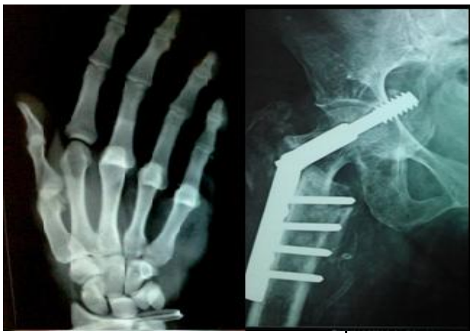

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Knee society score, mechanical tibiofemoral angle and the Fujisawa point: Do these variables determine a successful outcome of a high tibial osteotomy using an ilizarov fixator about the knee for medial compartmental osteoarthritis

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Abstract

Introduction: Medial compartment Osteoarthritis is an age related chronic disturbance of weight distribution over the articular surface of the knee joint. The compensatory Varus deformity which develops leads to "bowing" of the legs. Traditionally, treatment involved conservative regimen of analgesics, physiotherapy and lifestyle modifications. Before the advent of Arthroplasty, Osteotomies were the mode the treatment. The treatment modality is divided into two phases. The first phase involves in correcting the mechanical axis deviation, through a high Tibial Osteotomy. The second phase involves stabilizing this accomplishment with an Ilizarov external fixator and achieving the co-linearity of the Mechanical axis of the lower extremity through angular correction using distraction Osteosynthesis.
Aim: The aim of present study was to evaluate the results of High Tibial osteotomy using Ilizarov technique in medial compartment osteoarthritis of the knee.
Materials and Methods: In this prospective study, thirty cases of medial compartment osteoarthritis of the Knee with genu Varus deformity were treated using monofocal corticotomy and ring fixator. Bone and functional results were evaluated clinically using the Knee Society score (knee score and functional score) and radiologically using the mechanical tibiofemoral angle and the Mechanical axis deviation from the Fujisawa point.
Results and Discussion: In the present series of thirty cases, there were 20 females and 2 males with a maximum age of 52 years and minimum of 32 years. There was a predominance of Varus deformity seen on the right knee. The mean follow up was 30 months. The results observed were 60% excellent, 33% fair and 6.7% poor by knee society score. The mean knee society score (Knee score) at 12 months was 71.27 ± 5.32 (p<0.001) and at 24 months was 78± 6.42(p<0.001). The mean Tibio femoral angle was 3.40 ± 1.07º of valgus (p<0.001) at 12 months postoperatively and at 24 months was 3.7 ± 1.35º of valgus (p<0.001). The mean Mechanical axis deviation from Fujisawa point was 0.76± 0.42 millimetres (p<0.001) at 12 months postoperatively and 0.75 ± 0.45 millimetres (p<0.001) at 24 months postoperatively. The correlation between Knee society score and the Tibiofemoral angle was significant at 12 months (r= 0.368) compared to the correlation between Knee society score and the deviation from Fujisawa point which was non significant at 12 months(r= -0.340) and was significant at the end of 24 months (r= -0.552).At the end of 24 months, 93.7% of the cases showed excellent to good results after the intervention and only 6.7% of the cases showed poor result.
Conclusion: In the light of these results, it was concluded that high Tibial osteotomy by Ilizarov technique, despite few unfavourable results and complications, can be used to treat angular deformity correction about the knee.

Keywords: Ilizarov, knee society score, high tibial osteotomy, fujisawa point

Introduction

Malalignment of the lower limb refers to the loss of collinearity of the Mechanical Axis of theLower extremity (MALE). This bears a serious brunt on the articular cartilage of the lower-extremity. Medial compartment osteoarthritis of the knee refers to the excessive loading of weight onto the medial femoral condyle and medial tibial plateau. This imbalance of load creates stress risers along the medial compartment of the knee, this leads to a cataclysmic cascade of events culminating with erosion of the articular surfaces, extrusion of articular cartilage with Subsequent endochondral ossification leading to the formation of osteophytes, these events ultimately culminates in the medialisation of the weight bearing axis of the lower limb.

High tibial osteotomy aims to reposition the Mechanical Axis of the Lower extremity (MALE) to its original axis, by creating cuts at the proximal end of tibia and realigning the proximal and distal segments so that the MALE is reestablished.

Osteoarthritis of the knee is a mechanical problem and there are usually coexisting problems of deformity, articular cartilage erosion, joint effusion, ligamentous laxity and soft tissue contractures. The malalignment may be treated with minimum operative exposure but a technically demanding procedure that permits early weight bearing and allows early mobilization.

The causes of osteoarthritis may include older age, obesity, sex, joint injuries, occupation, Genetics, bone deformities. Normal articular cartilage is composed of extraarticular matrix and Chondrocytes. In MCOA imbalance between synthetic and destructive forces leads to articular Cartilage erosion coupled with decreased synovial fluid may lead to decreased cushioning and lubricating properties of the joint.[1]

The treatment of genu varus through high tibial osteotomy, traditionally demands that the centre of angular rotation (CORA), angular correction axis (ACA), transverse bisector Line (Tbl), mechanical lateral distal femoral angle (mLDFA), the medial proximal tibial angle, Mechanical axis deviation (MAD) from the Fujisawa point and the mechanical tibiofemoral angle be determined preoperatively so that the osteotomy site can be decided. Clinical assessment pre-and postoperatively was based Using the Knee society score PART one (objective/Knee score) and changes graded based on this score. Radiologically Mechanical tibiofemoral angle and the mechanical axis deviation (MAD) from the Fujisawa point was used. The Fujisawa point in this study was taken to be thirty five percent average and expressed radiographically as a point and the MAD (mechanical axis deviation) measured as the distance away from this point.

Our selected method of high tibial osteotomy (HTO) was a dome osteotomy using the gigli saw technique at the centre of rotation angulation (CORA) to fashion out a dome after which an Ilizarov external fixator was used for correcting the angular deformity. The use of ilizarov external fixator in High tibial osteotomy (HTO) was first published by Catagni *et al*. [2] The results in achieving colinearity of the Mechanical axis using High tibial osteotomy (HTO) with Ilizarov fixator has been well documented.[3] Correction of deformities may delay the progression of MCOA (medial compartment osteoarthritis) or mitigate its effects, dome osteotomy is very useful for cases of alignment correction [4]. The power of Ilizarov frame lies in its ability to precisely control the final limb Alignment and perform a residual correction [5].

Aim

The aim of present study was to evaluate the results of High Tibial osteotomy using Ilizarov technique in medial compartment osteoarthritis of the knee.

Materials and Methods

In this prospective study, thirty cases of medial compartment osteoarthritis of the Knee with genu Varus deformity were treated using monofocal corticotomy and ring fixator. The present study involved retrospective review of 30 cases from May, 2011 to August, 2016 followed prospectively. Informed consent was obtained from the subjects prior to the study, The study was granted approval from the institutional review committee. All procedures performed were in accordance to the Helsinki declaration of 1975.

Preoperative photographs, X-rays, Scanogram for the evaluation of Mechanical Tibio Femoral angle and Mechanical axis deviation from the Fujisawa point, Knee society score (objective data) was obtained. Likewise, following the procedure; data was obtained at 12 and 24 months postoperatively for (a) Knee society score (objective), (b) Mechanical Tibiofemoral angle, (c) mechanical axis deviation from the Fujisawa point, (d) X-rays for the Regenerate appearance, (e) complications.

The criteria for inclusion in the present study were:

- Patients with medial compartment osteoarthritis,
- Patients with genu Varum deformity
- Patients fulfilling minimum follow-up of twenty-four months
- Patients of age group between 30 and 55 years.

The criteria for exclusion in our present study were:

- patients with pre-existing disease or trauma to the knee,
- patients with polyarticular involvement,
- patients with grossly unstable knee,
- Patients with inability to manage the external fixator,
- Patients with involvement of more than one compartment of the knee,
- Patients with restricted range of motion at the knee i.e. Knee flexion < 90º degrees or flexion contracture >15º.

The Knee society score has two parts (one) Objective and (two) Functional [6]. Based on the above values the patient is placed into one of the four categories: Excellent (80-100), Good (70-79), Fair (60-69), Poor (<60).

Mechanical axis of the lower extremity and mechanical tibiofemoral angle (Figure 1) – A mechanical axis is defined as a line that connects the centers of two joints at distal and proximal end. The mechanical axis of the lower extremity is a line drawn from the midpoint of the femoral head to the midpoint of the ankle joint. When the centre of the knee does not lie close to this line it is termed as malalignment. The mechanical axis deviation is the distance between the mechanical axis line and the centre of the knee joint. The angle formed between the mechanical axis and the joint line is called the joint orientation angle. The proximal knee joint line is formed by drawing lines at the most convex part of the femoral condyles. The distal knee joint line is formed by a line along the subchondral plane of the tibial plateau [7].

Mechanical tibiofemoral angle (Figure 2)-It is formed by the intersection of the tibial and femoral mechanical axis its normally 1.3 ± 2º varus. A commonly measured angle is the anatomic tibiofemoral angle formed by the intersection of the anatomic axis of the femur and the tibia and is 6 º valgus. In our study, we used the mechanical tibiofemoral angle, any mention of TFA (tibiofemoral angle) by default was assumed to be Mechanical tibiofemoral angle.

Mechanical axis planning (Figure: 3, 4, 5) - The point of intersection of the distal and proximal mechanical axis is termed as centre of rotation angulation. The CORA (centre of rotation angulation) can occur at any level on the bone or the joint. The imaginary line along which angular correction of a deformity occurs is called the ACA (angular correction axis). Based on the site and level of the osteotomy with respect to the CORA (centre of rotation angulation) and ACA (angular correction axis), correction of the deformity would occur through angulation, translation or both [8].

Mechanical axis deviation and the Fujisawa point (Fig 6) - Mechanical axis deviation is defined as the distance from the mechanical axis to the centre of the knee joint. According to Fujisawa the lateral edge of the lateral Tibial plateau is considered as 100% (total width of the knee being two hundred percent) and the centre of the knee is taken as 0%. As the mechanical axis approaches 30-40% of this distance the best results of HTO (high tibial osteotomy) was obtained. This point is called Fujisawa point. In this study, Fujisawa point is expressed as its name indicates a point the average 35% is taken and expressed radiographically. For example, if the lateral tibial plateau measures 10 cms then 3.5cms away from the centre of the knee joint towards lateral edge is taken as the Fujisawa point. The MAD (mechanical axis deviation) is then measured as the distance from this point [9].

Magnitude of correction (Figure: 7, 8, 9) – The amount of angular correction should be the sum of the angular deformity at the CORA (centre of rotation angulation) and the overcorrection amount. Measurement of the angular correction is done using 3 steps by the method described by Murphy. In the first step a line is drawn from the centre of the hip through the Fujisawa point and onto virtual ankle joint. In the second step a second line is drawn from the centre of the ankle joint to the ACA-CORA (Angular correction axis - centre of angular rotation). In the final step a third line from the ACA-CORA (Angular correction axis - centre of angular rotation) is drawn towards the first line at the level of the virtual ankle joint, the angle between the second and third lines are measured to provide the amount of deformity correction [10].

A high tibial osteotomy using the Maquet type of focal dome osteotomy was done at the level of CORA (centre of rotation angulation) using the Gigli saw technique; Small transverse incision was made over Tibial crest down the periosteum Anterolaterally. Similar transverse incision was made over Posteromedial corner. Lateral wall of periosteum was elevated around Posterolateral corner. Posterior Tibial periosteum was elevated. The process was repeated on the medial side until a sub periosteal channel was created and an vicryl suture thread was passed subperiosteally using two Mixter forceps to manoeuvre the circumference of the Tibia (Figure 10). One end of the suture thread was tied to a Gigli saw. The Gigli saw was passed subperiosteally by maintaining constant tension on the tape from posteromedial to anterolateral (Figure 11). The Medullary canal and two-thirds of the bone was then cut (Figure 12). The saw was then held parallel to the medial face of tibia. A Periosteal elevator was inserted down the medial aspect of tibia to elevate the medial periosteum thereby completing the cut.

Repositioning of the mechanical axis occured when the ACA (angular correction axis) was matched to a point on the tBL (transverse bisector line) of the CORA (centre of rotation angulation). This intersection is called the ACA-CORA (Angular correction axis-centre of rotation angulation), if the osteotomy is done through this point than correction occurs without translation [8]. Lastly, a Fibular osteotomy was performed (Figure 13).

Preoperative frame construction is advisable to save time during surgery. The placement of hinges and the distraction rod are crucial for the correction of the angular deformity. An Imaginary line passing through the axis of the two Ilizarov frame hinges is the ACA (Angular correction axis) (Figure 14). The position of the hinges should coincide with the CORA (centre of angular rotation) on the TBL (transverse bisector line) and perpendicular to the plane of the angulation. Ilizarov surgery is really a temporal extension of the surgical procedure and therefore needs the same high level of care and monitoring, that we apply during surgery.

Post-operatively distraction commenced after a latency period of 7 days, in the form of 1 millimetre a day increments done 4 times daily; 1 millimetre of distraction corresponded to 10º of angulation. After the desired correction was achieved, the Ilizarov fixator was continued until corticalization of the regenerate was detected radiographically. Postoperatively pin site dressing was done thoroughly daily. A follow up was done initially once weekly for the first month, twice weekly for the next two months and monthly visits from the remainder of the duration. Radiographic evaluation was done in the form of X-rays for 4 weeks, 8 weeks, 3 months, 6 months, 1 year, 18 months and 24 months.

Results

Age and Gender

The ages of the cases ranged from 35-52 years, with average being 43.20 years. 93.3% of the cases were female in the study group. 76.7% of the cases were right sided.

Knee society score

The mean Knee society score at pre-op was 55.40. After 12 months of treatment, mean knee society score showed a significant rise of 28.6% from baseline ($p<0.001$). At the end of 24 months mean knee society score showed a significant rise of 40.8% from Baseline ($p<0.001$) (Table 1).

Similarly, the knee functional score preoperatively was 45.1. After 12 months postoperatively, a significant rise of 50.71% increase from baseline ($p<0.001$) was seen. At the end of 24 months postoperatively, showed a significant rise of 80.7% increase from baseline ($p<0.001$) was observed.

Table 1: Denotes the correlation between Knee society score and mean Tibio Femoral angle preoperatively, at Twelve and Twenty-Four Months Post-operatively.

TIME	Mean knee society score (N = 30)	Mean tibiofemoral angle (N = 30)	r value	P value	Statistical test
Preoperative	55.40 ± 06.58	10.70 ±13.31(varus)	-0.074	0.695 (NS)	Pearson correlation coefficient
Postoperative 12 months	71.27± 05.32	03.40± 01.07(valgus)	0.368	0.045*	Pearson correlation coefficient
Postoperative 24 months	78.00± 06.42	03.77±01.25(valgus)	0.562	0.001*	Pearson correlation coefficient

* significant, NS (Not Significant).

Mechanical axis deviation from Fujisawa point

The mean Mechanical axis deviation from Fujisawa point at pre op was 2.12 mm. After 12 months of treatment, mean Mechanical axis from Fujisawa point showed a significant fall of 64.2% from the baseline(*p*<0.001).At the end of 24 months, mean Mechanical axis from Fujisawa Point showed a significant fall of 64.6% from the baseline (*p*<0.001).(Table 2).

Table 2: Denotes the preoperative and post-operative (twelve and twenty Four months) values of the Mean knee society score, Mechanical Tibio Femoral Angle and Mean Mechanical Deviation from the Fujisawa point.

Functional and Radiological results	Preoperatively	Postoperatively (12 months)	Postoperatively (24 months)	p value (12 months)	p value (24 months)	Statistical test
Mean Knee Society score	55.40 ± 06.58	71.27 ± 05.32	78.00 ± 06.42	0.001*	0.001*	Student t-test
Mean mechanical tibiofemoral angle.	10.7 ± 13.31 varus	03.40 ± 1.07 valgus	03.7 ± 01.25 valgus	0.001*	0.001*	Student t-test
Mean mechanical axis deviation from the Fujisawa point.	02.12 ± 0.75mm	0.76 ± 0.42mm	0.75 ± 0.45mm	0.001*	0.001*	Student t-test

Mm (millimeter), * significant

The correlation between Knee society score and the Tibiofemoral angle was significant at 12 months (r= 0.368) compared to the correlation between Knee society score and the deviation from Fujisawa point which was nonsignificant at 12 months(r= -0.340) and was significant at the end of 24 months (r= -0.552).At the end of 24 months, 93.7% of the cases showed excellent to good results after the intervention and only 6.7% of the cases showed poor result. (Table :3)

Table 3: Denotes the correlation between Mean Knee Society Score and the deviation of M.A.L.E. from the Fujisawa point; preoperatively and at Twelve and Twenty Four months Post Operatively.

TIME	Mean knee society score (N=30)	Mean mechanical axis from Fujisawa Point (N=30)	r Value	P value	Statistical test
Preoperative	55.40 ± 06.58	02.12 ± 0.75mm	-0.851	0.001*	Pearson correlation coefficient
Postoperative 12 months	71.27± 05.32	0.76 ± 0.42mm	-0.340	0.066 (NS)	Pearson correlation coefficient
Postoperative 24 months	78.00± 06.42	0.75 ± 0.45mm	-0.552	0.001*	Pearson correlation coefficient

Mm (millimeter), *(significant)

Radiographic assessment was done by two independent observers (orthopaedic surgeon and radiologist). The following factors were examined (a) commendatory outcome of distraction (b) quality of the regenerate (c) presence of nidus of infection (d) non-union (e) malunion. Likewise, scanograms were obtained postoperatively to assess the (a) male (mechanical axis of the lower extremity) (b) mechanical tibiofemoral angle (c) mechanical axis deviation from the Fujisawa point

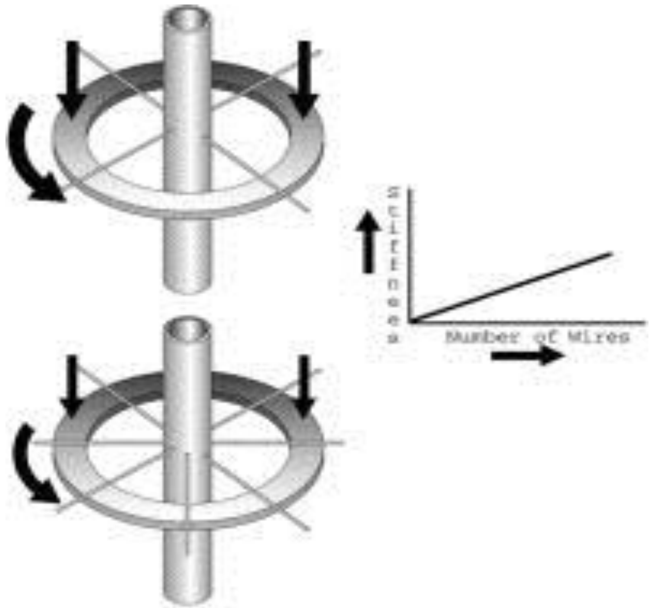

Fig 1: Effect of angulation between crossing wires over bending stiffness and stability

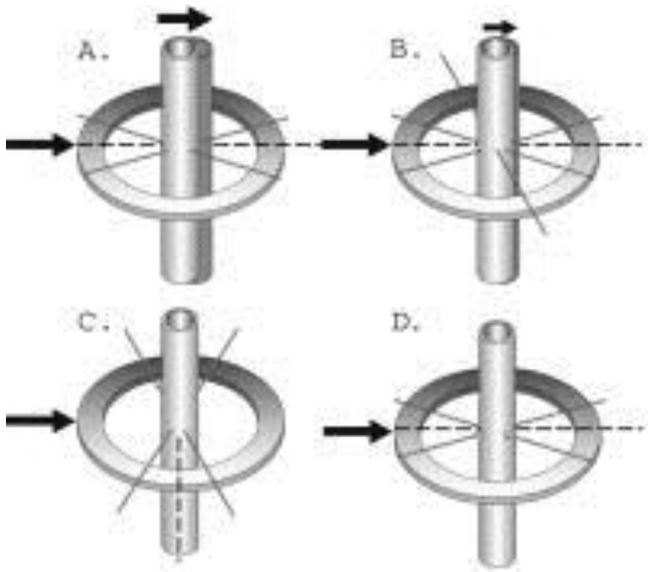

Fig 2: Effect of angulation and number of wires over translation.

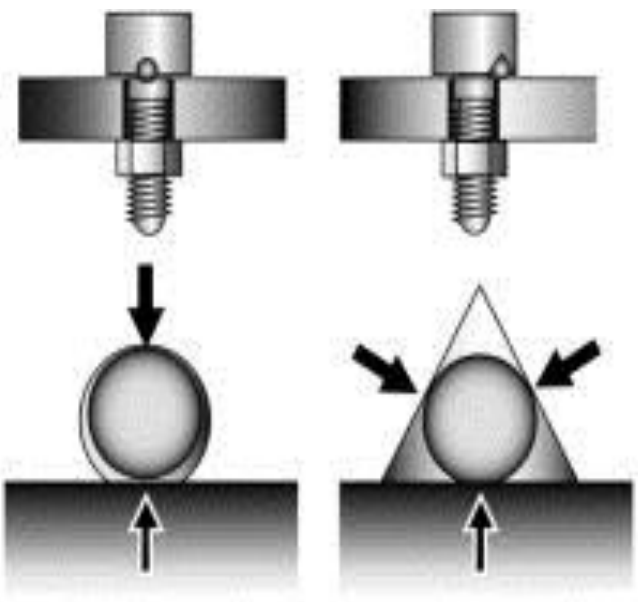

Fig 3: Mechanism of slotted and canulated bolts.

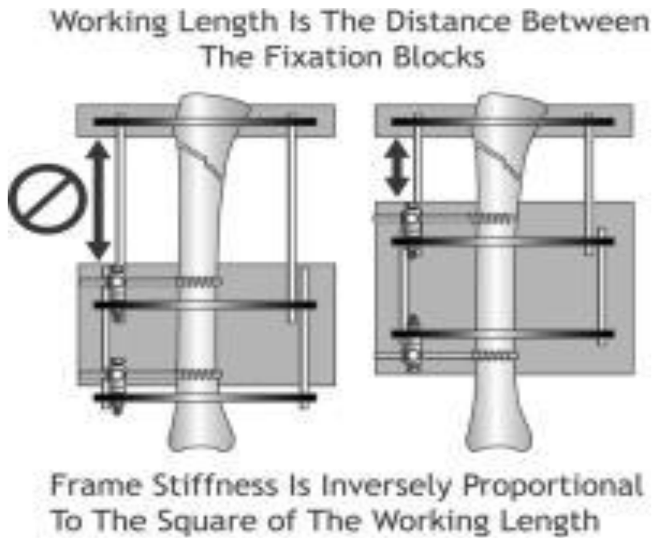

Fig 4: Showing working length

Fig 5: showing the MALE highlighted in red

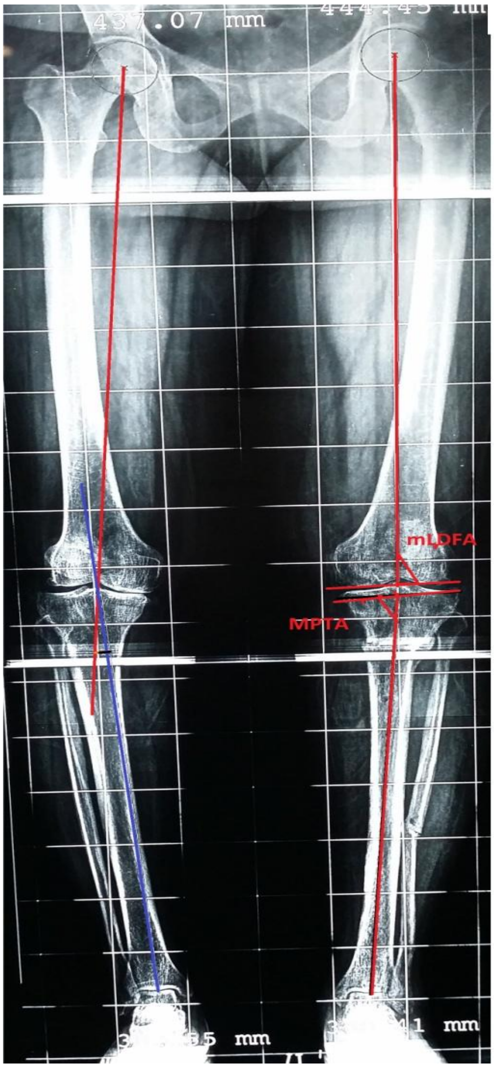

Fig 6: Mechanical tibiofemoral angle shown by the intersection of the mechanical axis of femur(red) and tibia(blue)on the right .On the left limb the mLDFA and MPTA

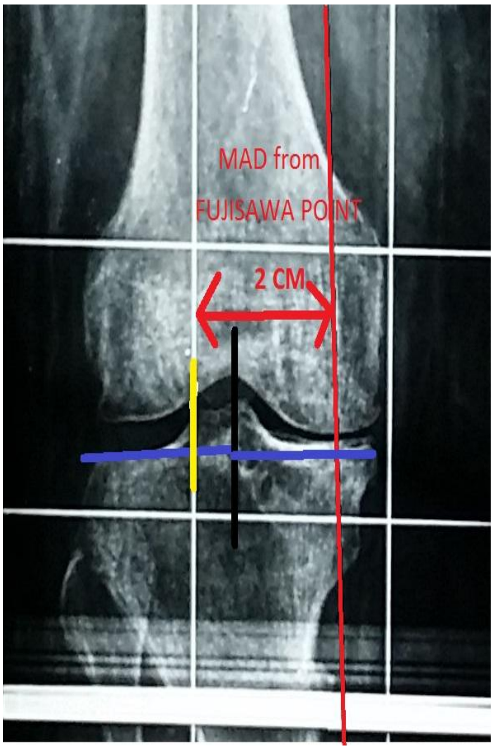

Fig 7: The Fujisawa point (yellow) ,Centre of knee joint (black), MALE(red)

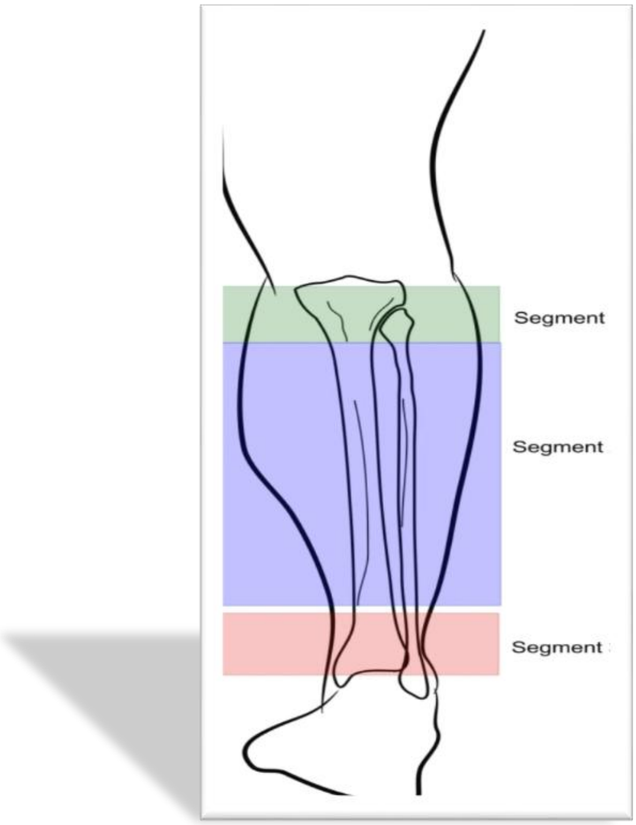

Fig 8: showing segments of tibia

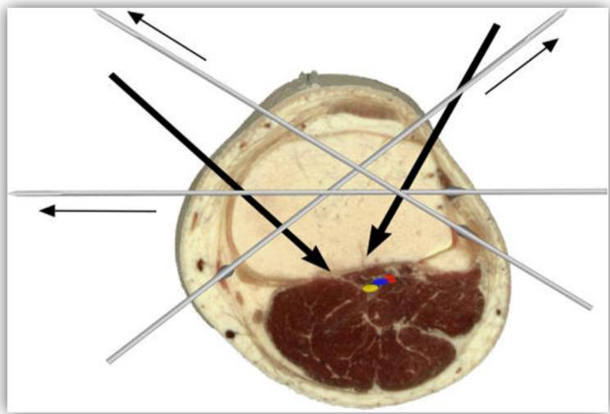

Fig 9: Segment 1-two fingers breadth distal to joint line of thee knee

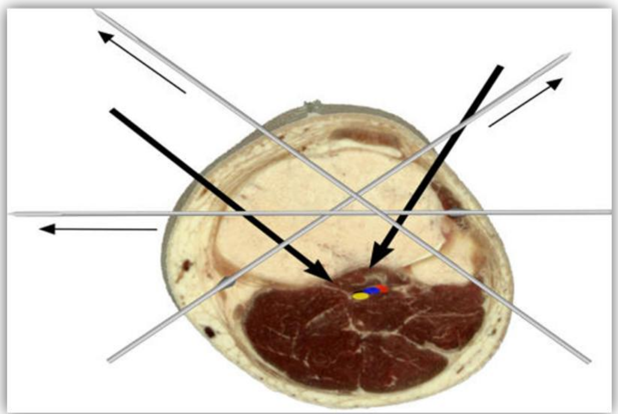

Fig 10: Segment 1: at the level of the fibula head

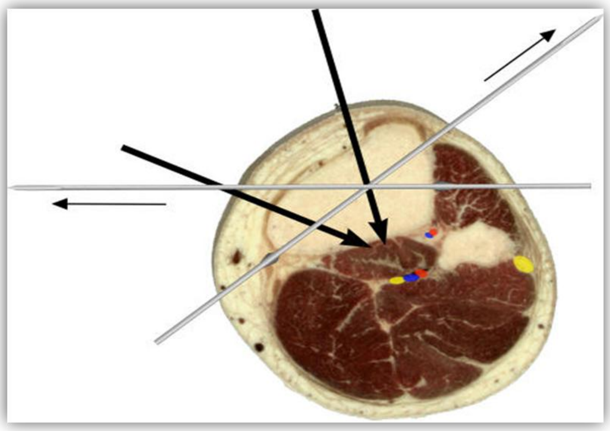

Fig. 11: Segment 1: at the level of the fibula neck

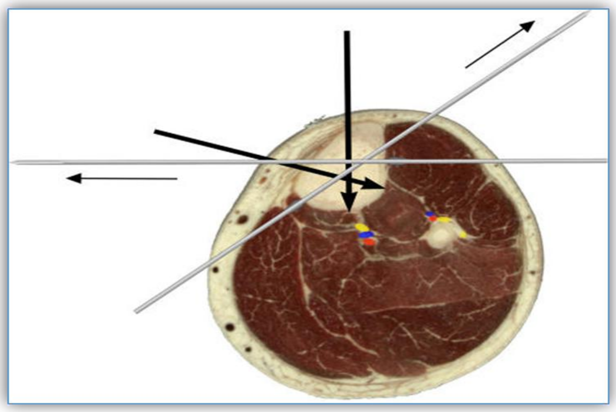

Fig 12: Segment 2: just distal to the tibial tuberosity

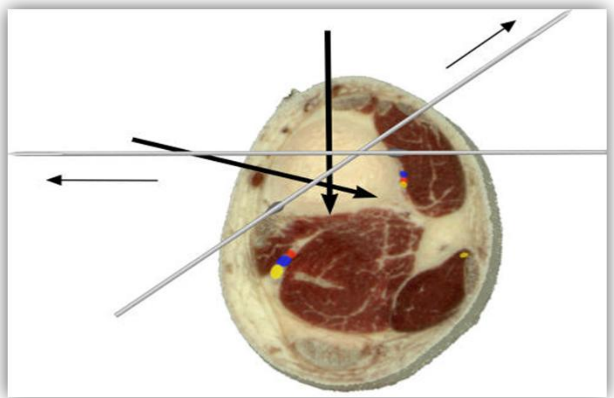

Fig 13: Segment 2: mid-shaft of the tibia

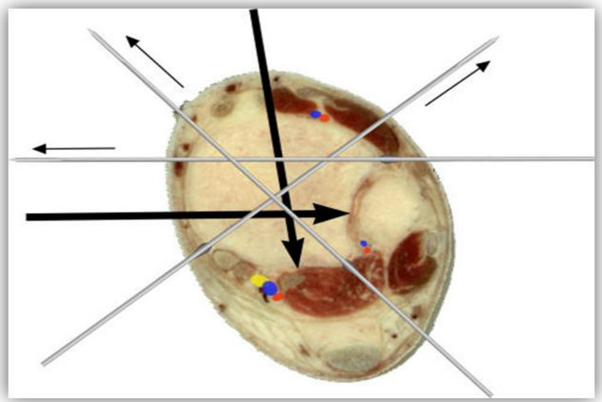

Fig 14: Segment 3: proximal to the ankle joint

Discussion

Medial compartment osteoarthritis arising due to uneven distribution of load is an inevitable Patho-Anatomic condition arising due to the biomechanics around the lower limb. The arrival of newer methods like Unicondylar knee replacement, such procedures offer the patient rapid correction of the deformity without dealing with a cumbersome external fixator apparatus.

The shortcomings of such devices remain the over and under correction of the deformity, the pricing and surgical skill set hard to acquire. The advantages over the remaining procedures are the absence of internal hardware, the ability to fine tune the correction of the deformity and the ability to weight bear postoperatively. The aim of the study was to evaluate the results of High Tibial osteotomy using Ilizarov technique in medial compartment osteoarthritis of the knee. From May, 2011 to august, 2016, we treated 30 patients with medial compartment osteoarthritis using the Ilizarov technique.

The patients age ranged from 35-52 years with the mean age being 43.20 years. It shows that incidence of medial compartment Osteoarthritis was common in 4th decade. Higher incidence in this age group probably indicates an age-related cause for the degenerative changes.

The mean follow up in the present study was 30 months. Phaler M *et al.* [11] reported the results of high Tibial osteotomy (open wedge osteotomy with stable plate fixation) in 49 patients with an average follow-up of 10.2 years, 44 patients had excellent knee society scores and only 5 patients had poor scores. Similarly, Bonasia DE *et al.* [12] reported on the outcomes of 141 open wedge high Tibial osteotomy performed from January, 2001 to December, 2009 with a mean follow up 51.5 ± 23.8 months. The mean knee society score and functional scores preoperatively were 55.40 ± 5.32 and 45.1 ± 7.12, which improved to 71.27 ± 5.32 and 68 ± 8.05 at 12 months and further increased to 78 ± 6.42 and 81.5 ± 7.32 at 24 months. Saito T *et al.* [13] reported the outcomes of 64 patients who had undergone medial opening wedge high tibial osteotomy and stable plate fixation with a mean follow up of 6.5 years, The mean Knee Society knee score and function score improved from 49.6 and 56.6 before surgery to 88.1 and 89.4 at final follow-up (p<0.001) respectively. Aydoğdu S *et al.* [14] reported outcomes of knee society score and functional society score in a retrospective study using dome osteotomy and Charnley external fixator in 45 knees with a mean follow-up of 50.3 months, the knee society score and the functional score had an improvement of 83 and 81 at final follow up compared to preoperative values of 54 and 55.

The TFA (Tibio Femoral angle) preoperatively was 10.70 ± 13.31°Varus, postoperatively the TFA (Tibio Femoral angle) shifted to 3.40 ± 1.07° Valgus and 3.77 °± 1.25 °Valgus at 12 and 24 months. Zaki *et al.* [15] reported on the outcomes of open wedge high tibial osteotomy using Tomofix plate in 46 patients with a mean follow up of 60 months, the mean tibiofemoral angle preoperatively was 7° varus (range of 5-10 °) and postoperatively at final follow up was 6° valgus (range 5-8°). Most authors reported a postoperative correction angle between 3-15° valgus [16, 23]. Change in the MAD (mechanical axis deviation) from the Fujisawa point was 2.12 ± 0.75 millimetre pre-operatively and changed to 0.76 ± 0.42 millimetre and 0.75 ± 0,45 millimetre post operatively at 12 and 24 months. In the present study, results were significant when the mechanical axis of the lower extremity crossed the Tibial plateau at the 67.5% mark of the transverse diameter of the Tibial plateau or 35.5% from the centre of the knee joint towards lateral edge of the knee joint. Most authors recommended the point where the mechanical axis crosses the TIbial plateau between 50 and 75% of the transverse diameter of the tibial plateau [24, 26].

The actuality that the current body of literature has a cornucopia of functional scores (Western Ontario and McMasters Universities osteoarthritis score, Knee society score, Boston-Leeds score) creates confusion for research article building in choosing a prime score that surpasses other scores in functional-radiological variables and superior outcome. Until date there is no mid -long term study available that reported functional radiological correlation between the Knee society score,Tibio femoral angle and the Mechanical axis deviation from the Fujisawa point. The current study demonstrates a betterment in knee score with change in TibioFemoral angle from varus to valgus 12 months (p <0.045) and 24 months (*p* value <0.001).This study also shows that as the Mechanical axis approaches the Fujisawa point there is a betterment in the knee society score p value of 0.066 at twelve months and p value of 0.001 at 24 months.

Conclusion

In the light of these results, we concluded that high tibial osteotomy by Ilizarov technique, can be used to treat angular deformity correction about the knee. The joint function, weightbearing while on treatment, the ability to finely correct the deformity and the lack of internal hardware is an advantage which cannot be matched by any other technique.

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