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Mid-term results of high tibial osteotomy for medial compartment arthritis using hemicallostasis by dynamic external fixator

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Abstract
Introduction: Medial Gonarthrosis of Knee in middle-aged (40-60yrs) physically active individuals has become a considerable cause for pain, immobility and disability. Varus malalignment at knee joint compromises biomechanics and sets up a vicious cycle which leads to progressive deterioration of medial compartment.
Medial open-wedge osteotomy using dynamic external fixator is a recent procedure introduced for axis correction and restoring joint biomechanics with good clinical results.
Material and Methods: We retrospectively reviewed 75 patients (78 knees) who were operated for medial compartment arthritis by High Tibial Osteotomy using Hemicallostasis between 2001-2007. Preoperative full length Hip knee axis standing radiographs were taken and femoro-tibial angle determined. Medial open wedge osteotomy using dynamic external fixator was done and axis correction by gradual distraction was achieved to desired angle. Post-operative full length radiographs were compared and evaluated. Oxford Knee Score was used as a clinical tool for assessment.
Results: In a mean follow-up period of 83 months, 54% patients showed excellent outcome with improved Oxford knee score. Most significant improvement was observed in females aged 51-60 years. Amongst 75 patients, 11 patients encountered pin-track infection, 4 patients had delayed union, 1 patient had lateral cortical fracture, and 7 patients had knee stiffness. No patients had loss of reduction or non-union of osteotomy site. No patients had conversion to total knee arthroplasty till last follow-up.
Conclusion: High Tibial Osteotomy using dynamic external fixator provides cheap alternative in young active patients with initial stages of Medial Compartment Arthritis with good survivorship, no internal implant, less difficulty in subsequent total knee arthroplasty, minimal scar, minimal tissue disturbance, re-usability of fixator frame and good long-term results.

Keywords: High tibial osteotomy, hemicallostasis, medial compartment arthritis, proximal tibial osteotomy, knee arthritis

Introduction
Medial Gonarthrosis of Knee in middle-aged (40-60yrs) physically active individuals has become a considerable cause for pain, immobility and disability [1]. Varus malalignment at knee joint compromises biomechanics and sets up a vicious cycle which leads to progressive deterioration of medial compartment.

Biomechanical Rationale of High Tibial Osteotomy
Strong adductor compartment in lower femur tends to adduct femur on tibia during weight acceptance phase leading to higher load-bearing on medial compartment of knee. Lateral muscular forces tend to bring dynamic equilibrium in load-sharing between both compartments. Over the time, degenerative changes in medial compartment overcome lateral forces to produce varus deformity and onward decline of knee biomechanics.
Realignment of Femoro-Tibial Axis (FTA) in medial gonarthrosis brings the center of load bearing axis laterally and counterbalances joint contact pressures amongst both compartments.
Most literature portrays Jackson and Waugh as original authors to describe valgisation of FTA by doing high tibial osteotomy at tibial tubercle [2].

Since its origin, numerous authors have described various methods to achieve FTA realignment. Principally, these are categorized in two varieties: Medial Open Wedge Osteotomy (MOWO) and Lateral Closed Wedge Osteotomy (LCWO). Another variation is a dome technique. Enumeration of methods of HTO, their evolution, advantages and disadvantages takes a book in itself for detailed description.

A not-so-recent addition to plethora of methods for HTO is open-wedge osteotomy with Hemicallostasis (HCO) described by Turi *et al* in 1987 [3]. Gradual distraction of osteotomy site is proposed to give anatomical healing, less soft tissue irritation, less proximal tibial distortion, no implant related complications, and controlled precision for axial correction.

We describe our experience on High Tibial Osteotomy using Hemicallostasis with monolateral external fixator and clinical as well as radiological outcomes on long term follow-up. This is a level IV study with retrospective data.

Material and Methods

We retrospectively reviewed 75 patients (78 knees) who were operated for medial compartment arthritis by High Tibial Osteotomy using Hemicallostasis between 2001-2007 by senior authors (JPP and PVA). Our inclusion criteria were unicompartmental osteoarthritis, fixed flexion deformity <10 degree, anterior and posterior drawer negative, and no varus-valgus instability. Patients were explained about procedure, prognosis and informed consent was taken. Patients with associated spinal deformity, ligamentous injuries, hip pathologies, vascular pathology and severe varus-valgus-flexion deformities were excluded from the study.

Total 78 knees (n=78) in 75 patients comprising of 48 females and 27 males with mean age 53.1 years (Age range 29 to 64) were included. Mean age in female patients was 53.5 years while in male patients was 52.3 years. 2 Females and 1 male patient had undergone bilateral osteotomies with inter-duration being 8-10 weeks. Of 75 patients, 4 male patients had post-traumatic early onset arthritis and 1 female patient had post-tibial diaphyseal osteomyelitis induced tibia vara deformity. Most patients suffered knee pain for duration between 6 months to 10 years. 26 patients (n=27 knees, 34.6%) belonged to age-group <50 years; 39 patients (n=41 knees, 52.6%) belonged to age group 50-59 years; while, 10 patients (n= 10 knees, 12.8%) belonged to age group >60 years. Pre-operative Oxford knee score was determinded [4]. We have also graded osteoarthritis in each patient by using Ahlback grading system [5].

A full weight-bearing standing radiograph of both lower limb from hip to knee was taken. Mechanical axis of lower limb was drawn on full length radiographs: It is a line extending from centre of hip joint to centre of ankle joint as described by Moreland *et al*. [6] The femorotibial angle (FTA) and Hip-knee angle (HKA) were measured on same radiographs. Position on tibial plateau where this axis crossed was recorded preoperatively and postoperatively and expressed in percentage of total tibial plateau width. Our aim was to do valgus overcorrection by 2-8 degrees, so as to lateralize the mechanical weight bearing axis from fugisawa point, which is located slightly lateral to lateral tibial spine or precisely at 62% of tibial plateau width as calculated from medial endpoint [7].

Surgical Procedure

Preoperatively injectable intravenous antibiotic cefoperazone and sulbactam were administered half hour prior to surgery. Surgery was conducted under spinal anesthesia with tourniquet inflated during osteotomy. Pillow was placed under operative leg for lateral imaging and sandbag was placed under ipsilateral greater trochanter to facilitate internal rotation of limb. Preferable position for operating surgeon was on medial side of operative leg. Under IITV guidance two 6.5mm Hydroxyapatite coated schanz screws (SH Pitkar Tools) were inserted at level of fibular head in lateral view. Two schanz screws are inserted at level of one half and one third of tibial length from tibial plateau in medio-lateral direction, usually after placing dynamic fixator apparatus on proximal schanz screws and then judging position of clamps on it. After placing schanz screws, fixator apparatus is removed. Limb is elevated and tourniquet inflated. Medial wedge osteotomy is done after determining the level of joint in dynamic fixator which is usually 1.5 inch below proximal schanz screws. A Steinmann pin is first driven from small medial incision towards fibular head to mark direction of osteotomy. Location of osteotomy is normally little below metaphyseo-diaphyseal junction. Before commencing osteotomy, periosteal elevation is done thoroughly as incomplete periosteum can lead to early union of osteotomy by early regenerate on gradual distraction. Once periosteum is adequately erased, osteotome is inserted and driven towards fibular head while falling short by 8-10 mm from lateral cortex. Care is taken to prevent lateral cortical breach as this can lead to unstable osteotomy precluding precise alignment. Both anteromedial and posterior cortex are osteotomised and confirmed under IITV. Dynamic external fixator apparatus is then mounted on schanz screws and attuned to it. Gradual distraction is exercised intraoperatively to confirm medial opening at osteotomy site following which it is closed. Incision is sutured and drain is kept at osteotomy site.

Distraction is started after 10 days of osteotomy. With 0.25 mm distraction caused by one turn thus one full turn of apparatus causes total 1 mm distraction in one day. Sutures of osteotomy are removed at 2 weeks. First check xray is taken at one month follow-up and then subsequently every month till 4 months. Standing radiographs are taken to determine Hip knee axis and femoro tibial angle. Once desired correction is achieved, fixator is locked and kept static till 3 months. When clinical as well as radiological union is confirmed, fixator apparatus is loosened and patient is allowed to walk with near-full weight bearing. This is continued for 2 weeks. At the end of 2 weeks another radiograph is taken to check collapse or any bony abnormality. Apparatus alongwith fixator pin is removed at the end of 3-4 months. Pin sites are irrigated and dressed. Patient is allowed full weight bearing. Subsequent follow-up xrays are taken at 6 months, 1 year and 2 year duration.

Results

Our mean follow-up period was 83.5 months (62-105). Our study included 27 males and 48 females with mean age 53.1 years. The age and sex distribution of study population is given in table 1.

Table 1: Age and Sex Distribution of patients.

Age group (Years)	Male	Female	Percentage
≤ 35	1	2	4
36-40	2	3	6.6
41-45	2	5	9.3
46-50	4	7	14.6
51-55	6	10	21.3
56-60	9	14	30.6
61-65	2	5	9.3
≥ 65	1	2	4
Total	n = 27	n = 48	75 (100 %)

As is evident, majority of patients belong to age group 51-60 years, comprising 52 % of total population. While <50 age group makes up for 35 % of sample population and >60 age group numbers at 12 %.

We have used Oxford Knee Score (OKS) as a clinical tool to measure results and clinical improvement of our patients. OKS is measured at an interval of 6 months, 1 year and 2 years in all patients. Mean of all successive post-op OKS is taken as final OKS of that patient. The given table features mean pre-operative oxford knee scores and post-operative knee scores age-wise as well as sex-wise. For the ease of presentation and understanding, the age-groups have been unified to <50 years, 51-60 years and >60 age group.

Table 2: Oxford Knee Score as a clinical tool for results.

Age group	Mean Pre-op OKS		Mean Post-op OKS	
	Males	Females	Males	Females
≤ 50	26.4	23.4	40.2	42.3
51-60	24.2	22.6	41.6	43.4
≥ 60	20.3	23.2	40.8	36.4
Mean	23.6	23.1	40.9	40.7

As is evident, most significant improvement in OKS is in females age group 51-60 years with pre-op OKS 22.6 improving to 43.4 post-operatively. On the other end, females with age group ≥60, show less improvement although significant. Overall, males have less improvement in OKS than females, but the difference is not so significant.

Time taken from initiating distraction to complete it till desired alignment is achieved was measured in all patients and varied according to pre-operative HKA deviation. However mean duration for complete distraction was 3.6 weeks (2.8 to 4.4 weeks). Mean duration for removal of frame was 14.2 weeks (12.2 to 16.2 weeks).

Table 3: Complications.

Pin track infections	11 patients(28 pins)
Delayed Union	4 patients(4 knees)
Lateral cortex fracture	1 patient
Knee stiffness	7 patients
Osteomyelitis	0
Neurovascular injury	0
Deep vein thrombosis	1
Intra-articular fracture	0

As is evident, pin track infections were amongst the most common complication in hemicallostasis. Amongst the 28 pins that got infected, barring 2, all were either grade 1 or grade 2 as per Otterburn classification [8]. However, all pin track infections resolved uneventfully by strict pin track care using alcohol based sterilizing agents with dry cleaning of pin tracks by sterile cotton gauze pieces. There was one incident of Deep vein thrombosis in a diabetic patient which required hospitalization and pneumatic stockings with anti-coagulation therapy. One patient suffered lateral cortex fracture intraoperatively following osteotomy after which osteotomy was fixed using locking T plate and graft used at osteotomy. Knee stiffness had been observed in 7 patients who responded excellently with physiotherapy sessions. 4 patients had delayed unions of osteotomy site and had to keep fixator frame for prolonged period, but eventually they showed favourable outcomes.

Discussion

High tibial osteotomy is widely accepted procedure for treatment of monoarthrosis of knee joint and appeals in its ability to restore natural knee and its homeostasis. Our study aims to prove effectiveness of high tibial osteotomy in improving clinical outcomes (as measured by Oxford knee score) in varus arthritic knee by changing knee alignment using hemicallostasis produced by dynamic external fixator.

Proponents of high tibial osteotomy emphasize newer cartilage regeneration in arthritic knee after overcorrecting varus deformity in medial compartment as demonstrated by Koshino *et al*. [9] Also as compared to surface replacement of arthritic surface as in Unicondylar Knee arthroplasty or total knee arthroplasty, HTO is highly cost effective and requires less stringent instrumentation and techniques [10, 11, 13, 14]. Although results of UKA and HTO are almost comparable, many recent long-term studies have proved 10-15 year survivorship of HTO if done by precise techniques. It has been suggested that UKA is a procedure of choice for older patients with monoarthrosis while HTO with overcorrection is procedure of choice in selected young patients [12, 14, 16]. Revision rate to TKA after either UKA or HTO is debatable in many series [16].

Many studies have demonstrated that success of HTO depends on ideal patient selection and precise axis correction [17, 18, 20]. Based on literature, ideal patient forTO is Age < 65 years, active lifestyle, HKA 5-15 degree, minimal antero-posterior instability, medio-lateral instability upto grade 2, ROM 0-120 degree with flexion deformity <5 degree, osteoarthritis Ahlback grade 1 and 2 and BMI < 30. [17-19] Poorer prognosis is likely in patients with severe articular degeneration (Ahlback grade 3 or more); advanced age; patellofemoral arthrosis; decreased range of motion; previous arthroscopic debridements; joint instability and lateral tibial thrust [20].

Controversy also surrounds in method of choice of proximal tibial osteotomy: Lateral closed wedge or Medial Open wedge. For many years, lateral closed wedge osteotomy as popularized by Coventry has remained gold standard for medial compartment arthritis [21]. However, on revising these knees for TKA, many shortcomings became surfaced for example requirement of fibular osteotomy, lateral muscle detachment, peroneal nerve dissection, proximal tibio-fibular joint disruption, and subsequent bone stock loss. For this reasons, medial open wedge has gained momentum recently [20, 21, 23].

Current criticism faced by medial open wedge osteotomies is in its loss of reduction and less accurate axis correction and henceforth suboptimal clinical results [23]. Use of grafts, implants, bioabsorbable cement, synthetic bone substitutes in open wedge has been subject of immense interest [24]. However, initial studies have warned risk of disease transmission, infection, reduced resistance to compressive loads and donor site morbidity.

In view of this, hemicallostasis offers a natural method for filling void with gradual autogenous callus. No donor morbidity as graft is not taken from external sources. Besides a precise control over correction of alignment can be done and measured and calibrated accordingly [25, 26]. This in addition to cheaper cost of involved fixator frame and its re-usability are major advantages. Concerns of patella infera, decreased tibial slope and medial ligament laxity in certain medial open wedge osteotomy using Tomofix plates, puddu plates have been nullified by gradual distraction using dynamic external fixator [27, 28].

Conclusion

High tibial osteotomy has gained considerable popularity in young surgeons inspite of lucrative knee replacement marketing. This is because HTO addresses key pathology of knee osteoarthritis by overcorrecting HKA to unload medial joint space. HTO using dynamic external fixator provides cheap alternative in young active patients with initial stages of MCA with good survivorship, no internal implant, less difficulty in subsequent TKA, minimal scar, minimal tissue disturbance, re-usability of fixator frame and good long-term results.

Images

Image 1: K wire insertion for determining first Proximal Schanz screw insertion. AP view.

Image 2: K wire insertion for determining first Proximal Schanz screw insertion. Lateral view.

Image 3: Proximal Schanz screws insertion. AP view.

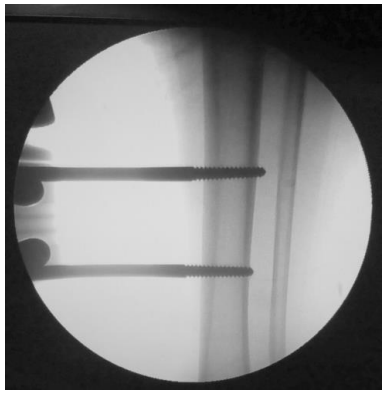

Image 4: Distal Schanz screws insertion. AP view

Image 5: Osteotomy done from medial side towards fibular head. Kept 1 cm away from lateral tibial border. AP view.

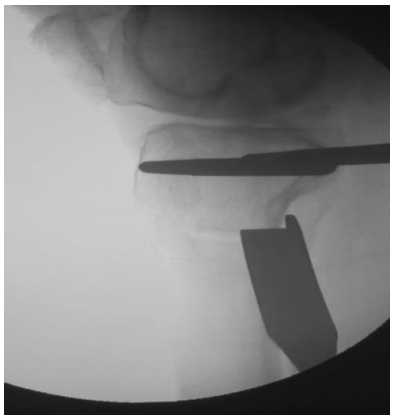

Image 6: Osteotomy completed posterior to posterior border in order to open wedge using corticotome. Lateral view.

Image 7: Osteotomy as visualised by IITV intensifier intraoperatively in AP View.

Image 8: Osteotomy widened by gradual distraction intra operatively to confirm axis correction.

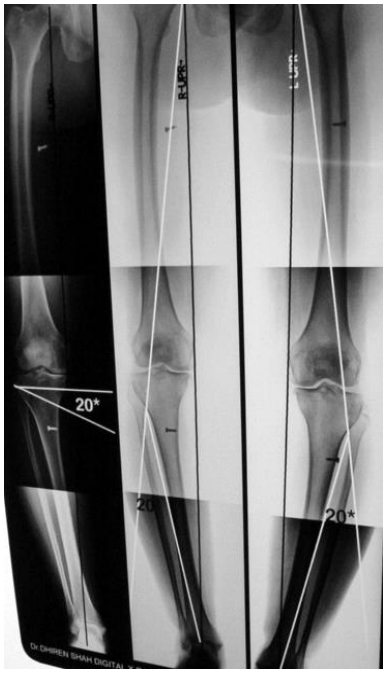

Image 9: Pre-operative Full axis weight bearing radiograph of patient

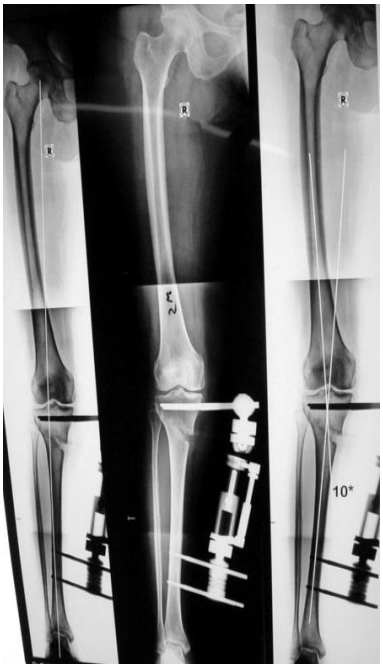

Image 10: 2 months postoperative Full axis weight bearing radiograph of patient following osteotomy

Image 11: Clinical photograph of varus knees of patient

Image 12: Post-osteotomy clinical photograph of corrected osteotomised knees of same patient

Image 13: Clinical photograph of ability to squat

Image 14: Clinical photograph of ability to sit cross-legged.

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