ORIGINAL RESEARCH

High Tibial Osteotomy by Hemicallostasis using a Dynamic Axial Fixator: A Study on Clinical Outcome of 52 Knees

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ABSTRACT

Background: Osteoarthritis is the major cause of osteoarticular disability in elderly population. Knee is the most commonly affected joint and replacement surgeries are main modality of treatment in advance cases. Whereas in unicompartmental disease especially in relatively younger age group joint preserving surgeries are preferred. The aim of present study was to evaluate functional outcome of graduated open wedge high tibial osteotomy in patients with osteoarthritis of knee with less than 65 years of age.**Methods:**High Tibial Osteotomy through medial open wedge technique was done in 48 patients (52 knees) and stabilized by Limb Reconstruction System. Distraction was started at 7th day at the rate of 1 mm/day and continued till proper alignment was achieved. The clinical outcome of patients has been calculated on the basis of anatomical correction and functional improvement. Anatomical correction was determined on the basis of a radiological criterion (HKA angle) on scanogram. Whereas, the functional outcomes of the patients were measured on Oxford knee score (OKS) and WOMAC score scales.**Result:** The valgus correction in varus knees of patients were achieved by gain in mean HKA angle (increase by 11 ± 0.90). The desired range of correction in HKA angle was seen at the final follow up of 41 out of 52 knees (78.8%). There was under correction in 4 knees (7.7%) and overcorrection in 7 (13.4%) knees. All the functional scores showed significant improvement in the postoperative scores. There was a positive correlation between the HKA angle with OKS and WOMAC Score. Most common complication was superficial pin tract infection, which was seen in 7 (13.4%) patients.**Conclusion:**High Tibial Osteotomy by unilateral external fixator produces good clinical outcome and also has its added benefits. It is less invasive, no internal hardware present and safer in terms of neurovascular complications.

Key words: High Tibial Osteotomy, Osteoarthritis of knee, Hemicallostasis, Open wedge osteotomy

INTRODUCTION

Osteoarthritis (OA) is considered as the age related degenerative disorder of joint. This condition leads to destruction of articular cartilage and erosion of the joint margins. Knee is the most commonly involved joint affecting 80% of population after 55 years of age.[1] Knee is divided into three compartments (medial, lateral and patellofemoral) and there is a possibility of either isolated or combined involvement of these compartments in osteoarthritis. Medial compartment is most commonly affected segment of knee in OA as it transmits maximum forces (60%) during stance phase of the gait cycle.[2] The mechanical axis of limb gets shifted to medial side in medial compartment OA and patient develops varus deformity of limb. As the disease progress surgical treatment options include High Tibial Osteotomy (HTO), Unicompartment knee arthroplasty (UKA) and Total knee arthroplasty (TKA). High tibial osteotomy produces satisfactory results in early stage of this disease. It corrects the malalignment and redistributes the stresses on knee joint by unloading of involved compartment. The techniques of a high tibial Osteotomy include medial opening wedge, lateral

closing wedge, dome osteotomy and Hemicallostasis osteotomy using an external fixator. The surgical technique of HTO by lateral close wedge osteotomy is associated with complications such as peroneal nerve palsy, need for fibular osteotomy, extensive muscle detachment and limb shortening, which can be dealt by use of medial opening wedge osteotomy.[3] Since its introduction the technique of medial opening wedge osteotomy has evolved with time. There is a shift from conventional plates to less invasive plate osteosynthesis and fixator assisted osteotomy in past decades. Conventional open medial wedge HTO provides good correction with angle stable plates. But it is associated with complications like implant breakage, delayed union or nonunion, delayed would healing, and deep infection. Most of the complications in conventional plate technique HTO are due to extensive soft tissue exposure to protect posterior neurovascular structures or to apply the plate while maintaining a distractor in place during the surgery. Use of less invasive plate osteosynthesis or external fixator has been seen to diminish soft tissue complications, implant related complications and promote biologic bone healing. However there is risk of soft tissue complications with less invasive plate osteosynthesis as compared to fixator technique.[4,5] Both the less invasive plate and external fixator assisted open medial wedge HTO has seen to produce similar functional results.[6] This study aims to evaluate the anatomical and functional results of HTO using a less invasive procedure like unilateral Dynamic axial external fixator.

MATERIALS AND METHODS

This is a prospective study in which we included 48 patients (52 knees) with medial compartment osteoarthritis. Left knee was operated in 28 cases and right knee was operated in 24 cases. All the patients were operated by a team of 3 surgeons (Dr A. Sarkar, Dr S. Kumar & Dr M. Chandra) at two different tertiary level Hospitals of Kolkata, India. These surgeries were done during the time period of March 2016 to June 2018.

All the patients included in our study were younger than 65 years with isolated involvement of medial compartment osteoarthritis. The indications of HTO in our patients were activity related pain over medial side of knee and Varus deformity (not more than 250). We excluded those patients with any of associated finding in knee- flexion arc of less than 1000, flexion deformity more than 150, lateral tibial subluxation of more than 1cm and ligamentous injury around knee. Patients with bi-compartmental, tri-compartmental osteoarthritis and inflammatory arthritis were not eligible for this study.

Written Informed consent of all the patients was taken. A detailed examination was done, Ligament laxity was checked by varus and valgus stress test which identifies the static or dynamic varus deformity. Patients were evaluated with AP view standing and lateral radiograph of both knees. Bilateral lower limb scanogram and varus, valgus stress view was also done. MRI was done preoperatively for assessment of patella, meniscus, ligamentous lesion, and cartilage damage of both medial and lateral compartment of the knee. The Preoperative and postoperative function of all patients was assessed using WOMAC (Western Ontario and McMaster Universities Osteoarthritis Index) and Oxford knee score (OKS).

Preoperative Planning

We have evaluated our patients with scanogram of bilateral lower limb. In this standing AP view of lower limb from hip to ankle was taken with the patella facing forward. The pre-operative planning was done by Miniaci method.[7] The measurements were done over the radiograph. The mechanical axis of femur and tibia were drawn first. The Hip- Knee-Ankle (HKA) angle was calculated by the mechanical axis of the femur and tibia on the medial aspect of knee. A line perpendicular to mechanical axes and a line tangential to articular surfaces were drawn to measure Mechanical lateral distal femoral angle (mLDFA), Medial proximal tibial angle (mMPTA) and Joint line convergence angle (JLCA). To get a valgus correction of deformity, the weight bearing axis from the centre of femoral head to the centre of tibial plafond was planned to pass through Fujisawa point in the knee. This is located at 62.5 % in the lateral compartment of proximal tibia. The hinge of osteotomy is taken at lateral cortex of tibia at the level of proximal tibiofemoral joint and the correction angle of valgus osteotomy was calculated (Figure no.1).

Surgical Procedure

All our patients were operated under spinal or general anesthesia with a tourniquet control. The surgical draping was done in a manner to assess the limb alignment intraoperatively. We choose osteotomy site just distal to the tibial tuberosity and osteotomy was completed after placement of pins. Firstly, a Limb Reconstruction System (LRS) of adequate length was positioned over the leg to check the position of the pin clamps, osteotomy site and hinge. To avoid joint penetration, proximal pins were placed at least 15-20 mm below the articular margin. The first pin was placed in the anterior half of tibial plateau and the second was placed as posterior as possible to get a good purchase. A LRS assembly was then connected with these proximal pins. Then two distal pins were inserted by the help of distal clamp in the system. Additional pins were applied according to specific patient's need. The LRS assembly was then detached before proceeding with osteotomy. A longitudinal incision of 3-5 cm length was given just medial to the tibial tuberosity and pes anserinus was reflected to expose the bone. An oblique osteotomy was done passing just distal to tibial tuberosity and directed towards proximal tibiofibular joint. The LRS assembly was reattached and fixed. We also checked the opening of osteotomy by distraction method. This

was done to confirm the desired amount of alignment. The osteotomy was closed at the end and LRS was locked leaving no gap at osteotomy site (Figure no.2). The periosteum was sutured to cover the osteotomy site and skin closed in layers.

Post-op Management

All the patients were given 2-3 doses of intravenous antibiotics followed by oral antibiotics for one week. Patients were advised static quadriceps, ankle, and toe movements from the immediate next day of surgery along with assisted knee range of motion started. The Patient was allowed to touch down weight-bearing initially and then stopped when distraction was started. Distraction was taught to the patient and started after 7 postoperative days and continued at a rate of 0.25 mm to be done four times a day (1mm per day) until the desired alignment was achieved. Patient kept partial weight bearing during distraction period and encouraged to do range of motion exercises. Daily pin tract dressing was taught to patients with normal saline. First, follow-up was done at two weeks for suture removal and an x-ray was done to check the adequate opening of the osteotomy, second follow-up was at four weeks and the third follow-up was after eight week to measure HKA angle and other radiological parameters. After completion of 12 weeks, the regenerate was fully consolidated. Distraction was stopped after desired correction and length is achieved. The fixator was left in situ for further period of double the time of distraction period to let bone consolidate. The removal of the fixator was done as an outpatient procedure without anesthesia. Further follow up was at three monthly intervals for next 3 year.

RESULTS

The mean follow up of patients included in our study was 28 months. A total 52 knees were operated in 48 patients as four patients were operated for bilateral disease. There were 26 females and 24 males with a mean age of 47 ± 3.4 years of our patients.

The mean HKA angle preoperatively was 172 ± 0.30. Our goal was to achieve HKA of 183-1860 measured on the medial side of knee. The mean HKA angle postoperatively was 184 ±0.2 and the mean change in HKA was 11 ± 0.90 (Figure no.3). Our goals were achieved in 41 of 52 patients (78.8%). There were under correction in 4 patients (7.7%) and overcorrection in 7 (13.7%) patients.

The mean preoperative mLDFA was 88 ± 0.250. The mean postoperative mLDFA was 86 ± 0.270. There was no significant change in mLDFA postoperatively because LDFA represents distal femur deformity as none of the patients in present study had a deformity in the distal femur. Mean mechanical MPTA preoperatively was 83 ± 0.250 and postoperatively was 94 ± 0.220. The mean preoperative JLCA was 3.4 ± 0.120 and Postoperative JLCA was 2.8 ± 0.080.

The mean value of preoperative Oxford Knee Score was 44.5 ± 0.28 and WOMAC Score was 79.5 ± 0.3. The mean value of postoperative Oxford Knee Score was 17.1 ± 0.24 and WOMAC Score was 45.1 ± 0.3, which showed significant improvement in respective scores. In the current study the HKA angle and the functional scores (OKS & WOMAC score) confirmed a positive correlation between the alignments achieved and reported functional outcome. In the current study mean preoperative flexion was 118.40 and postoperative was 129.30 (Table 1). The most frequent complication in our study was pin tract infection. Seven (13.4%) patients develop superficial pin site infection which was managed with debridement, pin tract care and IV antibiotics.

Table 1: Summary Statistics of Data

Patient Particulars	Pre-op mean value	Post-op mean value (2yr follow up)
HKA angle	172 ± 0.3^0	184 ± 0.2^0
mLDFA	88 ± 0.25^0	86 ± 0.27^0
mMPTA	83 ± 0.25^0	94 ± 0.22^0
JCA	3.4 ± 0.12^0	2.8 ± 0.08^0
Oxford knee score	44.5 ± 0.28	17.1 ± 0.24
WOMAC score	79.5 ± 0.3	45.1 ± 0.3
Knee- range of motion	118.4^0	129.3^0

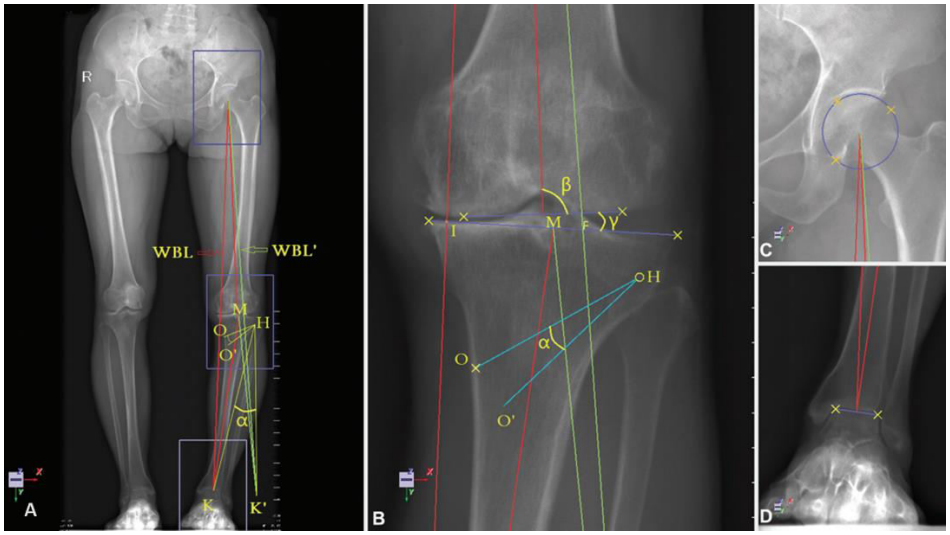

Figure No.1- Miniaci method for the preoperative planning of HTO- (A) Standing WLR of the lower limb showing H, the hinge point; O, the desired medial osteotomy site; M, the center of the tibial plateau; K, the preoperative center of the ankle joint; K', the post-planning center of the ankle joint; angle α, the Miniaci angle; WBL, the preoperative weight-bearing line; WBL', the post-planning weight-bearing line. (B) Standing WLR of the left knee showing I, the intersection point between the WBL and the tibial plateau; angle β, mLDFA; angle γ, JLCA. (C) The center of the femoral head. (D) The center of the ankle joint. HTO, high tibial osteotomy; JLCA, joint line convergence angle; mLDFA, mechanical lateral distal femoral angle.

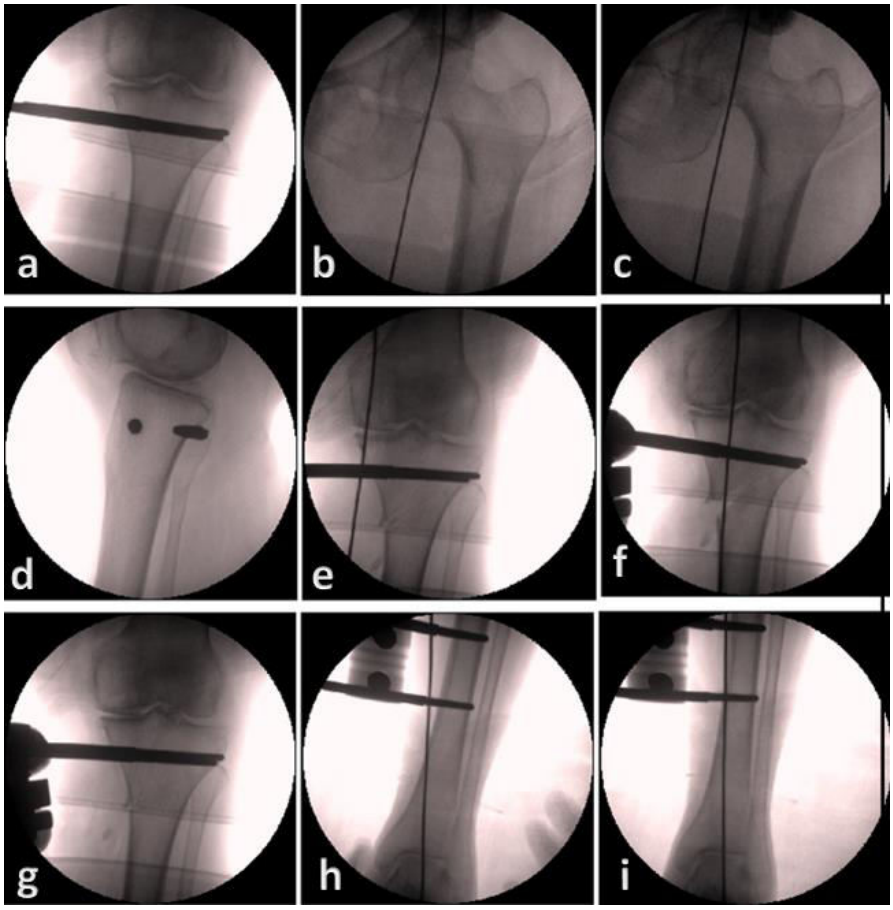

Figure no.2- Intra-operative images: a) the first pin is introduced about 2 cm below the joint line and as posterior as possible, b-c) mechanical axis is drawn from center of hip joint to ankle, c) Lateral view of pins in the proximal tibia, e) An oblique osteotomy of the medial two-thirds of the tibia, passing just distal to the tibial tuberosity and directed towards the proximal tibiofibular joint, f) osteotomy is opened to check for correction in mechanical axis, g) osteotomy is then closed under fluoroscopy guidance, h-i) Distal pins are placed and the fixator is locked in perfect alignment.

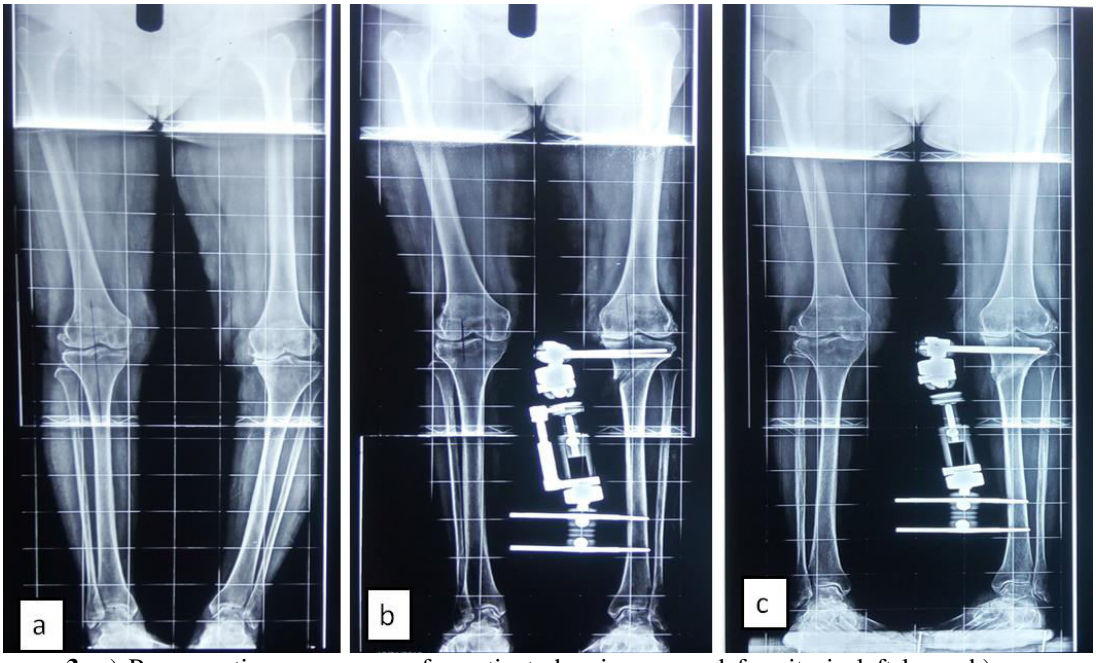

Figure no.3- a) Pre operative scanogram of a patient showing varus deformity in left knee, b) scanogram of same patient with oblique osteotomy during distraction phase with fixator in situ c) scanogram at 3 months follow up with healed osteotomy and corrected mechanical axis.

DISCUSSION

Although the various types of osteotomy were described for the treatment of osteoarthritis in the initial decades of 20th century, but the concept of High tibial osteotomy was 1st introduced by Jackson in 1958. Since then many other methodologies have been described by Conventry, Judet and other surgeons to correct the knee alignment with this HTO. The biomechanics of healing after HTO was described as a process of unloading of involved compartment by correcting the malalignment.[6] Achieving this desired alignment with precision is the key for the success in HTO. The accuracy of alignment in case of HTO has largely been measured by radiographic alignment of the mechanical axis of the limb. The recommendation to achieve best outcomes by this osteotomy is to get HKA angle of 183-1860 in the operated knee. Any over correction or under correction has been seen to produce unsatisfactory results.[8, 9]

In our study, we were able to achieve mean post operative HKA angle of 184 ± 0.2 degree from the preoperative mean value of 172 ± 0.3 degree. The desired value of postoperative HKA angle was obtained in 41 of 52 patients (78.8%). In 4 (7.7%) patients there was insufficient correction (angle <183) and in 7 (13.4%) patients the mean postoperative HKA angle was over 186 at their final follow up. The incidence of under correction and over correction has also been described in past studies on HTO. In a prospective study on functional outcome of HTO by Hemicallostasis using dynamic axial fixator, Yadav AK et al. have mentioned getting desired postoperative HKA angle in 24 out of 30 (80%) of their surgeries. They reported under correction in 10 % cases and over correction in 10 % cases. In a study over similar technique by V. Bachhal et al. the goal was kept to achieve a 2-8 degree of valgus correction in 37 knees. At the end of their study desired alignment was obtained in 31 of 37 (84%) knees, whereas there was under correction in five knees and overcorrection in one knee. Rajesh Kapila et al. kept their goal of achieving 6-8 degree of valgus in 30 knees operated with open wedge high tibial osteotomy with limb reconstruction system. However they could get 5-7 degree of valgus in 60% of their cases[3,10, 11]

The cause of under-correction in HTO by Hemicallostasis has largely been described as mismatch between fixator correction and healing which leads to loss of correction. Mondanelli N et al. did a study on 40 knees with long follow up of 7 years and found loss of correction by 1-3 degree in 15% of knee in their final follow ups.[12] According to Yadav AK et al. the reason of overcorrection may be the use of Miniaci method in planning so the angle calculated is more as few degrees are increased on correction with the tipping of the JLCA, this method ignore the dynamic component of deformity. By this technique, only static varus deformity is corrected. Recurrence of varus deformity is commonly encountered in under corrected knees, which may progress to medial compartment osteoarthritis. Coventry et al. in their study of 87 knees observed that inadequate correction was a major cause for failure of HTO. Although failure in overcorrected knees has not been as frequently documented as that in under corrected knees, too much valgus can create an unacceptable cosmetic deformity and may lead to lateral compartment osteoarthritis.[3, 8, 13 & 14]

We started supervised range of motion of knee and weight bearing in immediate post op day to all of our

patients. By this early range of motion we were able to achieve a post op mean flexion of 129.30 from pre op mean flexion of 118.40. Yadav AK et al. have reported a similar improvement in mean flexion of their patients with early range of motion. They reported mean postoperative flexion of 128.60 from preoperative mean value of 125.20. Similarly in V Bachhal et al. study there was no significant difference in the range of motion preoperatively and postoperatively. Rajesh Kapila et al. also found that only four patients had some decrease in range of motion after the procedure while the majority of patients maintained or improved their preoperative range of motion similar to the results described by Insall et al. in their long follow up. Stiffness is uncommon if preoperative motion is satisfactory. So it is necessary to start early knee mobilization to prevent stiffness.[3,10,11&15] The appropriate time to allow full weight-bearing post-operatively depends on the stability of construct. The stability of open wedge HTO by Hemicallostasis has been found stable comparable to other forms of close wedge and internal fixation. There is shift from tradition thought of full weight bearing after 6-12 weeks to allowing it in 1st week with distraction. The early full weight bearing should be delayed in cases of inadvertent lateral cortex fracture.[10, 16 & 17] We allowed partial assisted weight bearing during the distraction phase and then progressed to full weight bearing as tolerated during consolidation phase in all our patients and didn't encounter any complication.

Conventional open and closed wedge high tibial osteotomies are known to affect the tibial slope and patellar tendon length. The tibial slope decreases after closed wedge and increases after open wedge osteotomy, whereas it is relatively unaffected by Hemicallostasis.[18-20] Both closed- and open-wedge osteotomy have been shown to cause patella baja, which happens infrequently with Hemicallostasis. The principle of using osteotomy site distal to tibial tuberosity has the advantage that it does not affect patellar tendon height, no change in tibia slope, and does not increase patellofemoral contact stress. So the future conversion to total knee replacement will easier with Hemicallostasis than with other techniques.[3, 10, 21 & 22] In our study there was no alteration in the tibial slope and patellar height after opening-wedge osteotomy using a dynamic axial fixator.

The benefits of using Hemicallostasis in HTO are many as compared to other techniques and there is an added convenience of precision in achieving calculated correction. This is because the final alignment is checked by scanogram before the fixator is locked and with the fixator under correction and overcorrection manipulation can be easily done. The other advantages of this technique are minimally invasive (2-5 cm incision) osteotomy, fibular osteotomy not required, bone graft not needed, the limb is not shortened unlike in close wedge, restoration of physiologic alignment of limb and no alteration in patellofemoral function. There is no retained hardware inside the patient when osteotomy is united as the pins and fixator are removed after complete healing of osteotomy.[23-25]

There is a substantial concern of patient compliance with this technique. Patients had to bear a fixator for around 3 months, which brings dissatisfaction in many emotionally labile patients. The other considerable disadvantage of using an external fixator is pin tract infection which if progress to deep infection may compromise future knee replacement. Variable rates of such pin tract infections with hemicallotasis, ranging from 8% to 60% have been reported in past studies.[26-29] In our study there was 13.4% (7 patients) incidence of pin tract infection. All the cases had superficial pin site infections and we were able to manage it easily with pin site care and antibiotics. There here were no signs of deep infection in our study.

So, performing HTO by Hemicallostasis is a precise method of correcting the alignment of a knee with ease of early mobilization, minimal alteration in tibial or patellar anatomy and low risk of complications.

There are few limitations in our study. The sample size can increased to evaluate the result of this technique in larger population. The follow up is short for this type of surgery. This type of study will need long term follow up to know how long the effect of osteotomy remains upon the amount of pain relief and deformity recurrence. We are also not aware of how many and at what time the osteotomies will need a replacement surgery. We intentionally targeted to over correct the deformity in our patients which had lead to overcorrection in 13.4% of knees in our final follow up. This was done to avoid failure with under corrected knees as mentioned in literature on higher rates compared to over corrected knees.

CONCLUSION

It is quite clear from above discussion that hemicallotasis with fixator is an effective method of managing osteoarthritis of knee especially in patients with unicompartmental disease. It is minimally invasive, requires no fibular osteotomy, minimal chances of nerve injury, easy to perform and no internal hardware used requiring subsequent removal. We strongly recommend this procedure in relatively younger patients as it may delay the need of joint replacement and in some cases it may actually avoid it.

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