,7] Various approaches and techniques have been developed to address tibial plateau fractures, including the anterolateral and posteromedial inverted L-shaped approaches. However, it is important to note that ORIF, despite its effectiveness in managing these fractures, has been associated with several reported complications. These complications may include infections, hematoma formation, surgical wound dehiscence, and knee stiffness.[8] The role of arthroscopy in the management of tibial plateau fractures has evolved, and more recently, arthroscopically assisted internal fixation (ARIF) is considered a viable choice among available surgical techniques. This technique was initially developed

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in the 1980s by Reiner, McGlynn, and Jennings and has demonstrated its effectiveness, particularly in the treatment of Schatzker types 1, 2, and 3 fractures when compared to traditional ORIF. For Schatzker types 4, 5, and 6 fractures, arthroscopy appears to enhance the quality of reduction and eliminate the need for extensive arthrotomy.[9-13] The main advantage of this approach is its minimally invasive nature during surgery, which avoids damage to the articular cartilage, menisci, and other delicate knee structures. The combination of arthroscopy and percutaneous fixation brings several benefits, including enhanced fracture reduction, optimal visualization for joint reconstruction, and the ability to address associated injuries simultaneously.

Aim of study

The aim of the study was to assess the functional and radiological outcome of tibial plateau fractures Schatzker's type I, II, and III, which were managed with arthroscopic assistance.

Materials and Methods

A total of 64 patients were operated on during the study period, which started from August 2019 to ended in December 2022. Out of 64 patients, eight were lost to follow-up and six are still on follow-up yet to complete 12 months. The final analysis was done on 50 patients who were fulfilling the inclusion criteria.

Inclusion criteria

- Age 18–50
- All sexes
- Patients with tibial plateau fractures Schatzker's type 1, 2, and 3
- Patients who followed up for a minimum period of 12 months.

Exclusion criteria

- Schatzkers type 4, 5, and 6
- Open fractures
- Polytrauma
- Pathological fractures
- Proximal tibia fractures with neurovascular injuries
- Proximal tibia fractures with ligamentous injuries
- Degenerative disease of the knee joint
- Lost to follow-up before 12-month period.

A detailed history was taken, and clinical examination was done on each patient to assess the local skin condition and the neurovascular status of the fractured limb. Radiographs and CT scans were taken to assess the type of the fracture, the degree of depression, and joint widening. Patients with tibial plateau fractures Schatzker type I, II, and III presented to our hospital were included in this study. Patients gave written informed consent to participate in the study. These patients were followed up for 12 months and were evaluated radiologically and clinically using modified Rasmussen scoring.[14]

Classification

The Schatzker classification system was employed to categorize tibial plateau fractures, which comprises six distinct patterns: Type 1: pure split of the lateral plateau, Type 2: lateral split with depression, Type 3: pure depression of the lateral plateau, Type 4: medial plateau fracture, Type 5: bicondylar fracture, and Type 6: unicondylar or bicondylar tibial plateau fracture with diaphyseal separation[3] [Figure 1].

Radiographic evaluation

Plain radiographs of the proximal tibia in anteroposterior and lateral views often underestimate the severity of the injury; hence, the role of computed tomography is essentially important to understand the three-dimensional configuration of the proximal tibia fractures by illustrating the fracture patterns, size of articular fragments better than plain radiographs, and proper planning for surgery. For soft-tissue injuries (ligamentous, menisci, etc.), magnetic resonance imaging is highly useful.

Surgical technique

After spinal anesthesia, in the supine position, the knee was examined for stability. After the tourniquet application, the limb was prepared and draped in a routine fashion. With the affected knee in 90° of flexion, anterolateral, and anteromedial portals were created, and any hematoma present in the knee joint was drained subsequently [Figure 2].

After the evacuation of hematoma, normal saline was instilled into the joint to improve the visibility, and diagnostic arthroscopy was performed to assess for fractures and meniscal injuries, including ligamentous injuries [Figure 3]. Bony, cartilage, and other soft-tissue debris were cleared from the joint using arthroscopy. Then, the fracture of the tibial plateau was reduced using standard reduction techniques, and the intraarticular reduction was visualized arthroscopically.

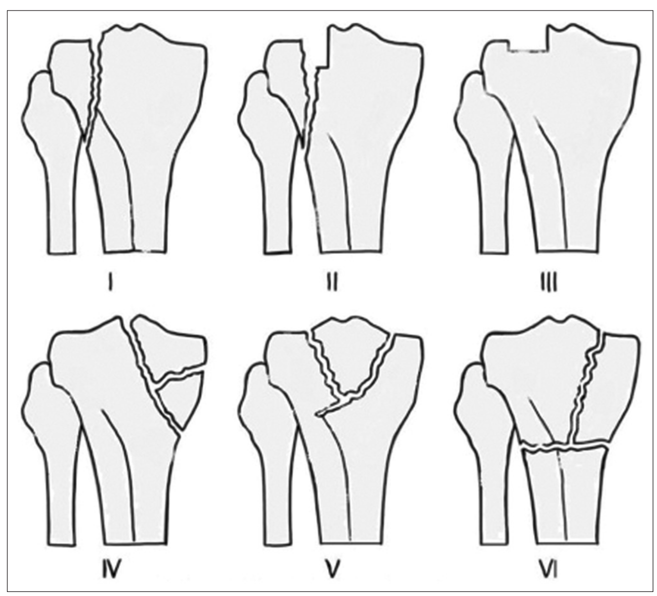

Figure 1: Schatzker classification

Once reduction was found acceptable having no intraarticular step, the fracture was fixed percutaneously using cancellous cannulated screws. Fluoroscopy was used to guide the screws into their desired position in the proximal tibia, optimally 1 cm just below the articular surface of the tibial plateau and parallel to the knee joint line [Figure 4]. These screws give support to the articular surface and subchondral bone by acting as rafters. In certain communited fractures, additional buttress plate was used through standard anterolateral approach [Figure 5]. The joint depression type of fractures was specifically treated by creating a window on the medial aspect of the tibia 10 cm distal to the joint line using a guidewire and reeming over it, followed by introducing a bone tamp through the tunnel, thereby lifting the fragment *en bloc* and bringing it to the level of the articular surface of the lateral tibial plateau and restoring the joint congruity [Figure 6]. Few fine K-wires were shot mediolateral to hold the elevated piece, and if the fragment was thick enough, a cannulated screw was drilled through it, but in smaller pieces, the cancellous cannulated screw was put just under it, providing a raft to prevent collapse. Autologous cancellous bone graft from the ipsilateral iliac crest was taken and placed in the tibial tunnel to fill the defect which was created during the elevation of joint fragments. At the end of the procedure, fluoroscopic and arthroscopic assessment was performed to ensure that reduction of fracture has not been disturbed.

Postoperative management

Weekly follow-up appointments were conducted for all patients to assess wound status until sutures were removed, which were removed at the end of the 2^{nd} week. During this initial period, the injured knee was immobilized using an above-knee slab. After the first 2 weeks, gentle active and passive range of motion exercises was initiated. For the initial 6 weeks following surgery, patients were strictly instructed to refrain from weight-bearing activities. After 6 weeks, toe-touch weight-bearing was permitted. Regular clinical and radiological follow-up assessments were carried out on a monthly basis. Patients were granted full weight-bearing privileges once both clinical and radiological evidence of union was observed. Final follow-up was performed at 12 months, and assessment was done both clinically and radiologically using modified Rasmussen scoring [Tables 1 and 2].[14]

Figure 2: Drainage of hematoma

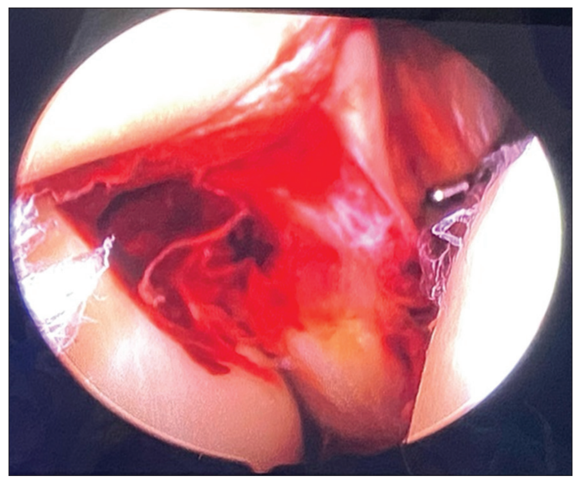

Figure 3: Arthroscopic visualization of articular surface

Figure 4: Reduction of a type 1 fracture and fixation with raft screw

Figure 5: Plate application of a type 1 fracture

Results

The average age of the patients was 39 years, with the majority falling within the 30–50-year age bracket. The study displayed a slight male predominance, with males comprising 58% of the patient population, while females constituted the remaining 42%. Injuries to the right knee were more prevalent (53%) than those to the left knee (47%). Fall from heights was the most common mechanism of injury, accounting for 41.5%, followed by road traffic accidents at 34% and other mechanisms at 24.5%. Among the fractures, Schatzker type 2 fractures were the most frequent (44.5%), followed by type 1 (37%) and type 3 (18.5%). Notably, Schatzker type 3 fractures were more common among females (68%) than males (32%). The average time for patients to achieve full weight-bearing after fixation was 10 weeks for Schatzker type 1 fractures, 11.5 weeks for type 2 fractures, and 13.5 weeks for type 3 fractures. Furthermore, the mean time to union was 13 weeks for Schatzker type 1 fractures, 15.5 weeks for type 2 fractures, and 16 weeks for type 3 fractures.

Union was evaluated through both clinical and radiological criteria. Clinically, union was determined by the absence of tenderness at the fracture site, as well as the ability to bear weight without discomfort. Radiologically, union was confirmed by the presence of at least three cortices showing evidence of fusion in both anteroposterior and lateral X-ray views. The assessment of clinical and radiological outcomes of the fractures was conducted using the modified Rasmussen scoring system.[14]

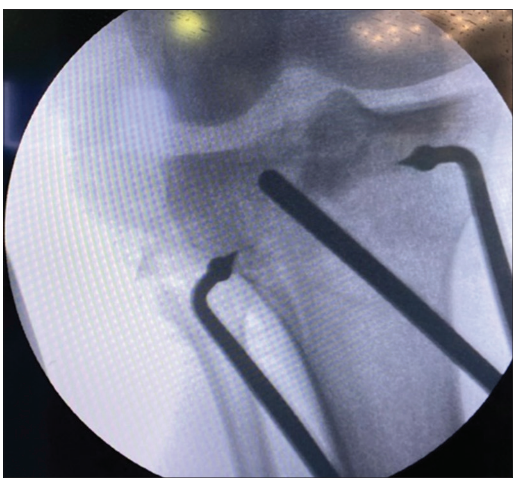

Figure 6: Elevation of a depressed fracture through medial cortical window by 6 mm rod

Table 1: Clinical assessment

Criteria	Score
Pain	
None	6
Occasional	5
Stabbing pain in certain position	3
Constant pain after activity	1
Significant rest pain	−3
Walking capacity	
Normal walking	6
Walking outdoors >1 h	5
Walking outdoors 15 min–1 h	3
Walking outdoors <15 min	1
Walking indoors only	0
Knee extension	
Lack of extension <10°	2
Lack of extension >10°	0
Lack of extension >20°	−2
Total range of motion	
Full	6
Up to 120°	5
Up to 90°	3
Up to 60°	1
<60°	−3
Stability	
Normal stability in extension and 20° flexion	6
Abnormal instability in 20° flexion	4
Instability in extension <10°	2
Instability in extension >10°	0
Power of quadriceps	
Grade 5	2
Grade 3–4	1
Grade <3	−2
Outcome	
Excellent	28–30
Good	24–27
Fair	20–23
Poor	<20

Figure 7: Series of radiographs showing Schatzker type 1 fracture and its fixation using 2 cancellous cortical screws. (a) Schatzker type 1 fracture, (b) immediate postoperative X-ray on day 1, (c) union at 6 months follow-up

The mean Rasmussen functional and radiological score at final follow up was 26.3 and 7.6 respectively [Tables 3 and 4].

Mean Rasmussen score with respect to type of fracture is given in Table 5.

Table 2: Radiological assessment

Criteria	Score
Articular depression	
None	3
<5 mm	2
6–10 mm	1
>10 mm	0
Condylar widening	
None	3
<5 mm	2
6–10 mm	1
>10 mm	0
Varus valgus angulation	
None	3
>10°	2
10°–20°	1
>20°	0
Osteoarthritis	
None	1
Progression by 1 grade	0
Progression by >1 grade	−1
Outcome	
Excellent	9–10
Good	7–8
Fair	5–6
Poor	<5

Table 3: Clinical assessment

Result	Number of patients (%)
Excellent (28–30)	28 (56)
Good (24–27)	14 (28)
Fair (20–23)	6 (12)
Poor (<20)	2 (4)
Total	50 (100)

The mean Rasmussen functional score at the final follow-up was 26.3

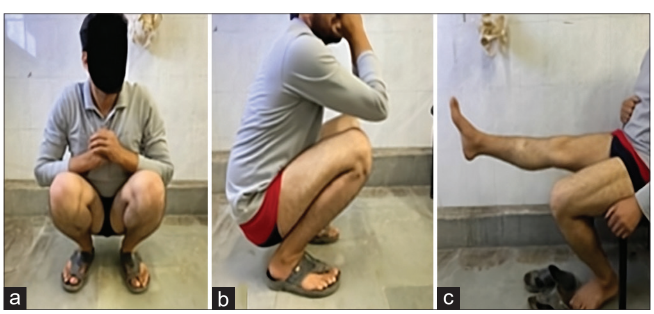

Figure 8: Clinical photographs showing (a and b) flexion, (c) extension of the knee following fixation of a Schatzker's Type 1 fracture

A case of 32 year old male patient who had Schatzker type one fracture of right proximal tibia due to road traffic accident and was fixed percutaneously with two cannulated cancellous screws [Figure 7]. The patients range of motion of the affected knee was comparable to opposite unaffected knee at six months of follow up [Figure 8].

Complications

The most frequently observed complication was knee stiffness, affecting six cases, and this issue was managed through physiotherapy. In addition, articular surface depression was noted in two patients, likely due to early weight-bearing in the violation of the postoperative rehabilitation protocol [Figure 9]. Furthermore, three patients developed secondary osteoarthritis, primarily as a consequence of inadequate reduction of the articular surface, leading to joint incongruity. Superficial infections were identified in two patients, and these were effectively treated with antibiotics and dressings. It is worth noting that none of our patients experienced deep or joint infections.

Discussion

Tibial plateau fractures typically result from high-energy injuries and primarily affect young adults, constituting approximately 1% of all fracture types. Managing these fractures has long been a subject of debate due to their complexity. It is imperative to address them properly, as complications such as wound dehiscence, fracture collapse, and osteoarthritis can arise if not managed effectively. These fractures are intraarticular in nature and necessitate precise anatomical and rigid stable fixation. Early initiation of both active and passive range of motion exercises is crucial to achieve favorable functional outcomes. Following surgery, prolonged immobilization of the limb with splints can lead to knee stiffness, while overly early weight-bearing may result in fracture collapse. In addition, tibial plateau fractures may be accompanied by injuries to the menisci,

Figure 9: Postoperative radiograph showing articular depression as a result of early weight-bearing

Table 4: Radiological assessment

Result	Number of patients (%)
Excellent (9–10)	20 (40)
Good (7–8)	19 (38)
Fair (5–6)	10 (20)
Poor (<5)	1 (2)
Total	50 (100)

The mean Rasmussen radiological score at the final follow-up was 7.6

Table 5: Mean Rasmussen score with respect to Schatzker classification

Schatzker's classification	Mean Rasmussen score	
	Clinical assessment	Radiological assessment
Type 1	28	9
Type II	26	8
Type III	25	6

cruciate ligaments, or collateral ligaments, as previously reported.[15,16] These associated injuries can be diagnosed and treated arthroscopically. Arthroscopy provides the advantage of retracting the meniscus, enhancing visualization of the articular surface, and facilitating the assessment of articular cartilage reduction. For depression-type fractures, it is essential to adequately elevate the depressed fragment to maintain joint congruity. This is typically achieved by creating a medial metaphyseal window to lift the depressed fragment and subsequently filling the tunnel with bone grafting. This technique has demonstrated positive midterm results in the existing literature. Numerous reports support the use of arthroscopy as an effective approach to managing tibial plateau fractures.[17-20] In the present study, it was observed that males were predominantly affected compared to females, with a mean age of approximately 39 years. The right knee was more frequently involved, accounting for 53% of cases. Schatzker's type II fracture pattern was the most commonly encountered, representing 44.5% of cases. On average, patients in the study began partial weight-bearing at 11 weeks postsurgery, and the mean time to full weight-bearing was 14.8 weeks.

Dall'oca *et al*. conducted a comprehensive study comparing arthroscopy-assisted internal fixation (ARIF) with ORIF. Their study involved a cohort of 100 patients and included an assessment of various parameters, including the Rasmussen score, The Hospital for Special Surgery knee-rating score, and complications. The study's findings indicated that, in the case of Schatzker type I fractures, there were no significant differences between ARIF and ORIF treatments. However, for Schatzker type II-III-IV fractures, the ARIF technique appeared to yield good clinical outcomes. In the context of Schatzker type V and VI fractures, both ARIF and ORIF techniques showed suboptimal medium- and long-term results. Nevertheless, when ARIF was deemed appropriate, it was considered the preferred choice due to its lower rate of infection-related complications.[21]

In a retrospective study carried out by Fowble *et al*., it was observed that open techniques did not consistently yield proper anatomic reductions. In contrast, arthroscopic fracture repair techniques achieved a remarkable 100% success rate in achieving anatomic reductions.[22]

Siegler *et al*. conducted a study involving 27 patients who underwent percutaneous fixation of tibial plateau fractures (classified as type I–III) with the assistance of arthroscopy. Over a follow-up period spanning 59.5 months, the researchers collected a comprehensive set of functional and clinical scores, ultimately concluding that the results were good and satisfactory. Notably, approximately 47.5% of the patients displayed signs of osteoarthritis, with 10% attributed to axis deviation. Furthermore, the study revealed a statistically significant correlation between the age of the patients at the time of surgery and the development of midterm postoperative osteoarthritis signs.[19]

Conclusions

In our study, we have observed several advantages associated with arthroscopically assisted fixation of tibial plateau fractures. This approach offers clear visualization of the articular surfaces, facilitating precise fracture reduction and ensuring the anatomical restoration of the joint surface. In addition, arthroscopy enables thorough joint lavage, effectively removing any intraarticular loose debris. Furthermore, it allows for the assessment and concurrent management of associated ligamentous and meniscal injuries. Notably, arthroscopy eliminates the necessity for a more invasive arthrotomy, resulting in minimal soft-tissue damage, a low rate of complications, and quicker recovery times. However, it is essential to acknowledge that Schatzker types IV, V, and VI fractures, which are typically the result of high-energy trauma and represent complex injuries, have limited applicability for arthroscopic intervention. For these fracture types, achieving a better outcome often necessitates open reduction and internal fixation or the use of an external Ilizarov ring fixator. The major drawbacks of this study were a small sample size, lack of a control group, and shorter follow-up period. In addition, the procedure has a longer learning curve and carries risks of compartment syndrome due to fluid leakage through fracture lines. Further studies are required to analyze if this technique gives better outcomes in the treatment of tibial plateau fractures.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Evaluation of the Results of Reconstruction of Medial Patellofemoral Ligament in the Treatment of Recurrent Patellar Instability Using Hamstring Autograft by Dual Patella Docking Technique

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Abstract

Background: Recurrent patellar instability can significantly affect a patient's life quality. This study evaluated the results of medial patellofemoral ligament (MPFL) reconstruction in the recurrent patellar instability treatment using hamstring autograft by dual patellar docking technique. **Materials and Methods:** This prospective study was performed on 20 recurrent patellar instability patients. Magnetic resonance imaging and computed tomography scans were performed to confirm MPFL tear and assess the tibial tubercle-trochlear groove distance. Various clinical and radiographic evaluations were performed preoperatively. The surgical technique involved diagnostic arthroscopy, graft preparation, patellar preparation, graft passage, femoral tunnel preparation, and graft fixation. **Results:** Postoperatively, a substantial progression was observed in the International Knee Documentation Committee score, Kujala score, Cincinnati score, and Lysholm score compared to preoperative values ($P < 0.001$). In addition, the postoperative measurements of patellar tilt angle and patellar congruence angle were significantly lower than their respective preoperative values ($P < 0.001$). All 20 (100%) patients had negative findings in the postapprehension test, indicating improved stability. In the postcompression test, 3 (15%) patients showed positive results, whereas 17 (85%) patients had negative results. In terms of complications, 2 (10%) patients experienced patellofemoral pain, 1 (5%) patient had residual patellar translation without dislocation, 1 (5%) patient had limited flexion, and the majority of patients (16, 80%) had no complications. **Conclusions:** MPFL reconstruction with patellar docking yielded good results with Kujala and Lysholm, as well as adequate, satisfactory congruence angles for most patients. This procedure has exhibited a high success rate in addressing patellofemoral instability.

Keywords: Docking, hamstring autograft, medial patellofemoral ligament, patellofemoral, reconstruction, recurrent patellar instability

Introduction

Recurrent patellar instability is a challenging problem characterized by repetitive patellar subluxation or dislocation from its usual position in the femoral groove. This condition often leads to pain, functional limitations, and reduced quality of life for affected individuals.[1]

Medial patellofemoral ligament (MPFL) has an essential function in stabilizing patella during knee motion, and when it is damaged or deficient, surgical treatment might be required to restore stability and prevent further episodes of instability.[2]

Various surgical approaches have been developed for MPFL reconstruction and address recurrent patellar instability. One such technique that has gained attention is the use of hamstring autograft by dual patella docking technique.[3] This approach involves utilizing a graft from the patient's own hamstring tendons to reconstruct the MPFL and stabilize the patella. The dual patella docking technique refers to graft fixation at both

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the patellar and femoral ends, providing a secure and stable construct.[4]

The selection of hamstring autograft for repair of the MPFL is dependent on its favorable characteristics, including its strength, low donor site morbidity, and abundant availability. The hamstring tendons, specifically the semitendinosus and gracilis tendons, offer suitable graft material due to their similar size and biomechanical properties to the native MPFL. By utilizing this autograft, the risk of graft rejection or disease transmission is eliminated.[5,6]

Previous studies have investigated MPFL reconstruction results by different techniques and graft materials.[5,7,8]

However, limited research has specifically focused on evaluating the results of MPFL reconstruction using hamstring autograft by the dual patella docking technique. Therefore, there is a need to assess the effectiveness of this technique in achieving stable patellar realignment and reducing the recurrence of patellar instability.

Evaluation of MPFL reconstruction results using hamstring autograft by the dual patella docking technique holds significant clinical implications.

This study aimed to evaluate MPFL reconstruction results in recurrent patellar instability treatment using hamstring autograft by patellar docking technique.

Materials and Methods

This prospective study was performed on 20 patients at the Orthopedic Surgery Department of Benha University Hospitals between August 2019 and August 2021. The study received approval from the institutional ethical committee, the study was accepted by the Faculty of Medicine, Benha University research ethics committee, all research participants gave their informed permission, and each participant was told of the study's goal, how their data would be used, they also gave their consent for publication; they all have agreed to publish this work. The data are available on reasonable request from the authors.

Inclusion criteria

patients between the ages of 11 and 35 who had experienced two or more patellar dislocations and had failed to respond to conservative treatment for a minimum of 3 months. In addition, patients were required to undergo a magnetic resonance imaging (MRI) to confirm a torn MPFL and a computed tomography (CT) scan to evaluate tibial tubercle-trochlear groove (TT-TG) distance which needed to be <20 mm.

Exclusion criteria for isolated MPFL reconstruction were as follows: presence of osteoarthritis greater than Grade 1, focal cartilage defects exceeding Grade 3 according to the Outerbridge classification, Trochlear Sulcus Angle of 145° or greater on the Merchant view, Dejour classification Grade B, C, or D, TT-TG distance exceeding 20 mm, Patella Alta with a Blackburne-Peel ratio >1, Q angle over 20° in females or 17° in males, and any injury to the knee's cruciate ligaments or medial collateral ligament.

Each patient underwent a comprehensive evaluation, which included obtaining informed consent, conducting a general examination, and performing a detailed local examination of the knee. The local examination included the assessment of tenderness around the medial epicondyle, the evaluation of patellar mobility in full extension, a comparison with the contralateral side, and the determination of lateral patellar quadrant translation. Patellar tracking was assessed by evaluating the J sign and performing various tests such as the patellar compression test (patellar grind test), patellar tilt test, and patellar apprehension test. In addition, the limb alignment was evaluated for genu valgum, femoral anteversion, and external tibial torsion. We measured the strengths of the quadriceps and hip muscles while also assessing the presence of generalized ligamentous laxity. This assessment involved examining the elbow for hyperextension and assessing metacarpal hyperextension and knee recurvatum.

Knee radiographic examination includes typical lateral, axial, and anteroposterior weight-bearing scans. Pictures were carefully examined for osteochondral fractures and intra-articular bodies. Lateral radiograph was utilized to evaluate femoral trochlea depth and patellar height. On the axial radiograph, congruence angle, femoral sulcus angle, lateral shift ratio, lateral patellofemoral tilt angle, and absolute lateral patellar displacement were measured. In addition, TT-TG distance was calculated with CT scan, and MRI was used to assess other patellar dislocation-related injuries, as bone contusions on the medial patella, lateral femoral condyle MPFL tears, and articular cartilage injuries.

The surgical technique

Diagnostic arthroscopy

On the operating table, the patient was positioned supine, and a tourniquet was placed on the upper thigh. Intraoperative testing was conducted to validate the clinical findings. We utilized a single-portal diagnostic arthroscopy technique from the superolateral portal, following the approach described by brief lateral patella. This approach allowed us to assess the cartilage, patellofemoral tracking, and laxity of the medial ligaments restricting the joint.

Graft harvesting and preparation

Following arthroscopy completion, 2 cm incision was created over the pes anserinus. The Hamstring tendon was carefully harvested, taking care to preserve its length and minimizing damage to the surrounding structures. The muscle tissue was stripped from the tendon, leaving only the tendinous portion. The tendon was then prepared for grafting.

The harvested tendon was folded in half and secured with a locking stitch, with the free ends emerging from the end of the graft. Individually, two FiberWire sutures are passed through the two graft limbs. The folded end and two graft limb diameters are evaluated and utilized to determine the dimensions of the femoral tunnel and patellar tunnel, respectively.

Patellar preparation, graft passage, and docking

Over the patella medial aspect, a longitudinal incision was done. Two Beath pins that are at least 1 cm apart and often placed in the upper and middle thirds of the patella and pass laterally through the skin. Two incomplete tunnels were drilled over the pins to 2 cm depth using a cannulated drill. The drill diameter corresponds to the graft limb diameter and is normally between 3.5 and 4.5 mm. A suitable skeletal bridge was proven between the two tunnels. Using Beath pins, the graft limb sutures are passed through the patella and out of the lateral incision. Individual graft limbs are "docked" into their corresponding tunnels. The sutures that exit laterally are tied at the lateral patellar rim [Figures 1 and 2].

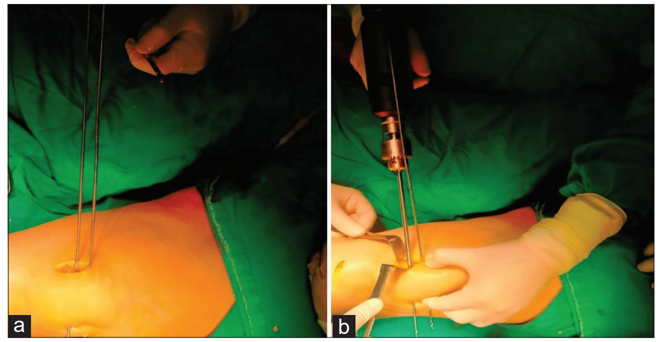

Figure 1: (a) The second guide pin is inserted 15 mmproximally and transversely to the first pin. (b) Both guide pins areover-drilled with a cannulated 4.5 mm drill bit 2 cm deep

Figure 2: The sutures exiting laterally are tied together at the lateral patella rim

Femoral tunnel preparation

An excellent lateral image of the knee was obtained using a C-arm. The MPFL insertion site is only 1 mm anterior to the distal posterior cortical line and 2.5 mm distal to the posterior origin of the medial femoral condyle superior to the Blumensaat line (Schottle's point). A Beath pin was put against the skin to verify the tip's position. Starting at the right insertion point, the Beath pin is moved across the femur parallel to the knee joint and out the lateral skin surface while aiming somewhat proximal and anterior to prevent the violation of the intercondylar notch. A cannulated reamer, whose diameter corresponds to the measured diameter of the folded graft end, is used to drill to a 5 mm depth above the pin. Using the Beath pin, a looped suture is then shuttled into the femur while bringing the pin out laterally. Graft is tensioned into the femoral tunnel. The knee is cycled 20 times with moderate stress on the graft, and then the graft is fixed at 20°–30° knee flexion with a 7 mm interference screw. The knee was next evaluated in full extension and flexion to confirm its flexibility. In addition, we verify that the patella does not have any excessive tilting or medial over constraint [Figures 3 and 4].

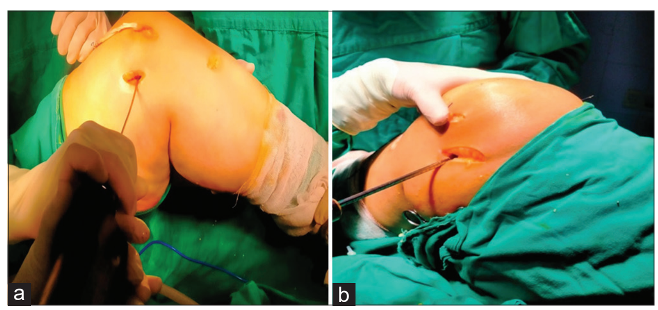

Figure 3: Guidewire introduced in the femur (a) Then cannulated reamer introduced over the guide pin to a depth of 30 mm (b)

Postoperative care

Following surgery, the knee was immobilized in extension using a knee brace for 1 week to protect the reconstructed MPFL. After 1 week, a hinged knee brace was applied, and a gradual range of motion exercises protocol was initiated. The patient was allowed full weight-bearing at 6 weeks postoperatively. Rehabilitation continued with physical therapy, focusing on regaining quadriceps strength, range of motion, and proprioception. Return to normal activities and contact sports were permitted at 3 and 6 months, respectively, based on the patient's progress and the surgeon's assessment. Regular follow-up appointments were scheduled to monitor the patient's recovery and assess any complications or recurrent dislocations [Figure 5].

Statistical analysis

Statistical analysis was carried out using SPSS version 25 software (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY, USA: IBM Corp.). Qualitative presentation was done using frequency and percentage of variables. Quantitative presentation was done using mean and standard deviation. Comparison of means in the same group was done using paired Student's *t*-test.

Results

The demographic characteristics of the study participants are shown in Table 1.

Trauma was the cause of patellar instability in 16 (80%) patients, whereas 4 (20%) patients were affected due to atraumatic causes. Forty-five percent (45%) of patients were affected on the right side, while fifty-five percent (55%) were affected on the left side. Regarding graft type, gracilis graft was used in 12 (60%) patients, whereas semi-T graft was used in 8 (40%) patients.

Follow-up of the patients is shown in Table 2.

International Knee Documentation Committee (IKDC) score, Kujala score, Cincinnati score, and Lysholm score were significantly higher postoperatively than preoperatively ($P < 0.001$), whereas patellar tilt angle and patellar congruence angle were significantly lower postoperatively than preoperatively [$P < 0.001$, Table 3].

Regarding postapprehension test, all 20 (100%) patients were negative. Regarding postcompression test, 3 (15%) patients were positive, whereas 17 (85%) were negative. Regarding complications, 2 (10%) patients had patellofemoral pain, 1 (5%) patient had residual subluxation, 1 (5%) patient had limited flexion, and 16 (80%) patients had no complications.

Table 1: Demographic characteristics of the study participants (*n*=20)

Parameter	Mean ± SD/*n*(%)
Age (years), mean±SD	25.2±5.91
Sex	
Male	7 (35)
Female	13 (65)
Profession	
Student	6 (30)
Worker	3 (15)
Driver	1 (5)
Carpenter	1 (5)
Housewife	6 (30)
Athlete	1 (5)
Nurse	1 (5)
Employee	1 (5)
Athletic activity	
Football	5 (25)

SD: Standard deviation

Table 2: Follow-up of the patients (*n*=20)

	Mean±SD (range)
Follow-up (months)	15.9±5.5 (6–24)
Full weight-bearing (weeks)	5.1±0.83 (4–6)
ROM (weeks)	7±0.89 (6–8)

SD: Standard deviation, ROM: Range of motion

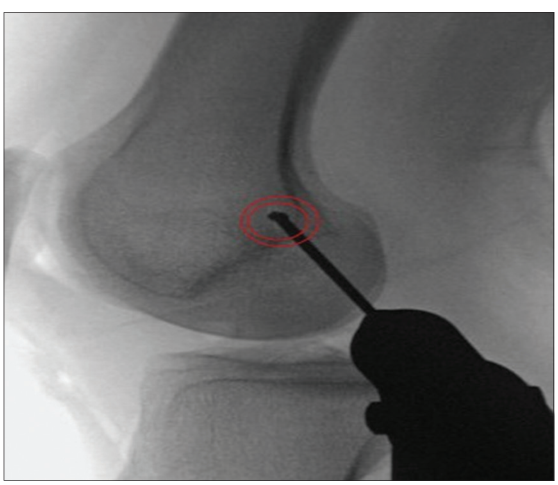

Figure 4: Confirmation by fluoroscopy of the appropriate placement of the guide pins at Schottle point

Discussion

The role of the MPFL as a crucial medial patellar stabilizer in lateral patellar dislocation has been noted throughout the last decade. Several biomechanical investigations have shown that the MPFL is the primary static restraint against pressures that displace the patella out of the sulcus, generating, on average 50%–60% of the total medial restraint force.[1]

Numerous surgical methods have been successfully described to replicate its check-rein action. The objective of a successful surgical procedure must be the restoration of the MPFL, which restores the length and rigidity of the native medial soft tissue. Using various kinds of grafts and methods, the success rate for reconstructing the MPFL varies between 83% and 93%. However, it has been shown that isolated restoration of the MPFL is inadequate to give mechanical strength for optimal MPFL function and yield considerably superior functional results.[2]

According to our results, the postoperative IKDC score was substantially higher compared to the preoperative score ($P < 0.001$).

Supporting our findings, Lee *et al*.[9] demonstrated positive outcomes in 9 cases where soft tissue was sutured onto the patella and femur, resulting in an IKDC score of 81.1. In addition, Carnesecchi *et al*.[10] reported an increase in the mean raw IKDC score from 51.5 preoperatively to 71.7 at the last follow-up. Moreover, the mean overall IKDC score improved from 38.5 to 61.7, and the Kujala score increased from 48.3 to 82.4, further supporting our findings.

In this study, the postoperative Kujala score was substantially greater than the preoperative score ($P < 0.001$). This finding

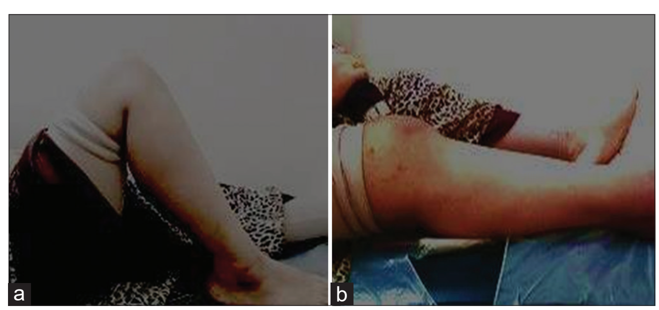

Figure 5: Postoperatively, the patient regained full range of motion (a) Flexion, (b)Extension

Table 3: Knee Documentation Committee score, Kujala score, Cincinnati score, Lysholm score, Patellar tilt angle, and patellar congruence angle of the study patients pre and postoperatively

	Preoperative	Postoperative	*P*
IKDC score, mean±SD	43.1±12.74	68.4±15.71	<0.001*
Kujala score, mean±SD	49.6±14.95	74.4±14.22	<0.001*
Kujala score, mean±SD	48±15.4	76.5±14.82	<0.001*
Lysholm score, mean±SD	57.8±14.37	83.6±12.42	<0.001*
Patellar tilt angle, mean±SD (range)	24.1±2.23 (18–27.5)	9.3±1.39 (7–12)	<0.001*
Patellar congruence angle, mean±SD	26.4±5.36	−7.4±1.27	<0.001*

*: Significant as *P*-value < 0.05. IKDC: International Knee Documentation Committee, SD: Standard deviation

is supported by a recent study conducted by Migliorini *et al*.,[11] which also reported improved postoperative Kujala scores (mean change ± 12.76; $P = 0.0003$) as well as improved Lysholm scores (mean change ± 15.69; $P < 0.0001$). Similarly, Kim *et al*.[12] observed a significant development in Kujala scores, with the average score increasing from 42.7 ± 8.4 before surgery to 79.6 ± 13.6 ($P = 0.008$) at the final follow-up.

In this study, the postoperative Cincinnati score was significantly higher compared to the preoperative score ($P < 0.001$). This finding is consistent with the results reported by Han *et al*.,[13] who found substantial changes between the mean preoperative modified Cincinnati scores and the scores at 12, 36, 60, and 84 months following MPFL reconstruction surgery ($P < 0.01$). Following surgery, the patients' ratings were much higher than their prior values.

In this study, results demonstrated that the postoperative lysholm score was substantially greater compared to the preoperative score ($P < 0.001$). This finding is supported by the study conducted by Kim *et al*.,[12] which revealed a significant improvement in the Lysholm score from 45.8 ± 5.7 to 82.0 ± 10.5 ($P = 0.008$). In addition, Lee *et al*.[9] reported a considerable rise in the Lysholm score from 47.8 points to 84.9 points ($P < 0.001$).

In the present study, we found that the postoperative patellar tilt angle and patellar congruence angle were significantly lower compared to the preoperative measurements ($P < 0.001$). These results align with those reported by Kim *et al*.,[12] who observed a significant improvement in the congruence angle from 26.5° ± 10.6° (range: 12° to 43°) before surgery to −4.0° ± 4.3° (range: −12° to 5; $P = 0.008$) at the final follow-up.

Regarding the postapprehension test, all 20 (100%) patients yielded negative results. As for the postcompression test, 3 (15%) patients tested positive, whereas 17 (85%) patients tested negative. These findings are consistent with the results documented by Ballal *et al*.,[14] who reported no cases of apprehension, maltracking, facet tenderness, or positive patellar quadrant tests postoperatively. However, in contrast to the findings in this study, Christiansen *et al*.[15] reported that 50% of their patients exhibited positive apprehension and pain with palpation. The differences observed may be attributed to the changes in patellar anatomy resulting from the reconstruction procedure and the influence of previous surgeries in some patients.

In our study, we propose a procedure, in which an anatomical reconstruction of the MPFL at both the femoral and patellar attachments is recreated. Our fixation approach employs a dual docking strategy, which provides potential advantages. By creating two incomplete transverse tunnels, we eliminate the need for implants for fixation, reducing surgical time, and lowering the risk of patellar fracture. In addition, this technique increases the surface area available for graft-to-bone healing.

A systematic review conducted by Jackson *et al*.[16] focused on the incidence of complications following primary MPFL reconstruction for recurrent patellar instability. The review analyzed data from 28 studies involving 1478 patients (1521 knees), with a mean age of 23.3 years (range: 19–34.3 years). The findings indicated that patellar fractures occurred in 0% to 8.3% of knees, primarily in patients who underwent full-length transverse tunnel reconstruction.

Another analysis and survey by Wierer *et al*.,[17] conducted within the International Patellofemoral Study Group, concluded that Patellar fracture risk after reconstruction of the MPFL relies on the drilling method and placement of the patellar bone tunnels. The study found that violating the anterior or lateral patellar cortex increased the likelihood of postoperative patellar fracture.

Compared to hardware-free fixation procedures, the use of screws and anchors for patella fixation is considered to be less time-consuming and easier to implement. However, it has been linked to possible side effects, including discomfort and inflammation at the insertion site. However, implant-free patellar fixation procedures have the benefit of being less expensive. As stress risers, thorough reaming and the use of entire transverse bone tunnels may enhance the likelihood of patellar fractures or collapse of the bone bridge.[18]

This technique has several advantages. First, it avoids breaching the anterior cortex of the patella, minimizing the need for extensive bone tunnels. Instead, blind transverse tunnels (not transpatellar tunnels) are utilized, which helps prevent the devascularization of the superior pole of the patella due to the use of a small incision and minimal exposure. Furthermore, our technique enables the assessment of graft isometry before finalizing the tunnel location on the femur. Using small guide pins during drilling across the patella, we ensure accurate isometric placement of the graft while minimizing the risk of chondral surface injury. Proper graft placement and isometry are crucial for the success of MPFL reconstruction.[19]

In this study, the graft was fixed to the femur with the knee flexed to 30°–60°, as this position has been reported to provide optimal graft length without over tightening. Furthermore, due to passive tension in the quadriceps and the patellofemoral articulation, the patella adopts its typical and repeatable position at this flexion angle. McCarthy *et al*.[20] emphasized the importance of anatomically placing the MPFL femoral tunnel to maximize outcomes. Proximally placed tunnels have been associated with increased stress and contact pressure on the medial patellar facet cartilage, potentially leading to medial overload, arthritis, pain, and disability. Malpositioned femoral tunnels can also increase stress on the nonisometric MPFL graft, resulting in reconstruction failure and recurrent lateral patellofemoral instability or iatrogenic medial patella subluxation.

Regarding complications in this study, two patients (10%) experienced patellofemoral pain, with one having a preexisting mild degree of patellofemoral arthrosis and the other presenting a small osteochondral lesion from the initial injury. In both cases, postoperative pain was mild and did not significantly affect their daily activities. One patient (5%) exhibited residual instability with increased patellar translation, but since they did not experience the same apprehension and recurrent dislocation episodes as before, they opted for quadriceps strengthening exercises instead of revision surgery. Another patient (5%) had limited flexion (up to 100°) without interference in daily activities, and postoperative CT scan confirmed satisfactory femoral tunnel placement. Sixteen patients (80%) had no complications. Shah *et al*.[21] reported that after surgery, 3.7% of patients suffered new subluxations/dislocations, and 8.3% of knees displayed fear, patellar hypermobility, or episodic instability, which could be attributed to underlying pathologies and the reliance on the reconstructed MPFL for patellar stability.

A systematic review by Jackson *et al*.[16] concluded that complications after initial reconstruction of the MPFL ranged from 0% to 32.3% of knees and consisted mostly of persistent anterior knee discomfort. Failure rates varied between 0% and 10.7%, whereas patellar fractures were observed in between 0% and 8.3% of knees.

It is important to acknowledge the limitations of our study. This is a single-center study with a relatively small sample size and a relatively short follow-up duration. The clinical evaluations were not blinded, and there was a lack of a control group and long-term follow-up.

Conclusions

MPFL reconstruction with patellar docking has demonstrated favorable outcomes, as evidenced by the improvement in Kujala and Lysholm scores, as well as the achievement of satisfactory congruence angles for the majority of patients. This surgical technique has shown a high success rate in addressing patellofemoral instability and effectively preventing future episodes of patellar subluxations or dislocations. By providing enhanced postoperative patellar stability, MPFL reconstruction significantly contributes to improving patients' quality of life and it is a cost-effective procedure.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Acromioclavicular Joint Reconstruction with Modified Weaver–Dunn Operation Versus Hamstring Tendon Autograft Comparative Study

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Abstract

Background: The dislocation of the acromioclavicular joint (ACJ) is recognized as one of the most frequently occurring injuries most often after either direct or indirect force is applied to the affected shoulder. The best method of AC reconstruction is still controversial. Modified Weaver–Dunn operation (WD) is one of the popular operations. Recent ACJ reconstruction methods include the usage of the gracilis, semitendinosus auto grafts, synthetic grafts, end buttons, nonabsorbable sutures, suture anchors, and tight-rope system. **Aim and Objectives:** Clinical and radiological results of hamstring autograft versus modified WD operation for reconsrtuction of coracoclavicular and acromioclavicular ligaments. **Patients and Methods:** This prospective study was carried out at the orthopedic department of Benha University Hospital carried out on 30 cases with chronic ACJ dislocation. They divided into two groups. The modified WD technique was employed on 15 patients, whereas an autogenous semitendinosus tendon graft was used on the other 15. There was a comparison of radiographs taken before and after surgery. **Results:** Mean surgical time and coracoclavicular (CC) distance differed statistically between groups. Neither demographic data nor postoperative information (pain, range of motion, and postop) showed a difference of statistical significance between the groups. Constant score and post operative American Shoulder and Elbow Surgeons Score (ASES) and post operative complications show no statistically significant difference. **Conclusion:** Both AC and CC reconstruction by hamstring tendon autograft showed good-to-excellent outcomes with no implant-related complications as some other treatment methods, also more anatomical procedure more than WD operation with better biomechanical vertical and horizontal stability.

Keywords: Acromioclavicular, hamstring tendon, joint reconstruction, modified Weaver–Dunn operation

Introduction

Injuries to the acromioclavicular joint (ACJ) are frequently seen by orthopedic surgeons. Involvement of the ACJ represents up to 12% of all shoulder injuries.[1] In 1963, these injuries were more prevalent in males under the age of 30 years who participated in contact sports. First classified by Allman into categories I, II, and III, ACJ injuries.[2]

In 1990, the classification was edited to add classes IV, V, and VI. Shoulder injuries can vary from minor sprains with no permanent effects to catastrophic dislocations with severe fascial tears.[3]

Acute type III injuries are controversially managed, but it is established that the treatment of type I and II injuries (nonoperative) and types IV and VI injuries (operative). The reduction and fixation of the ACJ were discussed in literature with 150 different techniques in 2013.[4] The ideal method would involve five steps: the restoration of normal anatomy to the ACJ, the restoration or reconstruction of the coracoclavicular (CC) ligaments, and the protection of these procedures while they recover.[4]

There have been different results with the Weaver–Dunn (WD) procedure,[5] the modified Dewar method,[6] and the Bosworth

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methods.[7] The ACJ and the CC ligaments can be stabilized and/or reconstructed in a variety of ways through each of these procedures. The surgical procedure referred to as the WD operation involves excising the distal segment of the clavicle and subsequently repositioning the coracoacromial (CA) ligament to the distal end of the clavicle.[8]

Extensive analysis of the WD technique has shown a failure rate of up to 30% and a biomechanical strength of only around 25% compared to that of undamaged CC ligaments.[9] Numerous articles elaborate on numerous modifications of the original WD method.[10]

The modified WD approach involved augmenting the transposed CA ligament with cerclage wires, screw fixation, or synthetics such as Dacron or carbon fibers; however, it appears that the majority of nonanatomic approaches were capable of restoring vertical stability at the ACJ, they still significantly lacked in anteroposterior stability.[11]

Anatomic restoration of the CC ligament complex with tendon grafts (e.g., hamstring autograft) has been the subject of recent biomechanical studies. Based on their findings, the authors come to the conclusion that this graft, which matches the trajectory of the ligaments, provides clavicular stability that is quite similar to that which is given by the original ligaments. In addition, as contrasted with ACJ stabilization with the use of a WD technique, the utilization of autogenous tissue provides a higher level of stability. As a result, the risk of experiencing postoperative discomfort as a consequence of residual anterior-posterior instability is decreased, which ultimately results in improved clinical outcomes.[8]

The study's goal was to evaluate the radiologic and clinical outcomes of two distinct methods of reconstructing the CC and AC ligaments: the modified weaver technique and an anatomic approach employing a hamstring autograft.

Patients and Methods

This prospective study was carried out at the Orthopedic Department of Benha University Hospital carried out on 30 cases with chronic AC dislocation. The participants were chosen from patients admitted to the orthopedic department from August 2020 to April 2022 upon completion of the postoperative follow-up period of at least 6 months and after meeting all inclusion and exclusion criteria.

Inclusion criteria

Chronic ACJ dislocation type III or V according to Rockwood classification.

Exclusion criteria

Patients with cervical spine disorders, coracoid fractures, rheumatoid arthritis, or previous surgery of the shoulder joint and old age with medical comorbidities and low demand.

Sampling method

In this study we had admitted 30 patients who suffered from ACJ disruption type III & V. Patients were a part of the research group after screening through the inclusion and exclusion criteria at least 6 months to follow up for evaluation. Sample Size: 30 patients subdivided randomly by into 2 groups, 15 patients for each group [Table 1].

Sample Size

Thirty patients were subdivided randomly into two groups, 15 patients for each group.

Group A: Patients treated by AC reconstruction using hamstring autograft and Group B: Patients treated by modified WD operation.

Privacy of data

All participant's names were hidden and coded in numbers.

Methods

All the affected patients which were included in this study were subjected to the following after obtaining informed consent: diagnosis (detailed history taking, complaint, careful clinical examination, and investigations).

Scoring systems

The American Shoulder and Elbow Surgeons Score (ASES) and Constant score.

Radiological evaluation

Laboratory investigations

Routine preoperative laboratory tests to assess the patient general condition and fitness for surgery.

First group (group A) 15 patients underwent ACJ reconstruction with hamstring autograft:

Our patients (15) were treated through grafting tissue from the patient's own ipsilateral semitendinosus tendon and reinforcing the resulting construct with fiber wire; we were able to successfully repair the CC and AC ligaments.

The first field for ACJ reconstruction: The shoulder was prepared by positioning the patient in a "beach chair position" under general anesthesia [Figure 1]. Another surgical area is prepared to extract the semitendinosus tendon graft from the same side using a tendon stripper. Subsequently, the graft was transported to the back table for preparation by the assistant surgeon.

The ACJ was exposed by making an approximately 5 cm long transverse incision along the length of the distal

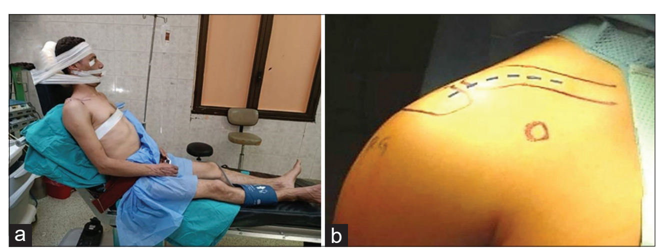

Figure 1: (a) Intraoperative photograph demonstrates the beach-chair position, (b) the skin incision approach for acromioclavicular joint (ACJ) reconstruction, where an approximately (5) cm horizontal incision (transverse blue dashes) was made to facilitate access to the ACJ

clavicle [Figure 1]. The superior clavicular edge and the deltotrapezial fascia were incised. The coracoid is identified and cleared up to the base with care. Finally, the exposure was considered completed; joint reduction was possible when soft tissues were released from the distal clavicle and the ACJ. The acromion can be raised by pulling up on the elbow and counter compressing the clavicle, a preliminary manual reduction of the ACJ was attempted, and the reducibility of the dislocation was evaluated.

Tunnels was drilled into anatomical sites of cracoclavicular ligaments in lateral end clavicle to provide passage to the graft. At 40 mm from the lateral end of the clavicle, a tunnel 5 mm in diameter was done for the conoid ligament. Then, a tunnel for the trapezoid ligament was performed 20 mm from the lateral edge of the clavicle, at the middle of the bone's superior aspect. The same procedure was then used to create an additional tunnel in the middle of the acromion. The acromion's articular surface was drilled at a lateral distance of 10 mm, parallel to the trapezoid ligament tunnel [Figure 2].

The graft was inserted into the conoid tunnel, passed medially under the coracoid, laterally into the trapezoid ligament tunnel, laterally across the acromion into the acromial tunnel, and finally medially back into the trapezoid tunnel. Sutures are placed over the graft to rebuild the superior and inferior AC ligaments after it has emerged through the trapezoid tunnel. After emerging from the conoid tunnel, the graft's first limb is sutured to the ACJ superior aspect. Along with the graft ,a No. (5) ethibond or fiber wire was passed through th tunnels to maintain reduction until graft ligamentization [Figure 3].

Second Group (group B) 15 patients underwent ACJ reconstruction with modified Weaver–Dunn (WD) operation:

Under general anesthesia, the treatment was carried out with the patient in a beach-chair position.

The skin incision measured about 5 cm extending from the clavicle to the coracoid. The anterior technique was utilized to achieve subperiosteal separation of the deltotrapezial fascia, thereby revealing the ACJ, lateral clavicle, and coracoid process [Figure 4]. The lateral aspect of the clavicle is cut down by 10 mm, followed by the identification and harvesting of the CA ligament using a tricortical bone block obtained from the acromion.

In conjunction with the acromial bone block, the CA ligament is prepared with two nonabsorbable sutures passed into two drilled holes was done in the lateral end of the clavicle. The clavicle is reduced, and the reduction is maintained by CC fiber wire No (5) sling passing under the coracoid process base. The CA ligament and the acromial bone block are then attached to the clavicle with Ethibond No (5), followed by the sequential closure of the wound in multiple layers.

There was no variation observed in the postoperative care across different surgical procedures. The shoulder underwent immobilization using a sling for a duration of 4 weeks. Afterward of that time, the range of motion (ROM) was increased to 90° for an additional duration of 8 weeks. A 3-months postoperative patients started full ROM. Radiologic controls were conducted at 4-week intervals. Clinical evaluations were performed both before and after surgery and scoring with the ASES[12] and constant score.[13] Measurements were taken of the ranges of motion for active abduction, flexion, and external rotation.

Results

Hamstring tendon autograft (group A) compared to modified Weaver–Dunn operation (group B).

Clinical outcome

According to pain assessment as apart of constant score and Visual Analog Scale as part from American shoulder and elbow surgeons score

The overall mean score increased from 3.33 (+2.4) preoperative to 12.78 (+3.2) at 6 months postoperative (*P* < 0.001) in the 30 patients included in this study which indicates highly significant pain relief.

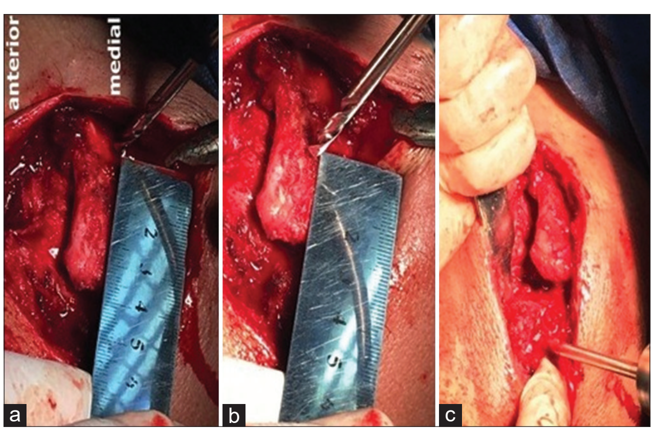

Figure 2: Intraoperative our photographs showing bony tunnels drilling. (a) Conoid tunnel 40 mm from lat. end clavicle. (b) Trapezoid tunnel 20 mm from lateral end clavicle. (c) Acromion tunnel

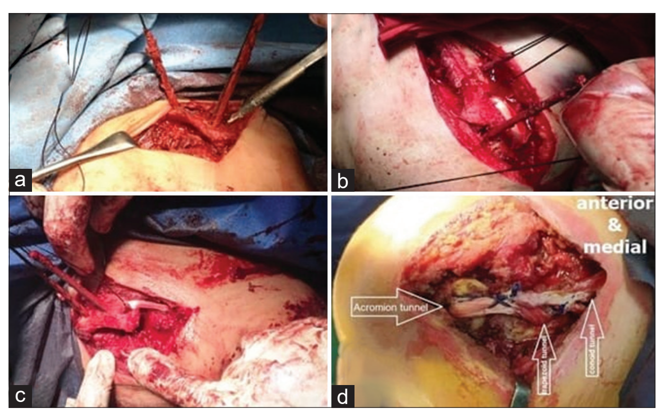

Figure 3: Intraoperative photographs showing (a) graft passage through the conoid and trapezoid tunnels at the lateral part of the clavicle, (b) graft trapezoid limb passage through the acromial tunnel, (c) graft back medially below the undersurface of the lateral part of the clavicle to trapezoid tunnel, (d) graft fixation and augmentation by Ethibond

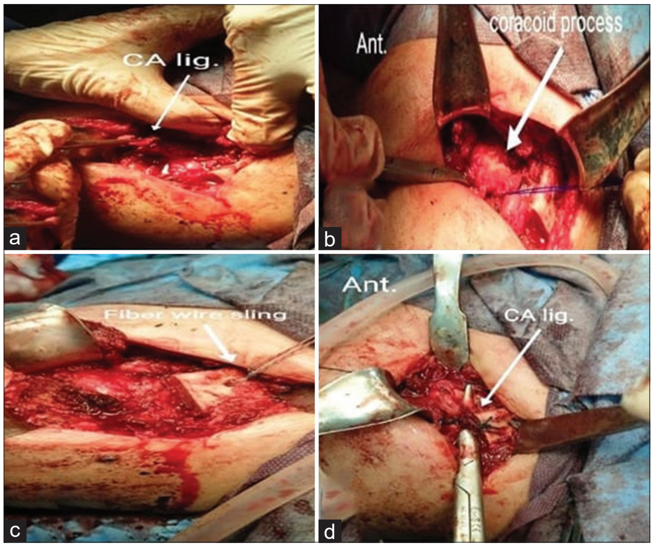

Figure 4: (a) Coracoacromial (CA) ligament dissection and separation (b) proline loop around the base of coracoid process (c) 2 drill holes in lat. clavicle for fiber wire passage and acromioclavicular joint reduction maintained with fiber wire sling. (d) Sutures made of Ethibond No. (5) protect the CA ligament during healing

In hamstring tendon autograft (Group A), mean preoperative pain score was 3 (±2.54) that improved to 16 (±3.2) at 6 months postoperative. In WD operation (Group B), mean preoperative pain score was 3.67 (±2.29) that improved to 14.33 (±1.76) at 6 months postoperative. A significant improvement ($P < 0.001$) was established among the preoperative and 6-month postoperative periods in both groups. Although Group A showed superior pain relief at the 6-month postoperative, there was no discernible statistical variance among the two groups ($P = 0.85$).

According to range of motion

The study includes 30 patients, and it was found that the average score increased significantly from 17.04 (+4.89) before the operation to 35.06 (+2.9) at 6 months postoperative ($P < 0.001$). This suggests a highly substantial improvement in ROM.

In Group A, mean preoperative ROM score was 17.40 (±4.89) that improved to 34.31 (±3.35) at 6 months postoperative. In Group B, mean preoperative ROM score was 17.40 (±4.84) that improved to 35.60 (±5.59) 6 months after surgery. There was a statistically very clear increase ($P < 0.001$) in both groups from before surgery to 6 months postoperative.

According to the constant score in Group A, mean preoperative constant score was 35.47 (+9.01) that improved to 90.69 (+7.83) at 6 months postoperative. In Group B, mean preoperative constant score was 37.73 (±9.01) that improved to 86.87 (±15.61) at 6 months postoperative. Even though both groups improved significantly ($P < 0.001$) between pre-and postoperative periods of 6 months, Group A had a higher constant score at 6 months postoperative. This difference, however, resulted in no substantial differences ($P = 0.8$) [Table 2].

The overall mean of the ASES score increased from 30.20 (+5.37) preoperatively to 86.89 (+21.16) at 6 months postoperative ($P < 0.001$) in the 30 patients included in this study which indicates highly significant improvement in ASES score.

In Group A, mean preoperative ASES score was 30.20 (±8.38) that improved to 86.07 (±25.34) at 6 months postoperative. In Group B, mean preoperative ASES score was 32.8 (±5.05) that improved to 84.80 (±21.16) at 6 months postoperative. The results indicated an improvement that can be measured statistically ($P < 0.001$) across the preoperative and 6-month postoperative periods in both groups. While Group A exhibited a higher 6-month postoperative ASES score, the disparity among the two sets was not substantially different ($P = 0.39$) [Tables 3 and 4].

Radiological outcome

The overall mean of CC distance difference (mm) decreased from 13.8 (+3.04) preoperative to 2.27 (+1.44) at 6 months postoperative ($P < 0.001$) in the 30 patients included in this study, which indicates a highly significant improvement.

In Group A, the mean preoperative CC distance difference (mm) was 13.80 (±2.86) that improved to 0.67 (±0.72) immediately postoperative then at the last follow-up reaches 2.27 (±1.44).

In Group B, the mean preoperative CC distance difference (mm) was 10.67 (±3.04) that improved to 0.33 (±0.49) immediately postoperative then at the last follow-up reaches 2.13 (±2.42).

There was a statistically highly significant improvement (P-value <0.001) between the pre operative and 6 months post-operatively in both groups [Figures 5 and 6 and Table 5].

Complications

Two cases of subluxation (partial loss of reduction, 50% of the preoperative CC distance difference), all occurred in Group A with no further intervention needed. Only one case with a failed reduction in Group B 2 months postoperative due to lost follow-up and not following postoperative instructions. Two cases with wound infection, one in Group A and the other in group B. The case of wound infection of group A not responded to wound dressing plus intravenous so operative debridement was needed, the patient later on developed oozing stitch sinus with secondary bony ossification and OA of the ACJ that resulted in residual shoulder pain. pain. The other case in Group B improved with daily dressing and intravenous antibiotics. The other case in Group B improved with daily dressing and intravenous antibiotics. There were no donor site complications occurred in Group A. There were no complications related to the donor knee in Group A.

Discussion

About 12% of all shoulder dislocations are occupied by dislocations of the ACJ, making them a prevalent injury in young athletes.[14] The ACJ is a diarthrodial joint that connects the medial facet of the acromion to the lateral aspect of the

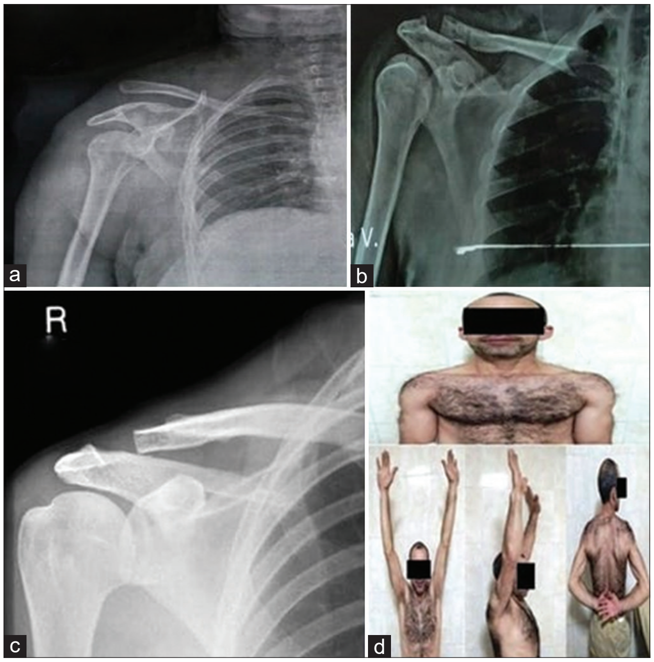

Figure 5: (a) Preoperative X-ray showing type V acromioclavicular dislocation, (b) Immediate postoperative X-ray with reduced acromioclavicular joint (ACJ), (c) Eight months last follow-up X-ray without subluxation and (d) range of motion. The patient's coracoclavicular distance returned to normal after the modified Weaver–Dunn surgery was performed on his right ACJ, as seen on serial X-rays taken at intervals

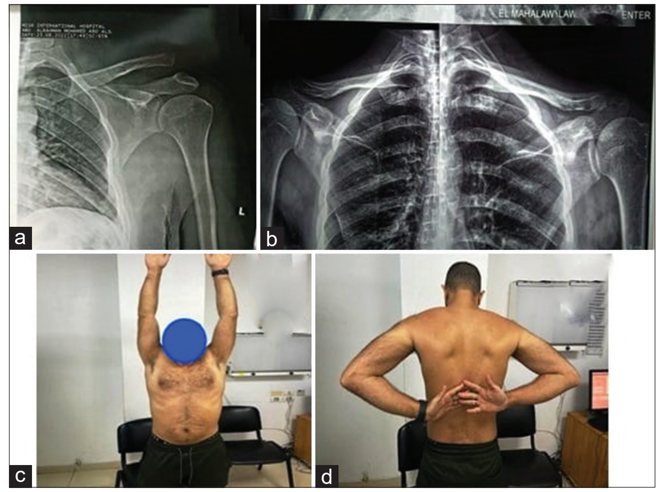

Figure 6: (a) Preoperative X-rays showing acromioclavicular joint (ACJ) dislocation, (b) postoperative X-ray ACJ reduced and (c and d) last range of motion of the same patient underwent AC reconstruction with Hamstring tendon autograft 9 months postoperative

clavicle.[14] AC joint injuries occur due to direct hits to the shoulder or indirect forces, such as a fall into an outstretched arm which more common in athletes who engage in contact sports. Resulting in bulging the lateral aspect of the clavicle ,pain and impaired shoulder function.[15] Rockwood defined ACJ injuries, and it is generally agreed that types I and II, which include less severe damage, can be managed nonoperatively. Types IV, V, and VI, however, typically need surgery.[16] The best treatment for acute Grade III is still controversial.[17]

The current study revealed no statistically significant difference of age and sex between the studied groups with mean age of group A is 34.93 years versus 33.67 for group B . All cases in group B versus 93.3% group A were males. Moreover, according to sex where all cases in Group B versus 93.3% of Group A were males.

The current study showed neither Group A nor Group B showed statistically significant differences with pain scores measured pre- and posttreatment. However, within each group, pain score showed statistically significant improvement after operation among Groups A and B. The mean pain score increased from 3 to 16 after operation for Group A and from 3.67 to 14.33 for Group B.

Furthermore, Groups A and B did not differ statistically from one another as regards ROM measured pre- and posttreatment. However, within each group, ROM showed statistically high improvement after operation among Group A and B with increasing mean ROM from 17.4 to 34.31 after operation for Group A and from (17.4 to 35.60) for Group B.

The current study showed better results for Group A more than Group B as regards total constant score measured pre- and posttreatment but without highly statistically obvious improvement. However, within each group, the total score showed statistically significant improvement after operation among Groups A and B. The mean total score increased from 35.47 to 90.69 after operation for Group A and from 37.73 to 86.87 for Group B.

The current study showed better results for Group A more than B as regards total ASES score measured pre- and posttreatment but not highly statistically significant improvement. However, within each group, ASES scores showed statistically significant improvement after operation among Groups A and B with increasing mean ASES scores from 30.20 to 86.07 after operation for Group A and from 32.8 to 84.8 for Group B.

The study found not an important improvement between Groups A and B as regards CC distance measured pre- and immediate posttreatment. CC distance was detected among Group A than B (13.8 vs. 10.67, preoperative) and (2.27 vs. 2.13 at last follow-up) for Group A, mean CC distance reduced from 13.8 to 2.27 at the last follow-up. For Group B, mean CC distance decreased from 10.67 to 2.13 at the last follow-up.

The current study showed a lack of statistically meaningful difference of follow-up periods with mean follow-up period for Group A (8.57 months) versus (9.4 months) for Group B.

A statistically significant higher mean operative duration was detected for Group A than Group B (80.78 min vs. 65.33 min, respectively).

Regarding the distribution of postoperative complications among different categories, two instances of subluxation,

Table 1: Patients data

Patient number	Age	Sex	Side	Dominant arm	Mechanism of injury	Time interval between injury to operation (months)	Method of fixation hamstring autograft=1 and WD=2	Type of AC dislocation	Follow up period (months)	Operation time (min)
1	23	Male	Right	Dominant	RTA	2	1	III	6	80
2	35	Male	Left	Non-D	RTA	1	2	III	20	45
3	38	Male	Right	Dominant	RTA	3	2	V	10	40
4	26	Male	Right	Dominant	Falling	2	1	III	20	100
5	30	Male	Right	Dominant	Falling	1	2	III	19	45
6	33	Male	Left	Non-D	RTA	4	2	III	10	40
7	38	Male	Right	Dominant	Falling	8	2	III	15	90
8	28	Male	Left	Non-D	Falling	1	1	V	16	60
9	30	Male	Left	Non-D	RTA	2	1	V	18	60
10	43	Male	Right	Dominant	RTA	1	1	V	17	65
11	44	Male	Left	Non-D	RTA	3	2	III	19	45
12	48	Male	Left	Non-D	Falling	1	1	V	18	55
13	60	Female	Left	Non-D	Falling	2	1	V	Failed	
14	24	Male	Left	Non-D	RTA	4	1	III	1	66
15	25	Male	Left	Non-D	Falling	3	2	V	16	40
16	15	Male	Left	Non-D	Falling	6	2	III	18	40
17	24	Male	Right	Dominant	RTA	2	2	V	9	35
18	38	Male	Right	Dominant	RTA	2	2	III	6	35
19	30	Male	Right	Dominant	RTA	5	2	III	18	40
20	31	Male	Left	Non-D	Falling	3	2	III	19	35
21	43	Male	Right	Dominant	Falling	1	2	V	18	30
22	36	Male	Right	Dominant	Falling	3	2	V	19	30
23	45	Male	Left	Non-D	Falling	4	2	III	18	45
24	27	Male	Left	Non-D	Falling	6	1	III	15	60
25	28	Male	Right	Dominant	RTA	8	1	III	12	70
26	37	Male	Right	Dominant	RTA	3	1	V	8	70
27	27	Male	Left	Non-D	RTA	2	1	V	15	55
28	22	Male	Right	Dominant	RTA	1	1	V	13	55
29	48	Male	Right	Dominant	Falling	3	1	V	8	70
30	53	Male	Right	Dominant	Falling	1	1	V	16	55

RTA: Road traffic accident, AC: Acromioclavicular, WD: Weaver Dunn

characterized by a partial loss of reduction amounting to 50% of the preoperative CC distance difference, were observed only within Group A. No additional intervention was required in these individuals.

In agreement with our results, Tolba *et al*. did a prospective comparative randomized control research on the operative management of AC dislocations in 40 cases with shoulders identified clinically and radiographically as Rockwood type III and type V dislocations; Group A consisted of 20 cases who underwent the modified WD procedure and had a mean follow-up of 14.4 months, whereas Group B consisted of 20 cases who underwent reconstruction using a semitendinosus autograft and had a mean follow-up of 12 months.[18]

The constant score was utilized for clinical evaluation. The pre- and postoperative radiographs were analyzed and revealed that the average constant score exhibited improvement in both the WD group (from 55 points to 86 points) and a cluster of tendons associated with the semitendinosus (scores of 60–89; $P = 0.37$). Radiological examinations showed a statistically significant variance among the groups, with the mean CC distance being 11.20 mm in the WD group and 10.6 mm in the semitendinosus tendon group ($P = 0.92$). The constant score demonstrates that both groups significantly improved their ROM and functional activities.

Like our results ,the previous study showed that the utilization of a semitendinosus tendon graft for the purpose of CC ligament repair has demonstrated enhanced clinical and radiologic outcomes when contrasted with the modified WD method.[18]

Tauber *et al*. made a prospective comparative randomized control study, to alleviate the pain and instability related to dislocations of the ACJ, 42 cases, with a mean age of 42 years old, underwent surgical repair. Twelve cases underwent a modified WD procedure, whereas another dozen underwent an autogenous semitendinosus tendon transplant. The clinical assessment

Table 2: Comparison of total constant score between the studied groups

Total score	Group A (n=15)	Group B (n=15)	Test of significance Mann–Whitney U-test
Pre	35.47±8.94	37.73±9.01	Z=1.17, P=0.252
Post	90.69±7.83	86.87±15.61	Z=1.09, P=0.287
Wilcoxon signed-rank test	Z=3.18, P=0.001	Z=3.36, P=0.001	
Percentage of improvement	150	130	

Table 3: Comparison of American Shoulder and Elbow Surgeon's Score between the studied groups

ASES	Group A (n=15)	Group B (n=15)	Test of significance Mann–Whitney U-test
Pre	30.20±8.38	32.8±5.05	Z=1.03, P=0.313
Post	86.07±25.34	84.80±21.16	Z=0.084, P=0.933
Wilcoxon signed-rank test	Z=3.24, P=0.001	Z=3.36, P=0.001	
Percentage of improvement	178	158	

ASES: American Shoulder and Elbow Surgeon's

involved the utilization of the ASES score and the constant score, following an average follow-up period of 37 months. A comparative analysis was conducted on radiographs obtained before and following surgical intervention.[19]

According to the findings of Tauber *et al*., when contrasted with the modified WD procedure, the clinical and radiologic outcomes of CC ligament repair with a semitendinosus tendon graft were much better.[19]

To assess the efficiency of anatomic repair of the CC and AC ligaments using a semitendinosus tendon graft for the management of chronic ACJ dislocation, Saccomanno *et al*. carried out a prospective, comparative, randomized controlled trial. The research was designed to compare two groups of patients. The study enrolled individuals who were diagnosed with chronic type III and V ACJ dislocations. The exclusion criteria encompassed the following factors: individuals below the age of 18 years, the concurrent presence of rotator cuff tears, prior surgical interventions on the affected shoulder, degenerative alterations in the glenohumeral joint, infections, neurological disorders, and patients who have had ligament reconstruction surgery in the past, on either the same or opposite side of the knee, requiring removal of the semitendinosus tendon.[20]

Better clinical and radiographic results were seen following the anatomic restoration of the CC and AC ligaments using a semitendinosus tendon graft in patients with chronic ACJ dislocation, as stated by Saccomanno *et al.*[20]

Galasso *et al*. carried out a study that was designed to be prospective, randomized and controlled. The study comprised a total of 30 patients who were experiencing chronic dislocations of type III ACJ; 27 of them had at least a 12-month follow-up. A variant of the WD operation was performed on each patient. The Constant-Murley scale was utilized to conduct an assessment of postoperative function. Patients' subjective assessments of their experiences during and after surgery were also recorded. After surgery, radiographic evaluation was used to check for superior-inferior and anterior-posterior joint stability.[10]

Patients who suffer from a chronic dislocation of the ACJ type III were found to benefit from the modified WD method in terms of restoring vertical joint stability but not horizontal stability following 4-year follow-up. It is possible to attain high levels of patient satisfaction with surgical procedures and functional outcomes that are equivalent to that of sex- and age-matched healthy individuals.[10]

Furthermore, Garofalo *et al*. used semitendinosus autograft in the reconstruction of chronic ACJ dislocation within the time frame of January 2005–December 2011, a total of 32 consecutive patients with symptomatic full ACJ dislocation of type V had the same surgical procedure. The average number of days between getting hurt and having surgery was 45 (range: 24–90). Clinical and radiological follow-up after surgery lasted a median of 30 months (range: 24–33). The ASES, the Visual Analog Scale (VAS), and the subjective patient satisfaction score were all used to evaluate clinical results. At least 2 years of data were collected.[21]

The ASES score went from a median of 38.2 ± 6.2 before surgery to 92.1 ± 4.7 after surgery ($P \leq 0.05$). At the end of the follow-up period, the median VAS score was 8 mm, compared to 62 mm before surgery (range: 45–100 mm; $P \leq 0.05$). The patient did not report any pain or discomfort during either the direct palpation of the ACJ or the cross-body adduction procedure. Final radiographs showed symmetric ACJ contour in 25/32 (78%). Radiographic examination revealed that seven patients (22%) had a superior translation of the distal clavicle relative to the superior edge of the acromion; however, this translation was <50% of the width of the clavicle. Thirty out of 32 patients, or 93%, were able to return to their preinjury level of job and sporting activities after receiving treatment.[21]

Conclusion

This study added evidence of an attractive alternative in the stabilization of chronic AC joint dislocations. The optimal operative method for the treatment of chronic AC joint dislocation Rockwood types III and V remains controversial.

Table 4: Clinical results

Patient number	Method of fixation Hamstring autograft=1 and WD=2	Preoperative Constant score Pain (15)	Activities of daily living (20)	ROM (40)	Strength (25)	Total score (100)	Last follow-up constant score					Preoperative ASES score (100)	Last follow up ASES score
							Pain	Activities of daily living	ROM	Strength	Total score		
1	1	0	10	24	5	39	15	18	34	20	87	32	92
2	2	5	10	15	8	38	15	17	30	25	88	28	88
3	2	5	12	24	9	50	15	20	40	23	98	42	95
4	1	5	11	10	8	34	15	18	32	25	90	37	94
5	2	5	12	28	11	56	15	20	40	23	99	42	95
6	2	5	11	22	11	49	10	18	32	23	33	32	86
7	2	0	10	20	5	35	15	17	32	21	85	32	90
8	1	0	8	12	3	23	15	18	34	25	90	31	94
9	1	5	12	24	5	46	15	20	40	25	98	42	95
10	1	0	8	14	5	27	10	19	32	25	84	25	86
11	2	5	10	14	5	34	15	19	32	23	89	28	90
12	1	0	8	14	2	24	5	17	26	18	66	30	66
13	1	5	12	24	9	50					Failed	14	0
14	1	5	9	20	8	42	15	19	36	23	93	18	90
15	2	5	8	16	5	34	15	17	52	4	85	32	9
16	2	0	9	14	5	28	15	18	35	22	95	31	88
17	2	5	15	14	5	34	10	18	35	23	86	33	88
18	2	5	10	14	5	34	15	17	32	25	89	32	92
19	2	0	9	14	5	28	15	18	35	22	90	31	88
20	2	5	10	14	5	34	15	19	32	23	89	28	90
21	2	5	10	14	5	34	15	19	32	23	89	28	90
22	2	5	12	24	9	50	15	20	40	23	98	42	95
23	2	0	9	14	5	28	15	18	35	22	90	31	88
24	1	0	9	16	5	30	15	18	34	25	92	32	93
25	1	5	9	20	8	42	15	19	36	23	93	18	90
26	1	5	12	24	9	50	10	17	32	22	86	43	88
27	1	0	9	16	5	30	15	18	34	25	92	32	93
28	1	5	10	15	5	35	10	18	34	22	84	35	94
29	1	5	8	16	3	32	15	18	38	22	93	30	96
30	1	5	8	12	3	28	10	20	36	25	91	34	94

ROM: Range of motion, ASES: American shoulder and elbow surgeon score, WD: Weaver–Dunn

Table 5: Radiological results

Patient number	Method of fixation hamstring autograft=1 and WD=2	Preoperative CC distance difference (mm)	Immediate postoperative CC distance difference	Last follow up CC distance difference
1	1	17	1	2
2	2	13	1	1
3	2	7	0	0
4	1	12	0	2
5	2	7	0	1
6	2	9	0	1
7	2	15	1	2
5	1	16	2	4
9	1	14	0	0
10	1	17	2	5
11	2	12	0	0
12	1	17	2	3
13	1	10	2	50
14	1	14	0	2
15	2	15	0	0
16	2	8	0	0
17	2	14	0	1
18	2	13	1	1
19	2	8	0	0
20	2	12	0	0
21	2	12	0	0
22	2	7	0	0
23	2	8	0	0
24	1	11	1	3
25	1	14	0	0
26	1	15	2	7
27	1	11	1	3
28	1	8	1	3
29	1	17	0	0
30	1	14	1	3

CC: Coracoclavicular, WD: Weaver–Dunn

Both AC and CC reconstruction by hamstring tendon autograft showed good-to-excellent results without complications linked to implants as some other treatment methods, also more anatomical procedure more than WD operation. Also provide stability to the clavicle that is very close to that provided by the intact ligaments, with the added advantage of autogenous tissue.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Functional Outcomes of Arthroscopic Bankart Repair in Indian Population: A Systematic Review and a Meta-analysis

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Abstract

Introduction: The past two decades have witnessed significant development in arthroscopic management for recurrent anterior shoulder instability. Currently, arthroscopic Bankart repair (ABR) is popular in the treatment of anterior shoulder instability. There is a dramatic rise in the number of orthopedic surgeons in India specializing in shoulder surgery and is believed to be secondary to the advancement in arthroscopic techniques and implants. However, there is a paucity of Indian literature on functional outcomes of ABR. The purpose of the current review is to better understand the functional outcomes of ABR in the Indian population. **Methods:** A search of major databases (Embase, Ovid Medline, Google Scholar, and Cochrane Library) was performed in April 2020. Reference lists of selected research articles were further screened in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. Inclusion and exclusion criteria for analysis were used to generate the final list of studies. **Results:** A total of ten research studies were included in the final analysis representing a pooled patient population set of 391 patients. The mean age for patients across the studies was 27 years (range: 24–29) of age and the average number of dislocations before surgery was five (range: 0–14). The average follow-up period post-surgery was 20 months (range: 6–27 months). Among the functional scores, the average UCLA score improved from 22 (range: 18–30) at preoperatively to 32 (range: 31–35), and the mean Rowe score improved from an average of 27 (range: 24–63) preoperatively to 91 (range: 90–94) during the follow up duration. The average postoperative re-dislocation rate was 7% (range: 0%–10%). **Conclusion:** In the Indian population, ABR provides consistently good functional outcomes with a low postoperative re-dislocation rate, which is at par with the global data. Further studies with larger sample sizes and longer follow-ups are needed to validate these results.

Keywords: Arthroscopic Bankart repair, functional outcomes, recurrent anterior shoulder instability, Rowe score, shoulder surgery, University of California at Los Angeles score

Introduction

Shoulder is the most dislocated joint, with anteroinferior instability secondary to Bankart's lesion accounting for over 90% of the cases.[1] Almost a century after Bankart described the "essential lesion" of shoulder instability, arthroscopic Bankart repair (ABR) has become one of the mainstays of treatment.[2]

ABR was first described in 1993, and the recent decades have witnessed a rapid rise in its popularity due to advancement in arthroscopic instrumentation and techniques.[3] Multiple studies and systematic reviews[4-9] have demonstrated good-to-excellent outcomes of ABR.[10] However, limited number of Indian orthopedic surgeons have been performing this procedure due to variety of factors including high cost of capital equipment and implants, lack of training, and limited number of fellowship training centers in the country.[11,12] In addition, patient-related factors including surgery cost and perceived poor outcomes continue to play an important role in surgical decision-making.

The purpose of the present review is to systematically analyze the available literature, assess functional outcome and re-dislocation rate, and establish benchmarks for shared decision-making between the surgeon and the patient.

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Methods

Criteria for considering studies for this review

The systematic review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [Figure 1]. A scoping search was initially performed in March 2020 to find the definition used in the final search strategy and corresponding inclusion criteria, which was then used to identify the relevant studies. The finalized criteria applied to address the research question were as follows: "bankart repair" AND/OR "India" AND/OR "Indian" AND/OR "arthroscopic bankart repair" AND/OR "mini-open bankart repair" AND/OR "open bankart repair." Various synonyms of the above terms were used during the searches. The purpose of including open Bankart repairs in the search methodology was to expand the scoping search to pick out arthroscopic comparative studies also.

Types of participants

Studies evaluating adult Indian population (18 years of age and above) who underwent glenoid labral repair for soft tissue or bony Bankart lesions were included. There were no restrictions applied regarding comorbidities, type of tear, presence or absence of Hill–Sachs lesions, or any other lesions such as SLAP tear or based on whether it was a primary tear or a re-tear. Those patients who underwent concurrent procedures for the additional lesions were also included.

Types of interventions

Most studies included had a single intervention group. When there were multiple intervention groups of the study, they were included if at least one arm was ABR. There was no restriction with regard to any comparison arm (physiotherapy, medications, etc.), neither regarding any technique of ABR nor the type of anchors/suture materials used. In addition, there was no restriction on the grade or experience of the surgeon who performed the surgery. Studies purely on open Bankart repairs were excluded, but if a study compared open Bankart repair to arthroscopic repair, then it was included.

Studies reporting only on nonrelevant interventions such as oral medications or physiotherapy were excluded. However, if these interventions represent a comparator arm, they were included.

Types of outcome measures

All outcomes were included regardless of follow-up duration. The primary outcomes of interest were limited to shoulder-specific function and pain scores assessed using a validated scale such as Rowe Score, Oxford Shoulder

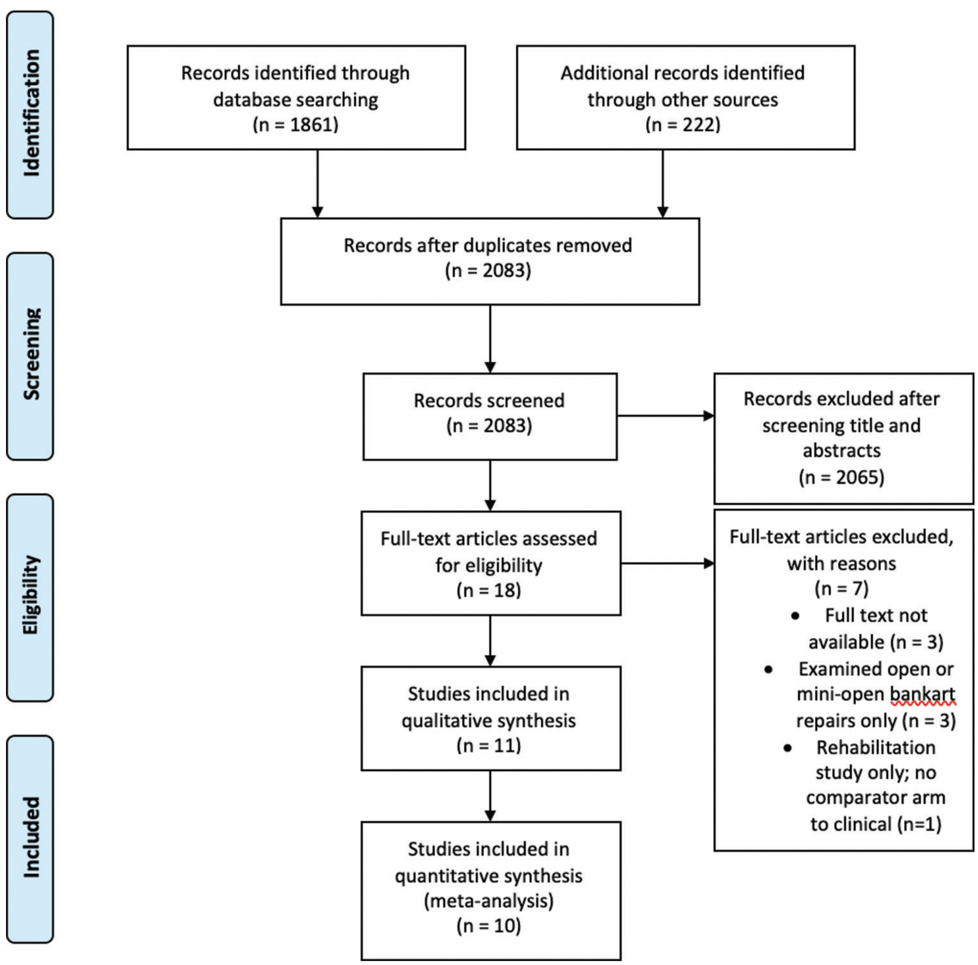

Figure 1: Preferred Reporting Items for Systematic Reviews and Meta-Analyses Flowchart

Score (OSS), American Shoulder and Elbow Surgeons Score (ASES), Simple Shoulder Test (SST), Constant and Murley Score (C and M), and University of California - Los Angeles scale (UCLA). The secondary outcomes were included if reported in the corresponding studies. These were included but were not limited to complications, pain outcomes as assessed by the Visual Analog Scale (VAS), rate of re-dislocations, implant failure rate, postoperative stiffness, and patient satisfaction.

Types of studies

We considered all the relevant randomized controlled trials. However, there were only a limited number of such studies in Indian literature. Therefore, we included nonrandomized studies (comparative and single intervention groups) involving more than five patients. Since all the studies were reported in English, no language restrictions had to be applied.

In vitro and animal studies, review articles, editorials, and single case reports were excluded. Initial scoping results did not reveal any economic or cost evaluation studies related to the topic in the Indian population.

Search methods for the identification of studies

A search strategy was developed in Embase and was adapted for the remaining electronic databases. The searches were conducted between January 2001 and March 2020, representing 20 years of literature on Bankart's repair. The following electronic databases were searched through OVID and Cochrane Library platforms:

- The Cochrane Library
- Ovid Medline, 1946 to present
- Ovid Embase, 1980 to present
- Google Scholar, 2001 to present.

Reference lists of available studies and any reviews were searched out in addition to identifying further studies.

Selection of studies

Two lead researchers (MA and SP) screened all the titles and abstracts selected through the search strategy. Full data were obtained for the potentially relevant studies, and complete reports that meet the inclusion criteria were included. Reasons to exclude studies were recorded at each stage and showed in a PRISMA flow diagram [Figure 1]. A third independent reviewer (JJC) was kept on standby to resolve any disputes between the primary two reviewers if they were to occur. The search methodology and study selection were as per PRISMA guidelines. All prospective studies including case series were included; however, case reports were excluded. A total of 12 studies were selected. Out of these, three studies lacked full texts; nevertheless, two were received from the authors after contacting them, but for the remaining one study, the details could not be procured and hence excluded. Another study assessed only the postoperative rehabilitation protocols but did not assess functional outcomes and hence that also had to be excluded.

Data extraction, management, and evidence synthesis

A standard data extraction table was used to extract all relevant data from studies including study design, patient population, and functional outcomes. An overall pooled comparison was performed with meta-analyses of available data.

Pooled data comparison

As many studies used common functional outcome measures, it was possible to do a pooled analysis of average means across studies using the following formula:

$$\text{Average mean} = \frac{\sum([n_1 \times \text{mean}_1] + [n_2 \times \text{mean}_2] + \ldots + [n_n \times \text{mean}_n])}{\sum(n_1 + n_2 + \ldots + n_n)}$$

n = Study population (study 1, study 2 etc.)

Mean = Overall mean of the study population

Pooled means and standard deviations were generated with 95% confidence intervals, and Mann–Whitney test was done to compare grouped data. Further, pre- and postoperative means were presented as grouped data and compared using Wilcoxon signed rank test with GraphPad Prism 9.0.0 (California, USA). A definition of statistical significance was used with $P < 0.05$.

Subgroup analyses for gender were not possible due to paucity of relevant data. Subgroup analyses were not performed for number of anchors used for repair due to underpowering of groups. Most studies (n = 7) reported UCLA scores, four reported Rowe scores, two used SST, one used ASES, and one used Oxford score. VAS was assessed in two studies for outcome in terms of pain relief. For descriptive purposes of the review, only two functional outcome measures were included for which most studies used UCLA and Rowe scores.

Results

A total of ten studies were included in the final review [Table 1] representing a pooled patient population set of 391 patients. The pooled mean age for patients across the studies was 27 (range: 24–29) years of age and the pooled average number of dislocations before surgery was 5 (range: 0–14). The pooled average follow-up period was 20 months (range: 6–27 months).

The pooled mean UCLA score across studies revealed a statistically significant improvement (P = 0.0022) from an average of 22 (range: 18–30) at baseline to 32 (range: 31–35) at the end of pooled average follow-up [Figure 2]. The pooled mean Rowe score showed a statistically significant improvement (P = 0.0286) from an average of 27 (range: 24–63) at baseline to 91 (range: 90–94) at the end of pooled average follow-up of 20 months [Figure 2].

The pooled average re-dislocation rate in studies was 7% (range: 0%–10%); one study did not report re-dislocation rates. All studies, except one, mentioned surgery complications. The average complication rate was 16% (range: 0%–36%), and these included re-dislocation, recurrent instability without

Table 1: Study characteristics of ten studies included in the systematic review and meta-analysis

Author and year	Number of patients	Mean age at time of surgery (years)	Number of anchors	Mean number of dislocations at time of study	Average follow-up (months)	Scoring system used	Mean preoperative functional score	Mean postoperative functional score	Complications
Mishra *et al*. (2012)	65	27	3	2	27	UCLA	18	32	3 recurrent instability
Sood and Ghai (2018)	51	26	2.88	8	22	Rowe	25	90	1 dislocation
Sud *et al*. (2013)	13	26	3	4	6	UCLA	25	34	No dislocation/ recurrent instability
Kerakkanavar *et al*. (2018)	40	27	3	6	12	UCLA and SST	UCLA - 20; SST -5	UCLA - 32; SST - 11	3 recurrent instability
Katti *et al*. (2016)	21	27		3	12	UCLA	No raw scores given	No raw scores given	1 dislocation
Ballal and Jayakumar (2020)	32	25	2	Not mentioned	6	Rowe, ASES, and VAS	Rowe - 24; ASES - 48; VAS - 5	Rowe - 91; ASES - 85; VAS - 1	No dislocation
Parmar *et al*. (2019)	30	26	3.86	14	24	Rowe and UCLA	Rowe - 63; UCLA - 21	Rowe - 94; UCLA - 34	2 dislocations
Jaju *et al*. (2018)	48	27	2.46	4	14	UCLA and VAS	UCLA - 30; VAS - 7	UCLA - 31; VAS - 2	12 recurrent instability
Ghai *et al*. (2020)	71	29	3.17	4	29	Rowe and Oxford	Rowe - 25; Oxford - 25	Rowe - 91; Oxford 42	3 dislocations
Kumar *et al*. (2014)	20	24		12	24	UCLA and SST	UCLA - 21, SST - 5	UCLA - 35, SST - 12	2 dislocations

UCLA: University of California Los Angeles Score, SST: Standard shoulder test, ASES: American Shoulder and Elbow Society, VAS: Visual Analog Scale

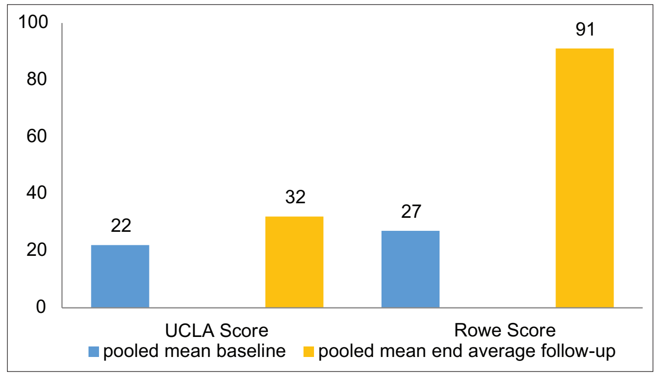

Figure 2: Pooled mean functional outcome measures across studies for University of California at Los Angeles and Rowe scores between baseline and the end of average follow-up period

dislocation, anchor failure, infection, and postoperative shoulder stiffness. The mean loss of external rotation between baseline and end of follow-up across studies was 5° (range: 0°–10°). However, only seven studies reported change in external rotation in their final data description.

Statistical correlations for number of anchors used (<3 vs. ≥3) were not possible due to under powering. However, the data show comparable UCLA and Rowe outcomes regardless of number of anchors used [Figures 3 and 4]. However, the mean postoperative functional scores seem to be better in studies where more than three anchors are used.

Discussion

Most studies in our review have used either UCLA or Rowe as a validated functional outcome measure.

University of California - Los Angeles scale (UCLA)

In one of the earlier studies in the Indian population, Mishra *et al*. in 2012 found that in 65 patients, the UCLA improved from 18 to 32 over an average follow-up period of 27 months. The authors used all-suture anchors in their study and noted that the average loss of ER was 5°, with 14% of patients having recurrent instability postoperatively but a zero-re-dislocation rate.[13] These findings were supported by Sud *et al*. in their study of 13 patients with recurrent dislocations, where they found UCLA improvement from 25 preoperatively to 34 at 6 months after surgery, with a zero-re-dislocation rate.[14] However, this study had high dropout rate, with only 46% of initial study participants were followed up at 6 months postoperatively, which results in participant bias.

Jaju *et al*. in 2018 studied 48 patients who underwent ABR with titanium anchors and found an average UCLA improvement from 30 at baseline to 31 at an average of 14-month follow up with a zero-dislocation rate.[15] In another study using titanium anchors, Kerakkanavar *et al*. noted an average UCLA improvement from 20 to 32 over a 12-month follow-up period with a 7.5% failure rate.[16] There was also an average SST improvement from 5 to 11 over the study period. Kumar *et al*. also studied UCLA and SST in their cohort of 20 patients

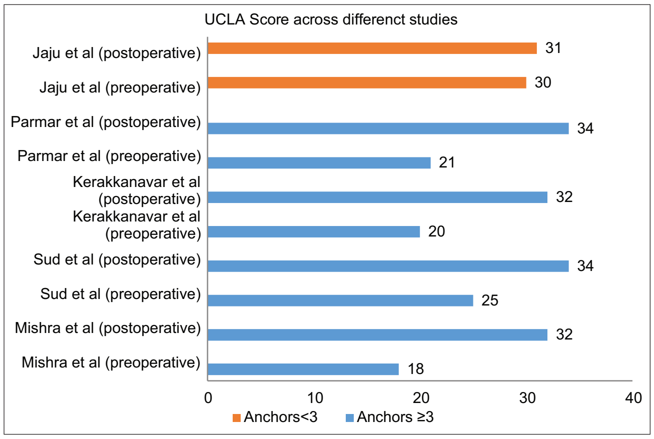

Figure 3: Distribution of Rowe score across different studies in relation to anchors used

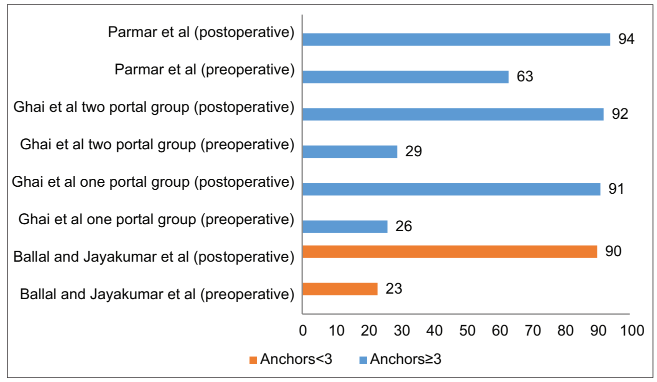

Figure 4: Distribution of University of California at Los Angeles score across different studies in relation to anchors used

undergoing ABR with a 2-year follow-up and observed that the average SST improved from 6 at baseline to 11 at the end of follow-up and the average UCLA from 21 at baseline to 32 at the end of follow-up with a re-dislocation rate of 10%.[17]

Further, using both titanium and bio-anchors, Katti *et al*. found that 83% had an excellent or good UCLA score at the end of 12-month follow-up, with an 18.8% complication rate (4.7% re-dislocation rate) in their study of 21 shoulders.[18] However, the study has not shown their UCLA scores in detail as part of functional outcome because of which it could not be considered for pooled mean analysis.

Overall, these six studies that explored the functional outcomes of ABR using UCLA (one additional study included in the discussion on Rowe scores) demonstrate that there is a trend toward improved functional outcomes after ABR with a low re-dislocation rate (range: 0%–10%). These findings appear to be independent of type of anchor used. However, the mean postoperative UCLA score was better in studies using a mean of three anchors or more compared to a study using <3 anchors [Figure 3]. Further, there appears to be an average ER loss of 5° across the studies.

Rowe studies

Sood and Ghai studied 51 patients over an average period of 22 months and divided their patients into two groups–the first (n = 44 patients) with ABR alone and the second (n = 7 patients) with additional Remplissage procedure. They observed that the average Rowe score improved from 25 in the preoperative period to 90 at the end of follow-up with only one re-dislocation (2%). Using titanium anchors across both arms of their study, they noticed that the mean ER loss in the ABR group was 5° and that in the ABR with Remplissage group was 9°.[19] Unfortunately, due to the mismatch between the two study arms, no intergroup analysis was carried out with regard to functional outcome. These findings have been supported by Ballal and Jayakumar in 2020; they studied 32 patients who underwent ABR with bio-anchors over an average follow-up period of 6 months and found that the average Rowe improved from 24 at baseline to 91 at follow-up with a zero-re-dislocation rate and an average ER loss of 5°. Further, they noted that the ASES improved from 48 to 85 and the VAS from 5 to 1 over the study duration.[20] In addition, they divided their study data into a ≤2-anchor group and a more than two-anchor group, likely reflecting tear size, and found that there was no difference in functional outcomes between the two groups.

Ghai *et al*. in a recent study compared the functional outcomes using a single anterior portal with standard two anterior portals in 71 patients over an average follow-up period of 29 months. They found that the average Rowe improved from 25 to 91 and that the OSS improved from 25 to 42 over the study duration, with a re-dislocation rate of 4% and an average ER loss of 6°.[21] Interestingly, there was no difference in functional outcomes between the two study groups, suggesting that either technique leads to similar outcomes. Parmar *et al*. studied both Rowe and UCLA outcomes in their study of 30 shoulders using titanium anchors over a 2-year follow-up and found that the average Rowe improved from 63 to 94 and the UCLA from 21 to 34 between baseline and the end of follow-up. They observed a re-dislocation rate of 7% in their study population.[22]

Overall, these four studies reporting Rowe as the primary outcome measure prove that there is a trend toward improvement of functional outcome in ABR with a low re-dislocation rate (range: 0%–7%). These findings appear to be independent of type of anchor used. However, the mean postoperative Rowe score was better in studies using a mean of 3 anchors or more compared to a study using <3 anchors [Figure 3] and also showed an average ER loss of 5°.

Overall comparison to global data

ABR is considered a safe and effective procedure, with a lower complication rate compared to open repair.[23] Postoperative outcomes may be assessed by several clinical metrics including recurrence of shoulder instability, related outcomes measure (ROM), return to work or sport, complication rate including revision surgery, and various PROMs.[10] In their review of the global literature on ABR, DeFroda *et al*. found that most studies used ASES and Rowe to assess functional outcomes, with ASES ranging from 87 to 98 and Rowe from 77 to 97 at an average follow-up of 2 years in most studies, with a re-dislocation rate in the range of 13% on average.[10] These figures are at par with the cumulative data from our review of the Indian population set.

When Indian studies on arthroscopic bankart surgery were collectively evaluated , there appears to be a trend toward improved functional outcomes in Indian population , irrespective of scoring system, age, number of dislocations prior to surgery, type of anchor or technique. Most Indian studies have used UCLA and Rowe to assess outcome measures with an average improvement in the range of 91 for Rowe score and 32 for UCLA at the average 20-month follow-up. It appears that the overall re-dislocation rate is low for the Indian population (range: 0%–10%) and there is minimal average loss of external rotation (average loss of 5° across the studies).

Limitations

The current study is limited by the quality and heterogeneity of the included studies, most of them being prospective case series which inherently can incorporate observer bias or selection bias. Moreover, the findings of this study may not translate to be true for the rest of the world. However, to the best of our knowledge, this is the first systematic review highlighting Bankart repair Indian population.

Conclusion

Functional outcome scores are improved in Indian patients undergoing ABR regardless of age, number of dislocations, type of anchor, and scoring outcome used with a low re-dislocation rate in the range of 0%–10%. These data are consistent with global review data on functional outcomes post ABR. More studies with larger sample sizes and longer follow-ups are required to better understand the above trends, and there should be an emphasis on randomized controlled trials comparing techniques and anchors in the Indian population.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Genu Recurvatum in Total Knee Arthorplasty: A Review

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Abstract

Genu recurvatum is a rare knee deformity that can be linked with osteoarthritis. The main causes of this deformity include neuromuscular disorders, rheumatoid arthritis, inverted tibial slope, or conditions associated with coronal deformities such as genu valgum. In cases of end-stage knee osteoarthritis, total knee arthroplasty is the indicated management to reduce pain and improve functionality and quality of life. Genu recurvatum is associated with an imbalance in the flexion and extension gaps, which is why it is necessary to have important considerations in the preoperative evaluation, implant selection, and surgical technique. We conducted a review in electronic databases including MEDLINE, EMBASE, and LILACS from 1990 to June 28, 2023. Two authors independently reviewed the titles and abstracts to identify studies that met the inclusion criteria. Thirty-four literature sources were included to address our inquiries. Results are presented in a narrative format, focusing on the design and study population for each specific research question. Genu recurvatum is a rare knee deformity which needs special considerations. Accurate assessment of the deformity magnitude and quadriceps weakness is crucial during the preoperative evaluation. The choice of implant should be tailored to the individual patient's characteristics. Surgical technique plays a critical role in achieving soft tissue and gap balance. Literature highlights an increased incidence of complications associated with this deformity, particularly in cases of poliomyelitis. Navigation and robotics offer promising alternatives to enhance surgical precision and appear to show a lower recurrence rate.

Keywords: Complications, functional outcome, genu recurvatum, hyperextension, neuromuscular diseases, poliomyelitis, postoperative rehabilitation, total knee arthroplasty, total knee replacement

Introduction

Osteoarthritis is a degenerative disease characterized by progressive joint damage.[1] The knee is one of the joints most affected by this pathology, and it is estimated that 10% of men and 13% of women older than 60 years present it.[2] It is characterized by pain, functional limitation, and reduction of quality of life.[3,4] Total knee arthroplasty is the treatment of choice for patients with end-stage osteoarthritis.[5] It is estimated that around 619,000 knee arthroplasties were performed in the United States in 2009.[6,7] Projections indicate that by the year 2030, around 3.4 million knee arthroplasties will be performed in the United States.[8] The literature demonstrates its benefit in terms of pain reduction, functional improvement, and amelioration of quality of life.[9]

Genu recurvatum is a rare condition of the knee, characterized by a deformity of the tibiofemoral angle in the sagittal plane where the knee achieves hyperextension >5°[10] [Figure 1]. Some authors have reported that between 0.5% and 1% of all patients undergoing total knee arthroplasty will present with this deformity preoperatively.[11] Since the appearance of navigation, it has been found that genu recurvatum is more frequent than previously thought, with a prevalence that varies between 4% and 12%.[12,13] Dejour described three types of genu recurvatum: pure bone deformity, soft-tissue laxity, and a mixed bone and soft-tissue deformity.[14] Quadriceps weakness or paralysis may lead the patient to lock the knee in hyperextension during gait as a compensatory mechanism.[15] The presence of ligamentous laxity of both

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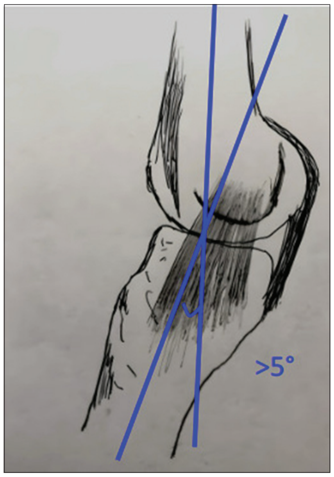

Figure 1: Sagital deformity of the tibiofemoral angle with hiperextension > 5°

the cruciate ligaments and the collateral ligaments could predispose to prosthetic instability and therefore influence the choice of implant.[11]

The main causes of this deformity include neuromuscular disorders, rheumatoid arthritis, inverted tibial slope, or conditions associated with coronal deformities such as genu valgum.[15-17] It is estimated that up to 19.5% of patients with neuromuscular diseases may develop genu recurvatum.[18] Other less frequent causes include rheumatoid arthritis, posttraumatic inverted tibial slope, osteomyelitis, postoperative inverted tibial slope following high tibial osteotomies, or associated coronal deformities such as genu valgum.[11,19,20]

All these conditions predispose individuals to develop degenerative changes in the knee that may ultimately derive in end-stage knee osteoarthritis.[19] Therefore, ligamentous balancing and proper implant selection represent some major challenges for the orthopedic surgeon.

Given the particular characteristics that this deformity generates, it is imperative for orthopedic and knee surgeons to acquire a comprehensive understanding of the preoperative planning, prosthesis selection, surgical technique, potential complications, and postoperative rehabilitation of patients with genu recurvatum and knee osteoarthritis undergoing total knee arthroplasty. Consequently, the objective of this narrative review is to go over the preoperative, intraoperative, and postoperative considerations that the surgeon should check when performing a total knee replacement in a patient with genu recurvatum, as well as the outcomes in terms of recovery of functionality, improvement of quality of life, and complications.

Materials and Methods

Questions

The following questions were formulated to be answered with the review:

- What considerations should be taken in presurgical planning in a patient with knee osteoarthritis and genu recurvatum who is a candidate for total knee arthroplasty?
- What type of knee prosthesis should I choose for my patient with knee osteoarthritis and genu recurvatum undergoing total knee arthroplasty?
- What is the appropriate surgical technique for patients with genu recurvatum and knee osteoarthritis undergoing total knee arthroplasty?
- What are the health outcomes in terms of functionality, quality of life, and main complications?
- What is the appropriate postoperative management and rehabilitation protocol that patients with genu recurvatum and knee osteoarthritis undergoing total knee arthroplasty should receive?

Selection criteria of the studies

By type of study: Clinical practice guidelines (CPGs), systematic reviews (SRs), orthopedic surgery textbooks, randomized clinical trials, cohorts, case series, or case reports.

By type of population: Patients with severe knee osteoarthritis.

By concept: Presence of genu recurvatum.

By type of intervention: Total knee arthroplasty in hospital context.

Search strategy

A comprehensive literature search was conducted in electronic databases including MEDLINE, EMBASE, and LILACS from 1990 to June 28, 2023. MeSH and DeCS terms such as "total knee arthroplasty" or "total knee replacement" combined with "genu recurvatum" or "hyperextension," "poliomyelitis" or "neuromuscular diseases," "postoperative rehabilitation," "functional outcome," and "complications" were used. Furthermore, a snowball search was conducted, and the reference list of relevant articles was scrutinized to identify additional papers. The search was limited to articles published in English or Spanish between the years 2000 and 2023.

Selection of studies and data extraction

Two authors independently reviewed the titles and abstracts to identify studies that met the inclusion criteria. In those in which inclusion criteria were apparently met, full-text articles were obtained for further evaluation. Finally, we included those studies that fulfilled the inclusion criteria. The results of the search were documented in a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart, outlining the number of titles screened, titles excluded due to duplicate publications, and studies ultimately included based on research questions.

Data extraction was performed by two researchers (HGL and HGD) using a standardized data collection form. Any disagreements between the two researchers were resolved by consensus. The following information was collected from the included studies and recorded in a spreadsheet: study design, patient characteristics (including age, sex, comorbidities, and type of hospital), severity of genu recurvatum, surgical technique performed, type of implant used, fixation method, complications, reoperations, revision rate, duration of follow-up, and functional outcomes at the end of the follow-up period.

Synthesis and presentation of results

The results were presented in a narrative format. We first describe the study selection process, the number of titles reviewed, the number of full-text studies reviewed, and the number of studies ultimately included. Then, each of the questions is answered: preoperative considerations, surgical technique and prosthesis, health outcomes, complications, postoperative management, rehabilitation plan, and knee functionality at 1 year are described.

Results

A total of 54 titles were initially screened, of which 44 were obtained in full text. Out of these, 13 documents were excluded as they did not address our research questions. Ultimately, 34 literature sources were included to address our inquiries. Among the selected studies, there were 16 narrative reviews,[11,18,21-34] 3 SRs,[10,35,36] 1 orthopedic surgery textbook,[16] 1 CPG,[37] 1 concordance-type study,[38] 1 case–control study,[39] 2 case reports,[14,40] and 9 retrospective studies.[12,13,16,41-46] The process of article selection is visually summarized in a PRISMA flowchart.

What considerations should be taken in presurgical planning in a patient with genu recurvatum and knee osteoarthritis who is a candidate for total knee arthroplasty?

The preoperative planning process begins with the anamnesis, focusing on the investigation of symptoms such as pain, instability, limping, weakness, and limb length discrepancy.[10] A thorough physical examination is crucial and should include the quantification of hyperextension deformity, assessment of ligament stability in the coronal plane, evaluation of range of motion, and measurement of quadriceps strength [Figure 2]. Careful evaluation of quadriceps muscle atrophy is particularly important, given that neuromuscular diseases are a common cause of genu recurvatum. Detection of ankle plantar flexion deformities and dorsiflexion weakness is also crucial, as these can affect walking ability and predispose the knee to hyperextension during the heel strike phase.[19] Gait analysis should be performed to assess the patient's walking pattern, and in case of detecting other abnormalities or uncertainties, a computerized gait analysis can be considered a complementary study.[18]

Radiological preoperative planning starts with anteroposterior (AP) and lateral radiographs with weight-bearing support [Figures 3 and 4]. These images help define the distal femoral cut and the proximal tibial cut. In addition, assessment of associated coronal deformities, bone quality, tibial slope, patellar height, presence of osteophytes, and bone defects is essential.[22] It is crucial to approximate the size of the prosthesis to be implanted using templates, software, or a hybrid method.[38]

Evaluation with full-length lower extremity radiographs is necessary to determine the mechanical axis of the limb, measure the femorotibial angle accurately, and exclude any extra-articular deformities that may not be visible on knee X-rays. In case any deformity is identified at the foot and ankle level during the physical examination, radiographs of the feet and ankles may need to be obtained as well.[22]

Figure 2: Physical examination demonstrating hyperextension deformity

Figure 3: AP radiograph with weight- bearing support

Figure 4: Lateral radiograph with weight- bearing support

What type of knee prosthesis should I choose for my patient with knee osteoarthritis and genu recurvatum undergoing total knee arthroplasty?

The selection of an appropriate knee prosthesis is a critical decision in total knee arthroplasty, with implications for surgical technique, patient satisfaction, and long-term implant performance.[23] In cases of genu recurvatum deformity, various prosthetic designs have been considered.[11]

In a study by Meding *et al*. in 2001, 57 posterior cruciate retention prostheses were utilized in 53 patients with genu recurvatum undergoing total knee arthroplasty. The average deformity angle was 11°, and none of the patients had significant ligamentous instability, neuromuscular disease, or inflammatory arthropathy. Follow-up was conducted over an average of 4.5 years, revealing a 98% correction rate, 3.5% recurrence rate, and 3% flexion contracture. Furthermore, all patients demonstrated functional improvement based on the Knee Society Score.[16]

Using a posterior-stabilized prosthesis offers the advantage of increased flexion gap through posterior cruciate ligament resection, thereby equalizing the gaps and aligning them with the extension gap. Mesnard *et al*. conducted a study with 32 cases of genu recurvatum and 64 controls without deformity, all treated with posterior-stabilized prostheses and an average follow-up of 60 months. The study showed no differences in radiological outcomes, complications, or revision rates between the groups. In addition, the recurvatum group reported 0% postoperative instability.[39]

The presence of neuromuscular diseases presents a significant challenge in knee arthroplasty, with low predictability, a high risk of deformity recurrence, and potential failure, leading to its classification as a relative contraindication.[41] Progressive constraint increase improves knee stability; however, patients with severe loading demands may experience early loosening at the prosthetic-bone interface.[19] The Istituto Ortopedico Rizzoli group reported the use of rotating-hinge prostheses in 15 patients with poliomyelitis and genu recurvatum who underwent total knee arthroplasty [Figure 5]. After an average follow-up of 3.1 years, they observed 100% functional improvement with no cases of loosening or deformity recurrence.[42] Prasad's SR highlighted quadriceps muscle strength as an important prognostic factor for postoperative functional outcomes. The review also recommended hinged prostheses for patients with quadriceps weakness preventing them from overcoming gravity.[35] Custom rotating-hinge prostheses have also been described, showing functional improvement, minimal complications, and 0 cases of loosening after a 72-month follow-up period.[43]

Figure 5: Rotating hinge prosthesis

Currently, knee arthrodesis is considered a salvage option only when other alternatives have failed or when a high failure rate is predicted due to the severity of the deformity and underlying disease.[19] Table 1 summarizes the tips and tricks for choosing the prosthesis design.

What is the appropriate surgical technique for patients with genu recurvatum and knee osteoarthritis undergoing total knee arthroplasty?

The success of total knee arthroplasty relies on precise bone cuts and appropriate periarticular soft-tissue release to achieve a balanced, aligned, and stable prosthesis. The goal is to create an extension gap that is a symmetrical rectangle of equal size and shape to the flexion gap.[24] Resection of the distal femur and proximal tibia determines the extension gap, whereas resection of the posterior femur and proximal tibia determines the flexion gap.[25] Patients with genu recurvatum typically exhibit an extension gap that is larger than the flexion gap[11] [Figure 6]. To achieve balance between the gaps, the surgical approach involves reducing the amount of distal femoral resection. This can be accomplished by adjusting the distal femoral resection guides, with suggestions from Meding to decrease by approximately 2–3 mm compared to the component thickness,[16] whereas Whiteside recommends a decrease of 4–6 mm[26] [Figure 7]. If the gap imbalance persists, modifying the AP diameter of the component may be considered. For prostheses that utilize an anterior reference guide to cut the posterior condyles, selecting a size smaller than the measured one can increase the thickness of the posterior condyle cut and subsequently enhance the flexion gap.[19] It

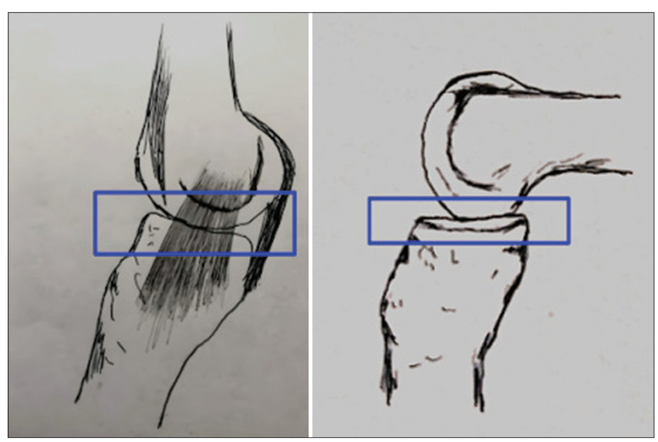

Figure 6: Extension gap (left) and flexion gap (right)

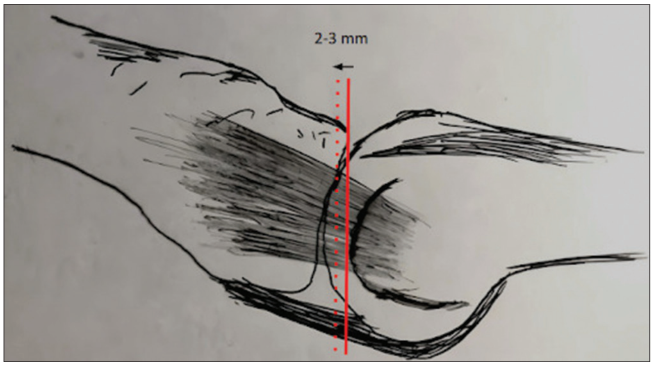

Figure 7: Distal femoral cut adjusted by 2-3 mm as suggested by Meding

Table 1: Tips and tricks for choosing prosthesis design

Severity	Tips and tricks
Mild due to soft-tissue laxity	Leave the knee tighter. Use a stabilized prosthesis
Moderate associated with neuromuscular disease	Correct bone deformity with resection. Depending on stability, use a posterior-stabilized or hinged prosthesis
Severe without extensor mechanism impairment	Use a rotating hinge prosthesis
Severe associated with extensor mechanism deficiency	Use a fixed hinge prosthesis

is important to note that the joint line should not be modified more than 4 mm proximally or distally to avoid instability in the midrange of flexion.[36] Another approach to achieve gap symmetry is the gap balancing technique, where the proximal tibia is initially cut at 90° of its mechanical axis. Subsequently, with the knee flexed to 90° and considering medial and lateral ligament tension, the distal femur and posterior femur are resected to achieve appropriate external rotation of the femoral component, thus equalizing both gaps.[27]

In cases where gaps cannot be balanced with the aforementioned measures, Dr. Krackow described the posterior capsule plication and transfer of the collateral ligaments proximally and posteriorly to improve their tension during extension.[28] It is essential to ensure that both the medial and lateral collateral ligaments are intact and functional to perform this technique.[19]

The most frequently associated deformity with genu recurvatum is genu valgum.[19,29] Sequential release of soft tissues is necessary for these patients to achieve medial and lateral symmetry.[44] Tense structures such as the posterolateral capsule and iliotibial band must be released.[45] In cases of severe fixed valgus deformities, an osteotomy of the lateral epicondyle may be required, allowing the simultaneous release of the lateral collateral ligament and the popliteus tendon to find their isometric point.[46]

In current joint arthroplasty surgery, new technologies such as intraoperative navigation and robotics have demonstrated their application in addressing genu recurvatum.[30] Mullaji *et al*. performed 45 total knee arthroplasties in patients with genu recurvatum secondary to osteoarthritis. In their average follow-up of 26.4 months, they reported no recurrences, 100% improvement in range of motion, and functional outcomes.[12] These results differ from the outcomes reported by Krackow and Weiss[28] and Meding *et al.*[16] mainly for differences in joint line elevation (average 0.6 mm in Meding's work and 1.1 mm in Mullaji's), as well as ethnic differences in Asian patients who tend to have a greater degree of preoperative knee flexion. Seo *et al*. demonstrated similar results in 55 patients with genu recurvatum due to osteoarthritis, with no significant differences observed in sagittal alignment and patient-reported outcomes within the recurvatum group.[13] Robotics has shown greater precision in component positioning and achieving adequate balance of flexion and extension gaps.[31] Cook-Richardson reported a case of a 38-year-old patient with intra- and extra-articular recurvatum deformity of the femur who underwent robotic total knee arthroplasty, successfully restoring the mechanical axis.[40] In the case of the genu recurvatum, as in the literature in general, robotics has not demonstrated better results in terms of functionality and long-term survival of the implants.[31]

What is the appropriate postoperative management and rehabilitation protocol that patients with genu recurvatum and knee osteoarthritis undergoing total knee arthroplasty should receive?

Although specific guidelines for the rehabilitation of these patients are lacking, literature suggests that rehabilitation protocols for traditional total knee arthroplasty generally apply to this population as well.[19] Early mobilization of the knee is emphasized to regain the range of motion,[37] and weight-bearing can typically begin immediately unless contraindicated by any intraoperative complications[32,33] Given that quadriceps muscle strength is a crucial prognostic factor, special attention should be given to its rehabilitation. The American Physical Therapy Association guidelines recommend the use of electrical stimulation and isometric exercises to enhance muscle strength and gait patterns, as well as to improve patient-reported outcomes.[33] Regular clinical and radiological follow-up, similar to that of standard knee arthroplasty, is typically conducted at the 1st week, after 4 weeks, 8 weeks, 6 months, and annually thereafter.[16]

What are the main complications of patients with genu recurvatum and knee osteoarthritis undergoing total knee arthroplasty?

The primary complication associated with this population is the recurrence of the recurvatum deformity, which is more prevalent among patients with underlying neuromuscular diseases. Prasad's SR reported a recurrence rate of 28%.[42] In cases without muscle weakness, recurrence rates are lower, as demonstrated by Mesnard's case–control study with an 18% recurrence rate.[39] Studies conducted by Mullaji *et al*. and Seo *et al*. using intraoperative navigation reported a recurrence rate of 0% in patients with genu recurvatum and osteoarthritis.[12,13] Aseptic loosening is another important complication, particularly in patients with constrained prostheses. Gan and Pang reported a 5.9% loosening rate at a 2-year follow-up.[34] Prasad indicated that 17% of revision cases in these patients were attributed to aseptic loosening.[42] However, it should be noted that most studies have relatively short follow-up periods ranging from 2 to 4.3 years, limiting long-term information.

Instability is a common complication in patients with neuromuscular diseases due to ligamentous and soft-tissue hypermobility. Among the 14 patients with poliomyelitis managed by Dr. Gan, one case presented postoperative instability.[34] Prasad found a potential postoperative instability rate of 11% in patients with poliomyelitis.[35] Other less frequent complications include persistent pain, which is more commonly associated with neuromuscular diseases and directly related to quadriceps weakness.[19] Late periprosthetic fractures have been reported with the use of rotating hinge prostheses,[43] along with extensor mechanism injuries (1%) and stiffness (6%).[42]

Literature indicates that the rate of periprosthetic infections does not significantly differ from traditional total knee arthroplasties.[42]

Conclusions

Conventionally, genu recurvatum was believed to be a rare knee deformity. However, recent studies have revealed that it is more prevalent than previously thought, particularly in association with neuromuscular diseases such as poliomyelitis. Accurate assessment of the deformity magnitude and quadriceps weakness is crucial during the preoperative evaluation. The choice of implant should be tailored to the individual patient's characteristics. Posterior-stabilized prostheses are recommended in the absence of underlying neuromuscular disease, whereas patients with neuromuscular disease and a high risk of recurrence should be treated with a rotating-hinge design. Surgical technique plays a critical role in achieving soft tissue and gap balance. Literature highlights an increased incidence of complications associated with this deformity, particularly in cases of poliomyelitis. However, long-term follow-up studies are needed to determine the overall prognosis. Navigation and robotics offer promising alternatives to enhance surgical precision and appear to show a lower recurrence rate, but further long-term investigations are necessary to establish their clinical benefits with certainty.

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Conflicts of interest

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