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ABOUT COVER

Editorial Board member of *World Journal of Orthopedics*, Dr. Alessandro Ramieri, MD, PhD, graduated in Medicine and Surgery and completed post-graduate study in Orthopedics and Traumatology at the Sapienza Rome University (Rome, Italy). He also received his PhD in Pathophysiology and Muscle-Skeletal Disorders from Sapienza Rome University. Afterwards, he earned a 2-year fellowship at the Spinal Surgery Department of S. Pertini Hospital in Rome. He is currently a researcher at Rome University "La Sapienza", with a teaching position as Professor. He has devoted much of his professional activities to the study and management of spinal diseases, applying conservative and surgical treatments. He is a Silver Member of the AO Spine and the AO Subaxial Fractures and Sacral Fractures International Validation Groups. Since 2011 and 2014, he has held, respectively, the European Spine Course Diploma and the TFR Course Diploma of the EUROSPINE Foundation. (L-Editor: Filipodia)

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Retrospective Study

Impact of medial open-wedge high tibial osteotomy for medial compartment osteoarthritis of the knee

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Abstract

BACKGROUND

Most populations worldwide, who are used to squatting and sitting cross-legged for their activities of daily living, largely comprise the lower socioeconomic strata, thus making them candidates for exclusion for total knee arthroplasty. Proximal/high tibial osteotomy (HTO) is a preferred strategy for clinically symptomatic osteoarthritis (OA) with genu varum due to painful medial compartment OA which is not amenable to conservative measures.

AIM

To evaluate the outcomes of medial open-wedge HTO along with autologous bone grafting and buttress plate for the treatment of genu varum due to OA of the knee in a rural population of central India.

METHODS

A total of 65 knees in 56 patients with a mean age of 58.22 ± 5.63 years with genu varum due to intractable painful knee OA were treated with medial open-wedge HTO along with autologous bone grafting and buttress plate osteosynthesis from June 2015 to May 2018. The mean preoperative radiological angle of genu varum was 13.4° . Clinical outcomes were assessed by the range of movement, knee scores, pain scores, and functional scores. Radiographic studies were performed preoperatively and at regular intervals during the follow-up period.

RESULTS

All patients reported pain relief immediately after the osteotomy and during the long-term analysis covering between one to three years. The genu varum angle was overcorrected to approximately four degrees in all patients. There was a loss

performed in this study were in accordance with the ethical standards of the committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards and were approved by the Datta Meghe Institute of Medical Sciences, Wardha, India (dated 30 May 2015).

Informed consent statement: All study participants, or their legal guardian, provided informed written consent prior to study enrollment.

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Data sharing statement: The data used to support the findings of this study are available on reasonable request from the corresponding author. The data are not publicly available due to information that might compromise the privacy of the research participants (patients).

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of reduction by approximately three degrees in all patients at around six weeks postoperatively. Preoperative knee movements were restored in all patients. No major perioperative complications were noted during surgery and postoperative follow-up and the clinical scores were significantly improved during the final analysis which revealed good pain relief.

CONCLUSION

Medial open-wedge HTO is a reliable, safe, practical, physiological, and feasible treatment for populations who are used to increased activity in their occupation and lifestyle and is associated with excellent short-term and long-term results for OA in genu varum knees.

Key Words: High tibial osteotomy; Total knee arthroplasty; Genu varum; Osteoarthritis; Osteosynthesis; Knee Society Score

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Core Tip: In recent times, unicompartment knee arthroplasty has been the procedure of choice for isolated medial compartment osteoarthritis in the developed world; however, this option is unsuitable for populations used to squatting and sitting cross-legged, and having greater physical demands on the knees. For these subsets of individuals, a physiological and biological procedure to correct the deformity and relieve pain in the long-term has been made possible by medial open-wedge high tibial osteotomy which does not compromise future knee surgery such as total knee arthroplasty if the situation demands.

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INTRODUCTION

Osteoarthritis (OA) is a chronic, progressive joint disease with high disability and teratogenicity in the joints. Deterioration of the articular cartilage is the main problem associated with OA, which decreases joint space between the two bones^[1]. The level of human cartilage glycoprotein chitinase 3-like-1 is known as a potential marker for the activation of chondrocytes and the progression of OA, whereas lubricin appears to be chondroprotective. These two glycoproteins are functionally associated with the development of OA and in particular with grade 2/3 of OA, suggesting that in the future they could be helpful in staging the severity and progression of the disease^[1].

OA of the knee joint is a frequent hindrance in communities resulting in disabling and painful knees with functional physical restriction, work loss along with hardships relating to the activities of daily living^[2]. While moderate physical activity acts as a biological key for OA prevention, based on its effects as a natural anti-inflammatory remedy that also enhances joint lubrication, this disease is largely distributed in the community and is probably one of the top ten conditions causing significant dysfunction and incapacitation throughout the globe^[3]. Knee OA initially results in medial compartment overload and disease progression in the knee, leading ultimately to a progressive genu varum deformity if left untreated^[4-6]. Undercorrection and overcorrection of the deformity during surgery and post-surgical period results in improper clinical outcomes, and hence appropriate correction of mechanical and anatomical limb alignment is necessary until comprehensive healing is achieved and maintained^[7].

OA is a degenerative disease of the articular cartilage, and it represents one of the most common causes of disability in the world linked to hypomobility^[8]. OA can be viewed as the clinical and pathological outcome of a range of disorders that result in structural and functional failure of synovial joints with loss and erosion of articular

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cartilage, subchondral bone alteration, meniscal degeneration, a synovial inflammatory response, and bone and cartilage overgrowth. Castorina *et al*^[9] used different functional tests such as the Barthel, MRC and VAS, and revealed that the function and movement of OA patients were normalized due to gradual and progressive improvement during 2 mo after surgery. The benefits of moderate physical activity in OA patients may have protective roles on joints as a non-surgical and non-pharmacological treatment, re-establishing the physiological function of synoviocytes, preventing the onset of OA, and/or postponing the need for joint replacement^[10].

High tibial osteotomy (HTO) is often referred to as proximal tibial osteotomy and is a frequently practiced surgical procedure for painful knees with varus malalignment due to OA and overload in the medial compartment. Initially, HTO was introduced by Jackson *et al*^[11] in 1961, and thereafter Sir Robert Jones mentioned the use of tibial osteotomies to correct genu varum due to rickets as documented by Wardle^[12] in 1962. However, Coventry^[13] popularized the technique in 1985. The primary objective of HTO is pain relief in OA in order to delay or avoid the need for knee replacement by unloading the medial joint compartment and realigning the mechanical axis of the lower limb thus slowing the degeneration. Moreover, HTO minimizes knee pain by shifting the loads during weight-bearing to the relatively unaffected lateral compartment after correction in varus knees. There are different HTO techniques such as open-medial wedge osteotomy, closed lateral wedge osteotomy, progressive callus distraction and dome osteotomy^[14]. In the present study, the painful medial compartment of knee OA was managed by a medial open-wedge HTO due to the several advantages of this technique over other methods.

Medial open-wedge osteotomy is a comparatively simple process involving only a couple of dissections and a single osteotomy where the lateral tibial cortex is kept intact. The procedure does not require either a fibular osteotomy which has been associated with bone resection of the lateral tibia and/or neurovascular complications. Consequently, after the procedure, the normal anatomical tibial bone shape is maintained which allows later reorganization during total knee arthroplasty (TKA) if the need arises^[13]. Varus malaligned knees can be treated by medial opening wedge high tibial osteotomy (MOWHTO). Nowadays, the use of MOWHTO has accelerated as it is superior to closed wedge techniques as it includes rectification of the deformity proximate to the origin. Moreover, it avoids injuries to the common peroneal nerve, proximal tibiofibular joint, is simpler to execute and provides additional expected adjustments alongside maintaining the original bone stock. However, many complications have been reported such as infection, non-union, osteotomy piercing or hardware device drifting within the tibiofemoral joint, iatrogenic proximal tibial plateau fracture, along with misplacement and miscalculated angle of correction^[13,14]. In the present study we evaluated the outcomes of medial open-wedge HTO along with autologous bone grafting and buttress plate for the treatment of genu varum due to OA of the knee in a rural population of central India.

MATERIALS AND METHODS

Patients

The present research was conducted, after validation by the ethical committee, in 65 knees of 56 patients with medial compartment OA and genu varum treated from June 2015 to May 2018 in the Department of Orthopedics at Jawaharlal Nehru Medical College and Hospital Wardha, Maharashtra, India. Ethical approval was obtained from the Departmental Ethical Committee of the hospital. The mean preoperative radiological angle of genu varum was 13.4° (range: 11°-15°). All adult patients with genu varum and painful OA were treated with an open-wedge osteotomy with the apex directed laterally. The criteria for preclusion were involvement of the lateral and the patellofemoral, severe osteoporosis (low bone mass density) and the presence of severe OA (Kellgren–Lawrence radiographic grading scale of 4), a genu varum of more than 15°, movement restriction in the knee less than 90° along with fixed flexion deformity of more than 10°.

Operative procedure

The study comprised 65 osteotomies in 56 patients by employing contoured T-buttress plates (4.5 mm screws) with autogenous tricortical iliac crest addition within the gap created by the opening of the osteotomy. Preoperative strategy and postoperative assessment were based on a standing hip to ankle radiographic examination (Figure 1).



Figure 1 Preoperative radiographs with mechanical axis demonstrating a medial compartment osteoarthritis and genu varum (measured as 13.8°) as compared to postoperative radiographs (anteroposterior and lateral) showing an overcorrection along with the immediate opening of the medial compartment.

The weight-bearing line was programmed and considered to cross the Fujisawa point 30%-40% lateral to the tibial plateau midpoint^[15]. Each patient was positioned on a radiolucent bench with a thigh tourniquet in the supine position. The surgical technique involved an incision obliquely placed from the medial aspect of the knee leveled at the joint line to the tuberosity of the tibia followed by subperiosteal release of the superficial portion of the medial collateral ligament and the location of which was doubly confirmed by fluoroscopic examination. At the upper border of the pes anserine an oblique Kirschner wire was inserted from the medial aspect and directed laterally towards the fibular head landmark. The knee was in a 15° flexed position and the osteotomies were performed using a thin osteotome and electric oscillating saw beneath the wire. The osteotomy to the lateral cortex ended within 5 mm medial to the lateral cortex, thus keeping it intact. The gaps were created medially by a valgus-directed force and maintained with a spreader. The intraoperative mechanical axis was controlled by keeping the knee in an extended position using the cable technique^[16]. The bone graft was harvested from the ipsilateral iliac crest and fashioned into an appropriate shape and size and was kept and impacted at the opened osteotomy site along with additional slivers of bone within the osteotomy site followed by osteosynthesis using a T-buttress plate as demonstrated in [Figure 1](#).

Pre-operative and post-operative assessment of medial compartment OA was performed by measuring range of movement (ROM), knee scores, pain scores, and functional scores. Each patient was followed-up postoperatively at four and eight weeks, three and four months and thereafter at six months, one year, two years, and three years. The data were assessed and analyzed using SPSS version 13.0.

RESULTS

A total of 65 knees in 56 OA patients with a mean age of 58.22 ± 5.63 years were enrolled for MOWHTO. Among these patients, almost 55% of women over the age of 60 years had symptoms not relieved by adequate conservative measures. Almost all the patients were right dominant; thus, of 65 knees, 76.93% were right and 23.07% were left, and it was noted that knee OA was more common in the dominant side of young active individuals where there was no limb length discrepancy postoperatively. The mean weight and body mass index of the patients was 65.25 ± 4.36 kg and 24.06 ± 4.69 , respectively. The preoperative mean knee pain score was 17 ± 6.57 and was 43 ± 5.23 in the postoperative period.

None of the patients had preoperative anteroposterior instability. Only one patient had 6 mm of medio-lateral instability. There was no change in stability in any patients

after surgery. In all patients, Knee Society Scores (KSS) improved significantly. The preoperative mean knee score was 42.96 ± 8.39 , whereas the postoperative knee score was 89.15 ± 8.26 . The mean preoperative functional knee score was 47.52 ± 8.15 , which improved in all patients postoperatively (78.56 ± 6.65). Table 1 shows the different scoring scales in these patients.

There were no non-unions at the osteotomy site and in 95.38% knees (62 knees) the osteotomy united within a 12-wk period. The final outcome of the study according to the KSS^[17,18] is depicted in Table 2.

The genu varum angle was overcorrected intraoperatively by approximately four degrees in all patients as every patient lost some degrees of correction. We noted a loss of reduction of approximately three degrees in all patients around six weeks postoperatively. Preoperative knee movements were restored in all patients. Complications such as vascular injuries, deep-seated infections, or events related to evident deep vein thrombosis of the calf were reported in four (7.14%) of 56 patients. Additionally, no untoward complications were reported at the iliac bone graft harvest site, such as major hematoma, iatrogenic fracture, or nerve palsies, but the harvest site continued to be a common source of pain for patients during the initial three months in the postoperative phase. None of the patients required a fixation revision or subsequent TKA of the knee or had an increase in patellofemoral joint pain. None of the patients were immobilized in a splint or cast and the knee ROM was started as soon as the comfort of the patient permitted after surgery.

DISCUSSION

The speculative benefits of the medial opening wedge osteotomy over the closing wedge osteotomy are numerous, and include (1) the capacity to attain consistent correction in the coronal and sagittal planes; (2) anatomical reconditioning with or without adding bone grafts to the osteotomy site; (3) proximal tibiofibular joint maintenance; (4) avoidance of lateral compartment penetration; (5) the ability to intraoperatively modify the need for amendment; (6) a single plane oblique bone cut; and (7) the advantage of simultaneous reconstruction of the anterior cruciate ligament if necessary. The drawbacks of this technique are few and involve the formation of a gap or defect which needs to be filled with bone grafts or substitutes to prevent early and late collapse, morbidity at donor graft sites, a potentially elevated risk of delayed- or non-union due to a relatively avascular area of the medial surface, and probably a longer duration of postoperative weight-bearing restriction^[19]. To support the above evidence, several studies have been performed which reported that opening wedge HTO is considered a safe procedure and convenient to both patient and surgeon, whereas the expectation that closing wedge HTO may be significantly associated with a greater incidence of complications, particularly peroneal nerve paralysis^[20,21].

HTO and unicompartmental knee arthroplasty (UKA) probably have indications that include the fifth or sixth decades of life without any joint instability, moderately active individuals who present with mild varus malalignment and moderate unicompartmental arthrosis, non-obese, and a fair range of knee flexion^[22]. HTO remains the most popular operation nowadays, and is primarily performed in young patients with osseous tibial varus deformity combined with a symptomatic medial knee compartment which is a bone and joint preserving technique and a more physiological procedure^[23]. Other possible alternatives such as TKA or UKA do not rescue the joint, and have the drawbacks of sacrificing part or whole of the knee joint^[24]. While the revision of UKA to TKA is a challenging and demanding procedure, the opening wedge HTO conversion to TKA is simpler and easy, overall it seems that these less bone-preserving strategies have different indications than HTO, specifically requiring a higher degree of OA, older age and lower activity level^[25,26].

Hormonal dissimilarities between males and females may play a significant role in the development of OA. In particular, postmenopausal women have a greater risk of developing arthritis, and this has been associated with a reduction in estrogen during this period^[27]. Insall *et al.*^[17] reported OA is a major cause of mobility impairment, particularly among females. A similar observation was found in the present study where 55% of women had OA.

A frequent issue with HTO is the difficulty in achieving an effective correctional degree. The optimal angular correction is uncertain, for the best long-term outcome. Less than acceptable results were reported where the deformity had been undercorrected probably because the preoperative radiographs were standing and the intraoperative correction is in the supine position. Even when a specific correction

Table 1 Different scoring among the patients during the follow-up period

Parameter	ROM (mean \pm SD)	Knee scores (mean \pm SD)	Pain scores (mean \pm SD)	Functional scores (mean \pm SD)
6 wk	115.65 \pm 6.45	82.25 \pm 8.63	27.9 \pm 4.98	52.52 \pm 16.82
3 mo	119.63 \pm 5.13	85.52 \pm 8.98	36.23 \pm 4.53	64.23 \pm 8.53
6 mo	121.9 \pm 6.26	89.15 \pm 8.26	42.65 \pm 5.75	78.56 \pm 6.65
P value	< 0.05	< 0.05	< 0.05	< 0.05

ROM: Range of movement; SD: Standard deviation.

Table 2 Final outcome according to the Knee Society Score

Final results	KSS score	No. of knees (n = 65)	Percentage
Excellent	80-100	57	87.69%
Good	70-79	5	7.69%
Fair	60-69	3	4.61%
Poor	< 60	0	0%

KSS: Knee Society Score (Insall *et al*^[17] and Asif *et al*^[18]).

angle has been pre-operatively planned, it has been reported that 20% of HTOs do not achieve optimum correction due to the above-stated reason. This could be due to difficulty in standardizing the radiographs, and some of the perceived deformity may be caused by rotational malalignment of the tibia. It has even been shown that there is no significant relationship between pain and knee alignment and so static deformity correction alone may not be reliable^[28]. In the present study, an attempt was made to treat painful OA of the knee with medial open-wedge HTO along with autologous bone grafting and buttress plate osteosynthesis, and this technique resulted in a stronger fixation along with increased stability in OA patients until the healing of osteotomy had been achieved.

Trieb *et al*^[29] claimed that elderly people (> 65 years old) had a greater incidence of HTO failure when they used the lateral closing wedge osteotomy. Osteotomy failure was not observed in the current study despite the age differences. After MOWHTO, antecedent research has demonstrated that the proportion of complications varies widely and ranges between 1.9% and 55%^[30,31]. When hardware-related issues were seen, the Puddu plates were accompanied by a high complication rate (37.7%-55%), while the use of non-locking T-plates and locking compression plates were associated with fairly good results and an acceptable surgical complication rate (1.9%-8.6%)^[32-35]. In comparison, a lower complication rate (6.15%) with the use of T-buttress plates was observed in the current study.

Although radiological assessments of the union stage are correct even in tibial shaft fractures in only about 50%, to increase the reliability of these examinations, we used separate assessments to evaluate both the clinical and radiographic unions. Unlike a previous study by Meidinger *et al*^[36], we found that within two to three months most of the osteotomies were united in our study. Also, the long-term follow-up revealed that the MOWHTO was successfully performed with excellent outcomes in terms of knee pain, muscle strength, gait, and activities in daily living.

CONCLUSION

It was revealed that better coordination and collaboration between the orthopedic surgeons, physiatrists, physical therapists and patients would possibly achieve faster recovery in patients who underwent TKA. These collaborations would normalize the function and movement of OA patients with reduced hospital stay and improved ROM, pain score, knee score and functional score. We continue to study this method to the surgery and the rehabilitation program. In this way we can achieve better results and have more data that will help the recovery, pain and ROM of patients.

Medial open wedge HTO is a reliable, safe and feasible treatment for people who tend to squat and sit cross-legged due to their lifestyle and is associated with excellent outcomes in the short-term and long-term follow-up for OA in genu varum knees. It was also revealed that MOWHTO results in good union along with few complications compared with the conventional approach and preserves the bone stock for subsequent conversion to a TKA if necessary. We believe that with proper indications and due considerations, a bone and joint preservation technique would be more beneficial compared to other techniques, especially UKA.

ARTICLE HIGHLIGHTS

Research background

Osteoarthritis (OA) of the knee joint continues to affect humans throughout the world and the general consensus is to treat it either non-operatively or by total knee arthroplasty (TKA) which has acceptable results but causes bone loss and the procedure cannot be undone. This review focused on the points which preserve the bone, cause pain relief due to mechanical alignment of the lower limb, and can provide good long-term outcomes in most populations.

Research motivation

Keeping the research background in mind an anatomical, physiological and biological management was sought to preserve the natural bone of the patient and at the same time reduce functional disability.

Research objectives

High tibial osteotomy (HTO) is common in orthopedic surgery and various techniques have been described, each claiming advantages over the other. However, we aim for precise patient selection, indications, procedures, and acceptable results along with a brief summary of already described surgical techniques, methods of fixation, and complications. This article focuses on the points that should be considered to achieve good long-term outcomes.

Research methods

Prospective clinical study: Level of evidence - Level II.

Research results

Very little data exists on the use of different pharmacological and non-pharmacological treatments for OA. These highly relevant research results are encouraging in terms of good outcomes, less morbidity, less economically disturbing for paying populations and good long-term results as there is a high incidence of comorbidities in this population. OA may be one of many health problems affecting function, and this may influence the appropriateness of management options.

Research conclusions

The goals of treatment for knee OA must include lasting relief of pain and inflammation, and improvement in or maintenance of mobility, function (including activities of daily living and improved health-related quality of life). The efficacy of TKA for improving pain and function has been demonstrated; however, not all patients are candidates for this surgery and it is not suited to the lifestyle of populations who squat and sit cross-legged. Additionally, the HTO provides an effective treatment approach that can relieve pain and improve function to delay or avoid TKA surgery.

Research perspectives

Future directions in knee OA point to more joint preservation techniques and protocols as compared to bone sacrificing extensive surgeries.

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