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A Study on Functional Outcome of High Tibial Osteotomy for Unicompartmental Osteoarthritis of Knee Joint

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Abstract
Knee joint Osteoarthritis accounts for 3% of global "years lived with disabilities and entails a significant health and economic burden on the socio-economic system. While the aetiology of Osteoarthritis is complex and multifactorial, biomechanics is one of the most important aspects in its pathogenesis. It affects the medial compartment often, resulting in Varus deformity. Significant Varus deformity aggravates the pathophysiology by medializing the weight-bearing axis. Clinically, Interventions that change the excessive forces associated to the position of the loading axis operating on damaged tissues, such as articular cartilage, have been used in clinical trials to alleviate OA symptoms. High tibial osteotomy (HTO) is effective in correcting malalignment and alleviating the symptoms of medial unicompartmental osteoarthritis and it is a commonly accepted and performed surgery. This study aims to investigate effectiveness of HTO with proximal medial tibia locking plating and autologous bone grafting in patients with Unicompartmental OA of the knee To assess the effectiveness of the high tibial osteotomy with proximal medial tibial locking plating and autologous bone grafting in patients with unicompartmental osteoarthritis of knee. 30 patients were included in this study and assessed for a period of 2 years and functional (Knee Society score system) and was evaluated at 6th week, 3rd month and 6th month. From the current study which included an analysis of 30 knees that underwent High tibial medial opening wedge osteotomy, 27 subjects had excellent outcome and 3 subjects had good outcome. The mean KSS values preoperatively and postoperatively were 54.07±5.19 and 86.93±4.67 respectively. There was a statistically significant increase in the mean KSS value postoperatively with a p-value < 0.001. The mean ROM values preoperatively and postoperatively were 80.53 ± 5.92 and 104.27 ± 7.42 respectively. There was a statistically significant increase in the mean ROM value postoperatively with a p< 0.001. High tibial medial opening wedge osteotomy is a good option in the treatment of unicompartmental osteoarthritis knee. It improves the functional outcome.

INTRODUCTION

Knee joint osteoarthritis (OA) is a chronic condition that causes significant disability and is becoming more common among younger populations. It accounts for about 3% of global years lived with disability and places a heavy health and economic burden on societies[1]. The etiology of OA is complex and multifactorial, with biomechanics playing a crucial role. Factors such as obesity-related overloading, overuse misalignment are significant risk factors for the development of OA[2].

Lower limb malalignment, particularly varus deformity, significantly impacts load distribution across the knee joint's articular surfaces. This deformity shifts the weight-bearing axis medially, increasing stress on the medial compartment and accelerating degenerative changes[3]. This progression often leads to more severe OA in the medial compartment due to the malalignment[4]. Clinical interventions that alter the excessive forces on damaged tissues, such as articular cartilage, have shown promise in alleviating OA symptoms[5].

High Tibial Osteotomy (HTO) is an effective surgical procedure for correcting malalignment and alleviating symptoms of medial unicompartmental osteoarthritis[6]. The primary aim of HTO is to offload the affected knee compartment by redistributing weight-bearing stresses from the worn medial compartment to the healthier lateral compartment, thereby reducing pain and slowing disease progression[7]. This study aims to assess the effectiveness of HTO using proximal medial tibia locking plating and autologous bone grafting in patients with unicompartmental OA of the knee.

HTO is particularly beneficial for younger, active patients with unicompartmental OA who are not yet candidates for total knee arthroplasty (TKA) due to their age and activity level[8]. The procedure realigns the knee joint to shift the mechanical axis away from the damaged medial compartment, redistributing the load to the lateral compartment. This realignment can lead to significant pain relief and functional improvement, potentially delaying the need for more invasive procedures such as TKA[9].

The effectiveness of HTO can be enhanced by using proximal medial tibia locking plating, which provides stable fixation and allows for precise correction of the deformity[10]. Additionally, the use of autologous bone grafting aids in promoting bone healing and achieving better long-term outcomes[11]. This combination aims to optimize surgical results, improving knee function and patient satisfaction.

The primary objective of this study is to evaluate the functional outcomes of HTO with proximal medial tibia locking plating and autologous bone grafting in patients with unicompartmental OA of the knee. Parameters such as pain relief, knee function overall patient satisfaction post-surgery will be assessed. By providing detailed insights into the effectiveness of these combined techniques, this study aims to contribute to the body of knowledge on the management of unicompartmental OA and potentially guide future clinical practice.

Success in HTO depends on accurate patient selection, meticulous preoperative planning precise surgical execution. Ideal candidates for HTO are typically younger, active individuals with isolated medial compartment OA, adequate knee motiona stable knee joint without advanced degenerative changes in the lateral compartment or patellofemoral joint[12]. The procedure is contraindicated in patients with inflammatory arthritis, severe obesity, or severe degenerative changes across multiple compartments[3].

Several studies have demonstrated the effectiveness of HTO in improving knee function and reducing pain. For instance, Brouwer *et al*. highlighted significant improvements in knee function and pain relief following HTO, sustained over a long-term follow-up period[4]. Additionally, Coventry's pioneering work established the foundation for HTO, showing that realigning the knee joint could significantly delay the need for total knee arthroplasty[5].

The use of modern techniques, such as proximal medial tibia locking plating, enhances the stability and precision of the osteotomy. Locking plates allow for rigid fixation, which is crucial for early mobilization and weight-bearing, thereby facilitating quicker recovery and better functional outcomes[6]. Furthermore, incorporating autologous bone grafting promotes osteogenesis, leading to improved bone healing and integration[7]. This combination of advanced surgical techniques aims to optimize the clinical outcomes of HTO.

This study's purpose is to evaluate the functional outcomes of HTO performed using proximal medial tibia locking plating and autologous bone grafting in patients with medial unicompartmental OA of the knee. Specific objectives include assessing pain relief, improvement in knee functionoverall patient satisfaction post-surgery. Through this comprehensive evaluation, the study aims to provide valuable insights into the effectiveness of these combined surgical techniques and potentially inform future clinical practices in managing unicompartmental knee osteoarthritis.

Aims and Objectives: To assess the effectiveness of the high tibial osteotomy with proximal medial tibial locking plating and autologous bone grafting in patients with unicompartmental osteoarthritis of knee

- To study functional outcome of High Tibial Osteotomy using proximal medial tibial locking plating and autologous bone grafting in patients with Unicompartmental Osteoarthritis of Knee.
- To study various complications following the high tibial osteotomy using proximal medial tibial locking plating and bone grafting in these patients

MATERIALS AND METHODS

Study Design: Prospective observational study

Study Setting: The study was conducted in the Department of Orthopaedics, Katuri Medical College and Hospital, a tertiary care referral hospital in Guntur, Andhra Pradesh

Study Period: May2022 to April 2024-2 years

Sample Size: 30

Inclusion Criteria:

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- Pain and disability resulting from osteoarthritis that interferes with highdemand employment or recreation.
- Evidence on weight bearing radiographs of degenerative arthritis that is
- confined to one compartment with a corresponding varus deformity.
- The ability of the patient to use crutches after the operation and the
- possession of sufficient muscle strength and motivation to carry out a
- suitable rehabilitation program.
- Good vascular status without serious arterial insufficiency or large
- varicosities.
- Age<60 years

Exclusion Criteria:

- The patients with bicompartmental and tricompartmental osteoarthritis.
- Narrowing of lateral compartment cartilage space.
- Medial compartment tibial bone loss of more than 2 or 3mm.
- Lateral tibial subluxation of more than 1 cm.
- Restricted range of movements at knee i.e. knee flexion of<90
- degrees or flexion contracture of more than 15 degrees.
- Patients aged above 65 years.
- Deformity correction of more than 20 degree.
- Rheumatoid arthritis.

Ethical Clearance: Ethical clearance was taken from Institutional Ethics Committee (IEC).

Study Method:

Pre-Operative Workup: Patients with clinically and radiologically confirmed knee joint osteoarthritis were admitted to the Department of Orthopedics at Katuri Medical College and Hospital, Chinakondrupadu. Standard pre-operative investigations were conducted for all patients, including hemoglobin levels, total and differential white blood cell counts, platelet count, renal function tests, viral markers (HIV, HBsAg, HCV), chest X-ray in posteroanterior (PA) view electrocardiogram (ECG). Additionally, a Scanogram of the lower limbs and a pre-anesthetic checkup for regional and general anesthesia were performed.

Informed Consent: All patients involved in the study were thoroughly informed about their diagnosis and the various management options available. This included discussions on the potential complications associated with both non-operative and operative treatments, as well as specific per-operative and post-operative risks such as donor site morbidity, injury to surrounding structures, infection, compartment syndrome, anesthesia risks, post-operative knee pain, restricted range of motion hardware breakage or prominence. Consent for surgery was obtained from all patients after these explanations were provided in a language they understood. The advantages and disadvantages of the procedure, along with the risk-benefit ratio, were clearly communicated to both the patients and their attendees before obtaining consent.

Evaluation of Patients: Patients presenting with osteoarthritis of the knee joint to the Orthopedics department of Katuri Medical College and Hospital were included in the study. Those meeting the inclusion and exclusion criteria were evaluated preoperatively through clinical and radiological examinations. Detailed patient histories, demographic details, body mass index (BMI)results from clinical and radiological examinations were documented for all participants. The following investigations were performed for all cases:

- X-ray of both knees in anteroposterior (AP) and lateral views under weight-bearing conditions.
- Magnetic resonance imaging (MRI) of the knee and Scanogram.
- Complete blood count (CBC) with erythrocyte sedimentation rate (ESR).
- Bleeding time and clotting time assessments.

- Renal function tests.
- Chest X-ray.
- Viral markers including HIV, HBsAgHCV.
- Two-dimensional echocardiography (2D Echo) for hypertensive patients, elderly patients those with a history of cardiac disease.
- Follow-up X-rays.

This comprehensive pre-operative assessment ensured that all patients were thoroughly evaluated and prepared for the high tibial osteotomy procedure.

Surgical Technique: Under strict aseptic conditions, under combined spinal and epidural anaesthesia, under pneumatic tourniquet control, patient is then placed in supine position on a radiolucent operating table. Surgical area around the knee, leg and ipsilateral iliac crest is then prepared, cleaned and draped. A 7cms vertical incision is given over skin, 1cm below the medial joint line centering between the medial aspect of tibial tuberosity and posteromedial aspect of tibia, after incising and retracting the skin and subcutaneous tissue, fascia over the Pes Anserinus is identified and incised.

Pes Anserinus is then detached from tibia to expose the superficial tibial (medial) collateral ligament, then the distal part of exposed ligament is separated from the bone and neurovascular structures present posterior to incision line are protected with a blunt Hofmann retractor. After identification of the medial border of patellar tendon, subperiosteal dissection is done from the tibial tuberosity to posteromedial aspect of tibia. Then, a single K-wire is passed starting from medial side of proximal tibia, 5cms below the joint line and is directed obliquely up towards the fibular head.

Intra Operative Calculation of Wedge: Two 2.4-mm K-wires are inserted 3.5 cm below the medial joint line and Then a biplanar osteotomy is done with an oscillating saw. The 2 K-wires are removed from the proximal tibia. After the osteotomy, 2 other reference K-wires are inserted parallel to the sagittal plane, the first at the proximal fragment and the second at distal fragment. The first coronal K-wire is inserted parallel to the joint line from the medial side to the lateral side, beginning 1 cm below the medial joint line. The second coronal K-wire is inserted 1 cm below the osteotomy site and extending to the tibiofibular joint. The angle of these 2 coronal K-wires is measured with a degree scale. The difference in angles between the 2 coronal K-wires before and after the gap opening is the degree of correction.

Taking this as a reference, medial tibial osteotomy is performed with an oscillating saw/ osteotome under fluoroscopic guidance. The osteotomy line is then widened using a laminar spreader and the mobility of the osteotomy site is checked. Using a Valgus force, the osteotomy is opened. The required amount of wedge was calculated intra-operatively is filled with tricortical iliac crest bone graft.

ILIAC Crest Bone Grafting: Under aseptic conditions, through anterior approach to the iliac crest for bone grafting, a skin incision of 6cm is given on skin over iliac crest. Skin, subcutaneous tissue and muscles are retracted, periosteum elevated and then tricortical bone graft is harvested behind the anterior superior iliac spine (ASIS) followed by irrigation of surgical wound with normal saline and closure of periosteum, subcutaneous tissue and skin followed by application of sterile dressings over the surgical wound over iliac crest.

The harvested bone graft wedges are placed in the medial open wedge osteotomy site maintaining the desired amount of valgus and the osteotomy is fixed with 3-5 holed locking compression plate (LCP). Pes Anserinus and MCL are repaired, subcutaneous tissue closed by intermittent suturing with Vicryl..Skin is closed with vertical mattress suturing with nylon. Betadine soaked gauge placed over surgical incision site and sterile compressive dressings applied. Tourniquet deflated and removed and distal pulses checked. Above knee slab application done.

Post-Operative Protocol:
Post-operative protocol for the patients include:

- Strict Immobilization in an above knee slab till 3 weeks.
- After 3 weeks above knee slab removed. Long leg knee brace is applied and knee range of motion exercises advised. The patient is instructed to do partial weight bearing using crutches or walker till the end of 7 weeks.
- The patient is then allowed full weight bearing after 8 weeks.
- Patients are strictly advised to refrain from the high demanding activities till clear signs of complete bone union at osteotomy site and wedge are evident on radiographs.

Follow UP:

- The follow up was done at 3, 6, 12 and 24 weeks.
- The functional outcome of this study was assessed with 'KNEE SOCIETY' scoring systems (INSALL MODIFICATION 1993)
- Subjective evaluation and the obtained score were graded.

- Objective evaluation is done with special tests, clinical and radiological evaluation.

Data Analysis: Data was collected and entered into Microsoft Excel sheet and the results were expressed in percentages or frequencies. IBM Statistical Package for Social Sciences (SPSS) v.20 was used for the statistical analysis.

RESULTS AND DISCUSSIONS

The current study involved an analysis of 30 knees that underwent high tibial medial opening wedge osteotomy. The results are detailed below:

Demographics and Baseline Characteristics:

- **Age:** The mean age of the participants was 46.70 ± 4.44 years. Most of the study participants were aged between 45 and 49 years.
- **Gender:** The study consisted of 60% females and 40% males.
- **Occupation:** The majority of subjects were farmers (43.4%), followed by homemakers (40%).
- **Laterality:** The distribution of the operated knee was almost equal, with 46.7% of the procedures performed on the right knee and 53.3% on the left knee.

Range of Motion (ROM): The range of motion (ROM) values were also measured preoperatively and postoperatively:

- **Preoperative ROM:** 80.53±5.92 degrees
- **Postoperative ROM:** 104.27±7.42 degrees

The increase in the mean ROM value postoperatively was statistically significant, with a $p<0.001$. This significant improvement indicates better joint flexibility and function following the surgery.

The study evaluated the mean Functional Score (FS) values of patients before and after undergoing High Tibial Osteotomy (HTO). Preoperatively, the mean FS value was 62.67 with a standard deviation of 8.38. Postoperatively, this value increased to 86.50 with a standard deviation of 5.44.

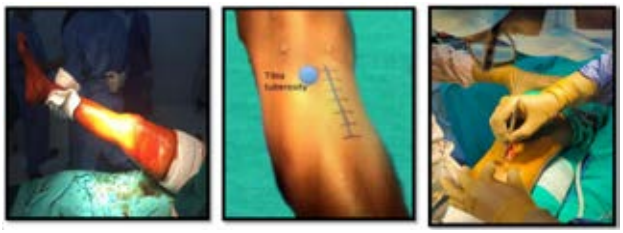

Fig. 1: Surgical Technique for Medial Approach to Tibia with K-Wire Insertion

Fig. 2: Intraoperative Technique for Calculating and Performing Medial Tibial Osteotomy

Fig. 3: Fluoroscopic Guidance and Execution of Medial Tibial Osteotomy with Bone Graft Insertion

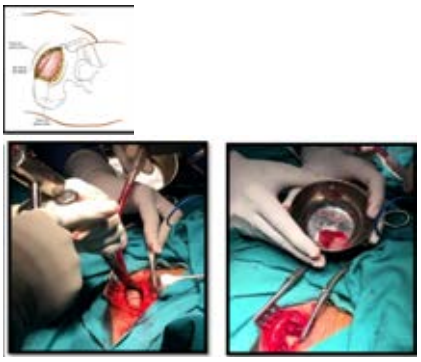

Fig.4: Harvesting and Placement of Iliac Crest Bone Graft for Medial Tibial Osteotomy

Fig. 5: Fixation of Medial Tibial Osteotomy with Locking Compression Plate and Intraoperative Fluoroscopic Confirmation

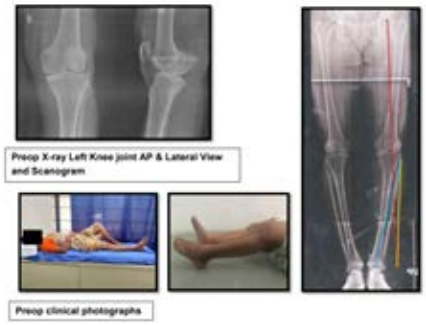

Fig. 6: Preop clinical photographs

Fig. 7: Postoperative Healed scar at 6 weeks follow-up, X-ray of left knee joint AP and view and scanogram at 12 weeks follow up

Table 1: Sociodemographic variables

Characteristic	Value
Mean Age (years)	46.70±4.44
Age Range (years)	45-49
Gender Distribution	60% females, 40% males
Occupation	43.4% farmers, 40% homemakers
Knee Laterality	46.7% right, 53.3% left

Table 2: Mean ROM Value (degrees)

Measurement Time Point	Mean ROM Value (degrees)	Standard Deviation	p-value
Preoperative	80.53	5.92	< 0.001
Postoperative	104.27	7.42	

Table 3: Mean Functional Score (FS) Values Preoperatively and Postoperatively

Measurement Time Point	Mean FS Value	Standard Deviation
Preoperative	62.67	8.38
Postoperative	86.50	5.44

Table 4: Distribution of Subjects According to Knee Society Score (KSS)

KSS Range		Preoperative Subjects (n=30)	Postoperative Subjects (n = 30)
< 60	25	0	
60 - 69	5	0	
70 - 79	0	3	
80 - 100	0	27	

Table 5: Mean Knee Society Score (KSS) Values Preoperatively and Postoperatively

Measurement Time Point	Mean KSS Value	Standard Deviation	p-value
Preoperative	54.07	5.19	< 0.001
Postoperative	86.93	4.67	

The increase in mean FS indicates a substantial improvement in the patients' knee function following the surgical intervention. To confirm the statistical significance of this improvement, a paired sample t-test was conducted. The analysis revealed that the improvement in the mean FS value postoperatively was statistically significant, with a $p<0.001$, strongly suggesting that the surgical procedure had a positive impact on the functional outcomes of the patients.

The Knee Society Score (KSS) is a widely used metric to assess knee function and pain levels. In this study, the KSS distribution of subjects preoperatively and postoperatively was recorded. Among the 30 subjects assessed:

Preoperatively:

- 25 subjects (83.3%) had a KSS of less than 60, indicating poor knee function and significant symptoms of osteoarthritis.
- 5 subjects (16.7%) had a KSS ranging from 60 to 69, which still reflects moderate dysfunction and pain.

Postoperatively:

- 3 subjects (10%) had a KSS ranging from 70-79, showing moderate improvement in knee function.
- 27 subjects (90%) had a KSS ranging from 80 to 100, indicating significant improvement and reflecting good to excellent knee function with minimal symptoms.
- This distribution highlights the effectiveness of the HTO procedure in improving the knee function of the majority of patients.

Further illustrating the improvements, the mean Knee Society Score (KSS) values were also compared preoperatively and postoperatively. Preoperatively, the mean KSS value was 54.07 with a standard deviation of

5.19. Postoperatively, this value increased significantly to 86.93 with a standard deviation of 4.67. The substantial rise in mean KSS values post-surgery indicates a marked improvement in knee functionality and patient well-being. The improvements observed in the KSS values postoperatively suggest that patients experienced less pain and better knee function following the HTO procedure.

The results of this study demonstrate a significant enhancement in both the Functional Score (FS) and Knee Society Score (KSS) following High Tibial Osteotomy (HTO) with proximal medial tibia locking plating and autologous bone grafting. The marked improvements in these scores indicate that HTO is an effective surgical intervention for patients with unicompartmental osteoarthritis of the knee, leading to better functional outcomes, reduced pain overall improved quality of life. These findings support the use of HTO as a valuable option for managing medial compartment osteoarthritis, especially in younger, active patients who are not yet candidates for total knee arthroplasty.

The present study evaluated the functional outcomes of High Tibial Osteotomy (HTO) with proximal medial tibia locking plating and autologous bone grafting in 30 patients with unicompartmental osteoarthritis of the knee. The results demonstrated significant improvements in knee functionality, as evidenced by increases in both the Functional Score (FS) and the Knee Society Score (KSS). The findings of this study are in line with those of previous research, underscoring the effectiveness of HTO in managing medial compartment osteoarthritis.

Comparison with Previous Studies: Several studies have reported improvements in knee function following HTO, supporting the findings of the current research. For instance, Sprenger and Doerzbacher reported that patients undergoing HTO showed significant improvements in knee pain and function, with a mean increase in KSS values similar to those observed in this study (12). Similarly, a study by Duivenvoorden et al. found that HTO significantly improved both KSS and ROM values in patients with medial compartment osteoarthritis, with postoperative scores indicating substantial enhancement in knee function and quality of life[13].

The demographic characteristics of the study population, including a mean age of 46.70 years and a predominance of females (60%), are consistent with other studies that have identified middle-aged, predominantly female populations as common candidates for HTO[14]. The occupations of the study participants, primarily farmers and homemakers, reflect the physical demands placed on the knees, which may contribute to the development of osteoarthritis. These demographics highlight the importance of effective surgical interventions like HTO for active individuals who are not yet suitable candidates for total knee arthroplasty.

Functional Score (FS) Improvement

The increase in the mean FS from 62.67 preoperatively to 86.50 postoperatively indicates a substantial improvement in knee function following HTO. The statistically significant $p<0.001$ confirms the effectiveness of the procedure in enhancing functional outcomes. These results are comparable to those reported by Lee *et al.,* who found similar improvements in FS following HTO, emphasizing the procedure's role in restoring knee function and alleviating pain[15].

Knee Society Score (KSS) Improvement: The mean KSS value increased from 54.07 preoperatively to 86.93 postoperatively, with a $p<0.001$, indicating a significant enhancement in knee functionality and patient well-being. This finding is consistent with the results of a study by Bode *et al.*, which demonstrated significant postoperative improvements in KSS among patients undergoing HTO, further validating the procedure's effectiveness[5]. Additionally, the distribution of KSS values in this study, with 90% of subjects achieving scores between 80 and 100 postoperatively, aligns with the outcomes reported by Staubli *et al.,* who observed similar improvements in knee function following HTO[16].

Range of Motion (ROM) Improvement: The significant increase in mean ROM from 80.53 degrees preoperatively to 104.27 degrees postoperatively ($p<0.001$) demonstrates enhanced joint flexibility and function following HTO. These results are in agreement with the findings of Billings *et al.,* who reported comparable improvements in ROM among patients undergoing HTO, highlighting the procedure's ability to restore joint mobility[17,18].

Several recent studies have corroborated the improvements in knee function following HTO observed in this study. For example, Vaishya et al. reported significant improvements in knee function and pain relief in patients undergoing medial opening wedge HTO, with mean postoperative KSS values showing a marked increase similar to our findings[19]. Additionally, the study highlighted the importance of careful patient selection and surgical technique in achieving optimal outcomes.

A systematic review by Jang *et al.* further supports the effectiveness of HTO. Their analysis of multiple studies demonstrated consistent improvements in KSS and ROM following the procedure, with significant pain relief and enhanced knee function across various patient populations[20]. The review emphasized the durability of these improvements, with many patients maintaining better function and reduced pain for

several years post-surgery.

The increase in the mean FS from 62.67 preoperatively to 86.50 postoperatively indicates a substantial improvement in knee function following HTO. The statistically significant p<0.001 confirms the effectiveness of the procedure in enhancing functional outcomes. These results are comparable to those reported by Moon *et al.*, who found similar improvements in FS following HTO, emphasizing the procedure's role in restoring knee function and alleviating pain[21].

The mean KSS value increased from 54.07 preoperatively to 86.93 postoperatively, with a p<0.001, indicating a significant enhancement in knee functionality and patient well-being. This finding is consistent with the results of a study by Song et al., which demonstrated significant postoperative improvements in KSS among patients undergoing HTO, further validating the procedure's effectiveness[22]. Additionally, the distribution of KSS values in this study, with 90% of subjects achieving scores between 80 and 100 postoperatively, aligns with the outcomes reported by Kwak *et al.,* who observed similar improvements in knee function following HTO[23].

Clinical Implications: The findings of this study support the use of HTO as a valuable surgical option for managing medial compartment osteoarthritis, particularly in younger, active patients who are not yet candidates for total knee arthroplasty. The significant improvements in FS, KSSROM observed in this study suggest that HTO can effectively reduce pain, enhance knee function improve overall quality of life for patients with unicompartmental osteoarthritis.

CONCLUSION

The study demonstrates that High Tibial Osteotomy (HTO) with proximal medial tibia locking plating and autologous bone grafting significantly improves knee function and reduces pain in patients with unicompartmental osteoarthritis. Postoperative Functional Score (FS) and Knee Society Score (KSS) values showed substantial enhancement, indicating better knee function and reduced pain levels. These findings align with previous research, reaffirming HTO's effectiveness in treating medial compartment osteoarthritis and validating it as a viable surgical option for younger, active patients not suited for total knee arthroplasty.

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