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Functional outcomes of high tibial osteotomy for symptomatic medial compartment osteoarthritis in middle-aged patients-both prospective and retrospective study in Indian population in the quaternary care center

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Abstract
Background: High Tibial osteotomy is a surgical procedure to reposition the mechanical axis of a painful varus knee into a slightly valgus one, which minimizes joint tenderness and also decreases the rate of cartilage degeneration so the joint replacement surgery can be postponed.
Materials & Methods: 500 patients were evaluated in the study. The study population included patients who underwent HTO at Manipal Hospital, Bangalore & those who came for follow-up after surgery during the period 2008 to 2017. An X-ray scanogram was done pre-operatively & post-operatively to assess the correction. Visual analogue score and Knee society score are used to evaluate the functional outcome.
Results: The mean follow-up was 5 years. All the patients showed significant improvement in their postoperative scores. The mean age of the patients in our study at the time of surgery was 46.7 & sex distribution was 55.6% and 44.4% in Females and Males respectively. 44.4 % of the patients underwent left-sided HTO and 55.6 % of the patients were right HTO. The mean BMI was 25.5, the minimum was 19.3 & the maximum was 30.1. 47.2% of patients had normal BMI. The overall complication rate was 4.8% in our study. These complications include Delayed Union (2.4%), Stiffness of the knee (1.6%) and only 4 patients required revision to TKR (0.8%) at 5 years follow-up. The longest follow-up was 14 years and the minimum follow-up was 5 years. All these complications were manageable conservatively as all these complications were minor, and none of the patients required revision surgery.
The visual analogue scale (VAS) was used to assess pain both preoperatively and postoperatively. The VAS and KSS scores significantly improved after surgery (p<0.001). The Knee Society score (knee score and functional score) at 5 years of follow-up was excellent in 22.8%, good in 55.6%, fair in 16.2% and poor in 5.4%.
Conclusions: HTO alleviates pain, enhances activities of daily living, and improves the function and quality of life of patients suffering from symptomatic medial compartmental osteoarthritis of the knee. The success of HTO depends on the correct selection of patients, proper osteotomy, and precise surgical techniques. There are a few complications associated with this procedure, and it has a good success rate. It's an alternative procedure for Knee arthroplasty in symptomatic medial compartmental osteoarthritis patients and can delay the need for Knee arthroplasty which is the end procedure for Osteoarthritis knee.

Keywords: Osteoarthritis knee, high tibial osteotomy, functional outcome

Introduction
Knee osteoarthritis (OA) is one of the most common progressive joint diseases. It is characterized by chronic pain and functional disability [1]. Knee OA accounts for almost four-fifths of the burden of OA worldwide and increases with age and obesity [2]. High tibial osteotomy was first described by Langenbeck in 1854. It is a very effective method to treat unicondylar osteoarthrosis [3]. Friedrich Pauwels and Paul Macquet defined the fundamental principles of osseous deformity correction in 1964 and 1976. Many techniques have been developed for osteotomies around the knee after that.

HTO tactics include the dome, closing wedge, and opening wedge (OWHTO). OWHTO prevents metaphyseal deformity and provides precise healing by opening gradually while maintaining bone mass [4]. It preserves the proximal tibia better and poses no risk of harming the peroneal nerve when considering a future complete knee replacement. An open-wedge high tibial osteotomy proximal to the tibial tuberosity was first described by Debeyre and Patte in 1951 but the disadvantage of this method is the requirement of bone grafts and the risk of donor-site morbidity (Costa Mendes *et al.* 1990-2015) [5]. Following high tibial osteotomy, a fibrocartilaginous layer completely covers the damaged portions of the articular surface, significantly reducing osteosclerosis in the medial compartment of the arthritic knee (Fujisawa *et al.*, 1979) [6].

HTO produces effective long-term effects when precise selection criteria are used and a strict procedure is followed, indicating that these approaches have a place in the treatment of osteoarthritis in its early stages that results from axial deviation. The careful design of the osteotomy, degree of correction, implant, and axis of correction resulted in fewer issues, such as nerve damage, instability, and pseudoarthrosis [7]. Since the development of locking compression plates, periarticular corrective osteotomies have gained importance with or without autografting, and comorbidities resulting from autografts were eliminated with the use of locking plates [8]. We examined the mediolateral and anterior-posterior ligamentous stability, as well as the length of the legs. In the supine position and with the lower extremities fully supported, the alignment is assessed.

Radiographic views: Joint 2 images (AP and lateral views) and a weight-bearing x-ray of the complete lower limb are required for preoperative assessment of the anatomy and the leg axis radiography of the knee.

Fig 1. X-ray scanogram

Aims and Objectives

1. To conduct a combined retro-prospective analysis of high tibial osteotomy in middle-aged patients (aged < 60 years) for the symptomatic medial compartmental osteoarthritis of the knee.
2. To assess the relief of symptoms of osteoarthritis, function, pain and patient satisfaction using VAS and Knee Society scoring system (Knee score and functional score).
3. To evaluate the deformity correction by X-ray.

Inclusion Criteria

1. All the physiologically middle-aged patients admitted to the orthopaedics ward with complaints of knee pain and on the clinical examination have a good range of motion at the knee and require surgical intervention under study and are willing for surgery.
2. The maximum deficiency of 10 degrees in extension at the knee.
3. Isolated symptomatic medial compartment osteoarthritis.

Exclusion Criteria

1. The patients with symptomatic bicompartmental and tricompartmental osteoarthritis.
2. Restricted range of movements at the knee i.e., knee flexion of fewer than 90 degrees or flexion contracture of more than 15 degrees.
3. Patients aged above 60 years.
4. Diagnosed inflammatory osteoarthritis.
5. Deformity correction of more than 20 degrees.
6. Ligamentous instability
7. History of surgery for proximal tibia fracture
8. Secondary osteoarthritis

The patients were explained about osteotomy and its advantages and disadvantages were discussed. Those patients who were willing for the procedure were selected and their consent was obtained.

Methodology: Plain radiography is still the gold standard for OA diagnosis. Kellgren and Lawrence (KL) documented the first official attempts to create a radiographic categorization scheme for OA in 1957 [9].

Level of osteotomy: The peak of the deformity should be the site of the osteotomy. This will lead to the best possible fix. If osteotomy is carried out at a different level, the physiological axis won't be restored and a new deformity will be produced. The area with the best ability to heal is the metaphysis of a long bone. To have a good result, the horizontal joint line (mid-joint line) must be restored or preserved.

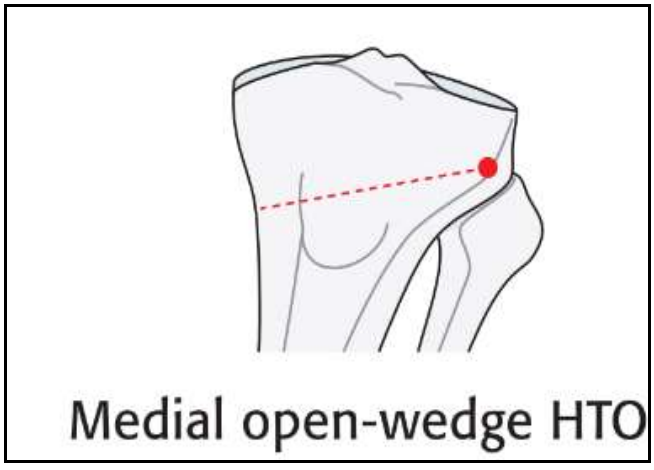


Fig 2: Location of hinge for the planning of varus correction in a left knee (AO – osteotomies around the knee)

Planning method by MINIACI [10]: The preoperative sketch can be completed after the localization and type of osteotomy are determined. Either a digital workstation or the leg's weight-bearing X-ray can be used for this. Fujisawa *et al.* and Miniaci's planning approach is used in our study.

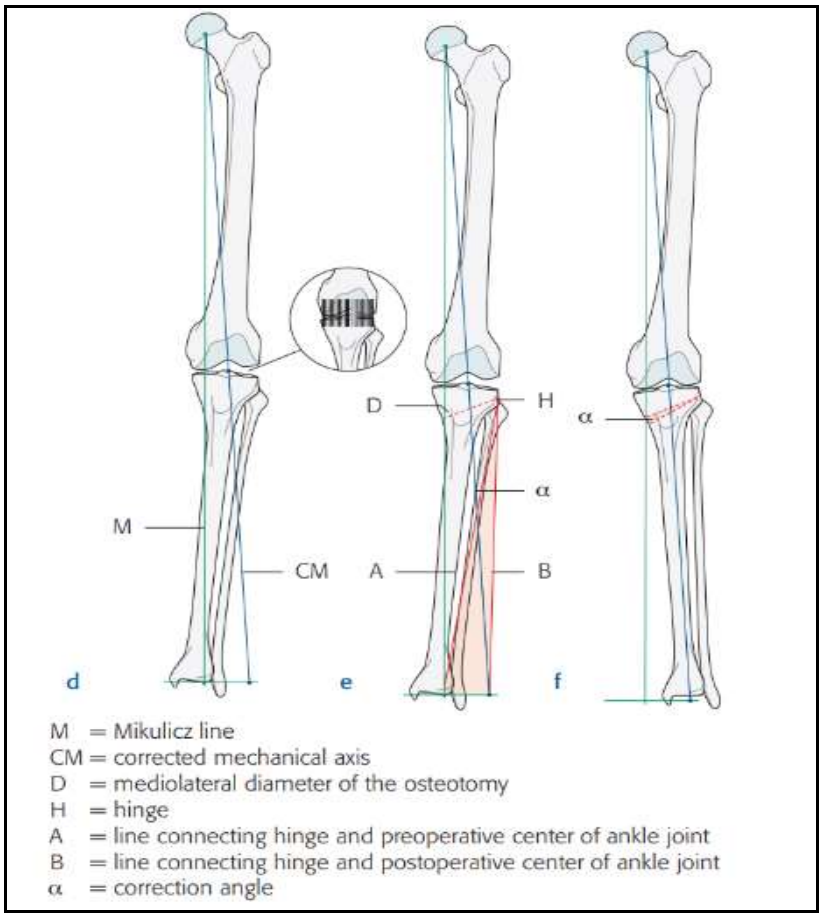


Fig 3: Determining the corrective angle (AO - Knee Osteotomies) The weight-bearing line (WBL) was employed by Miniaci *et al.* to calculate the corrective angle. The WBL for correction is the first line, running from the hip's centre through 60 to 70 percent of the tibial plateau's breadth past the ankle. The second line runs from the ankle's centre to the hinge point. The osteotomy hinge point and the first line's arc junction are connected by the third line. The intended corrective angle is the angle created by the second and third lines (x).

The hinge point in closed-wedge osteotomies is situated 2.5 cm below the joint line in the medial proximal tibial metaphysis. This hinge projects onto the lateral proximal metaphysis during an open-wedge osteotomy, around 15 mm below the subchondral sclerosis zone of the lateral plateau, at the level of the proximal border of the tibiofibular joint. The hinge point in closed-wedge osteotomies is situated 2.5 cm below the joint line in the medial proximal tibial metaphysis. This hinge projects onto the lateral proximal metaphysis during an open-wedge osteotomy, around 15 mm below the subchondral sclerosis zone of the lateral plateau, at the level of the proximal border of the tibiofibular joint. This angle (x) can now be drawn on the proximal tibia using the defined hinge point as the tip of the triangle. In an open-wedge osteotomy, the triangle should also be drawn and the base of the triangle on the medial cortex corresponds to the opening of the osteotomy.

Fig 4: Miniaci method (AO – Osteotomies around the knee)

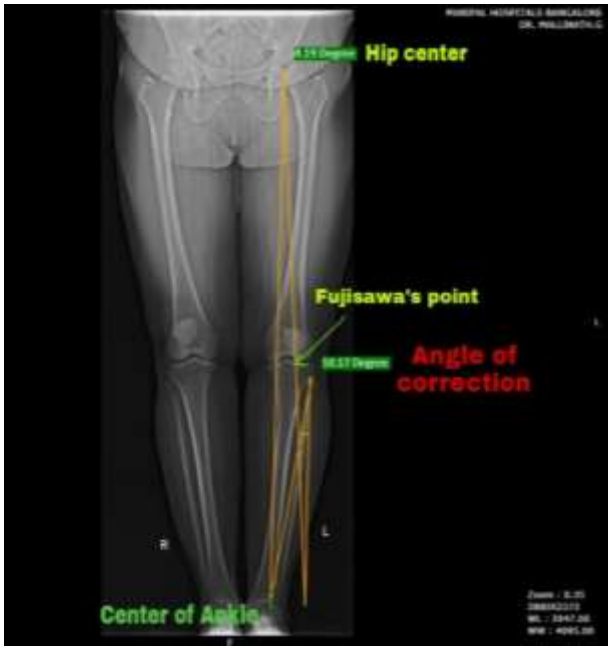


Fig 5: Angle of correction

Degree of correction [11]:
According to Fujisawa's theory, the mechanical axis should pass through 30 to 40 percent of the tibial plateau for optimal outcomes, and 62.5 percent of the tibial plateau's medial breadth should be used.
According to Miniaci's theory, the mechanical axis should pass through 60 to 70% of the tibial plateau as measured from the medial plateau.
Depending on the severity of the illness, Jacob and Murphy altered Fujisawa's prescriptions. The mechanical axis should travel 1/3 the distance to the Fujisawa's point in cases of mild osteoarthritis and the full distance in cases of severe osteoarthritis. A 3-degree overcorrection on average has been found to produce the best results.

Effects of Osteotomy: The degenerated medial compartment cartilage is thus decompressed resulting in a relief of pain and a delay of cartilage damage. This helps the patient to walk without pain and thereby increases the functional outcome of the knee joint.

AO HTO Plate (Tomofix)

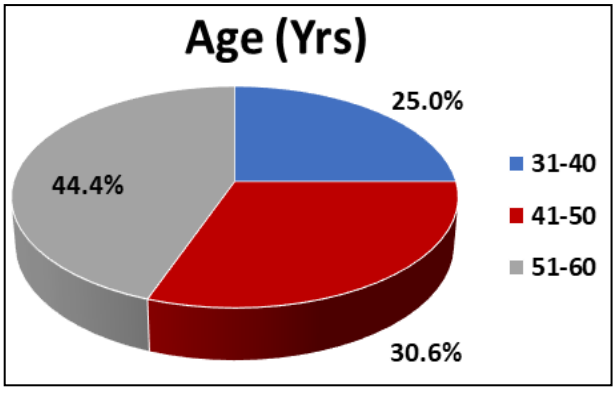
Fig 6-7: The clinical image and the pictorial demonstration of the TomoFix internal plate fixator with three threaded holes in the T-arm and 5 combination holes on the longitudinal arm.

Results & Observations

Table 1: Distribution of Cases according to Age

Age (Yrs)	No. of cases	%
31-40	125	25
41-50	153	30.6
51-60	222	44.4
Total	500	100

Descriptive Statistics	Min	Max	Mean	SD
Age (Yrs)	31.0	59.0	46.7	7.9

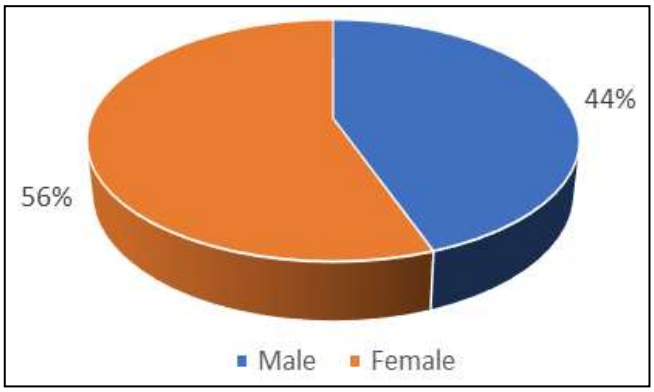


Graph 1: Distribution of Cases according to Age

The mean age of the patients in our study at the time of surgery was 46.7 and the patients above the age of 50 have a higher incidence of Osteoarthritis (Haq *et al.* 2003) [12]

Table 2: Distribution of Cases according to Sex

Sex	No. of cases	%
Male	220	44
Female	280	56
Total	500	100

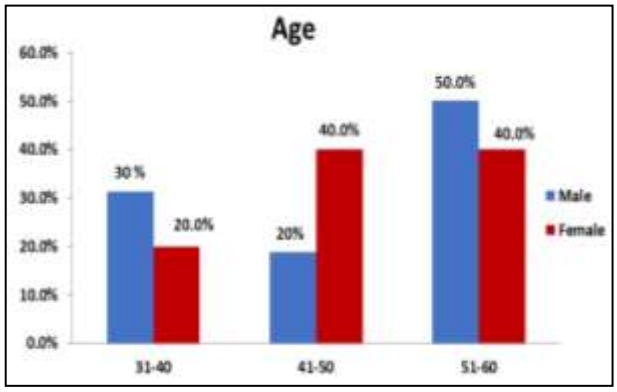


Graph 2: Distribution of Cases according to Sex

The distribution of sex in your study was 56% and 44% in females and males respectively. Srikanth *et al.* [13] 2005 study results demonstrate the presence of sex differences in OA prevalence and incidence, with females generally at a higher risk. Females also tend to have more severe knee OA, particularly after menopausal age.

Table 3: Association of Age and Sex

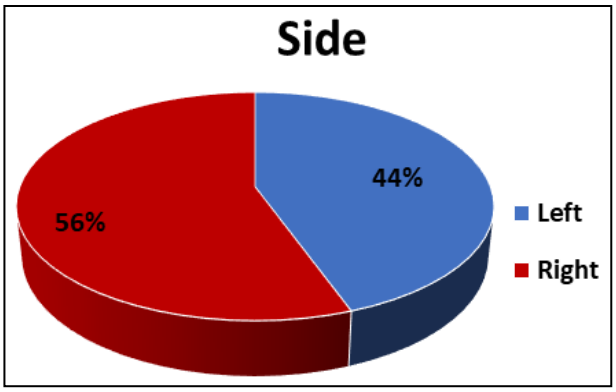
Age (Yrs)	Male		Female		p-value
	N	%	N	%	
31-40	66	30%	56	20%	0.375
41-50	44	20%	112	40%	
51-60	110	50%	112	40%	
Total	220	100%	280	100.0%	



Graph 3: Association of Age and Sex

Table 4: Distribution of Cases according to Side

Side	No. of cases	%
Left	126	45
Right	154	55
Total	500	100



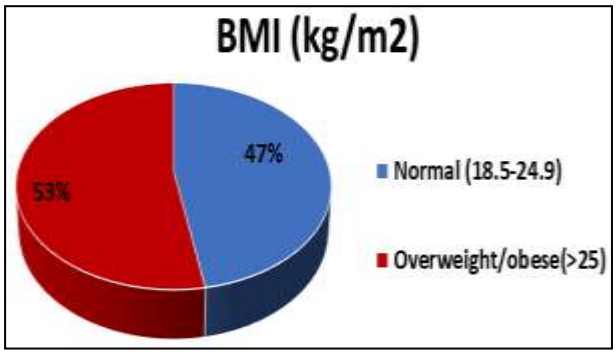
Graph 4: Distribution of Cases according to Side

44 % of the patients underwent left HTO and 56 % of the patients were Right HTO.

Table 5: Distribution of Cases according to BMI

BMI (kg/m2)	No. of cases	%
Normal (18.5-24.9)	235	47
Overweight (>25)	250	50
Obese (>30)	15	3
Total	500	100

Descriptive Statistics	Min	Max	Mean	SD
BMI (kg/m2)	19.3	30.1	25.5	2.6

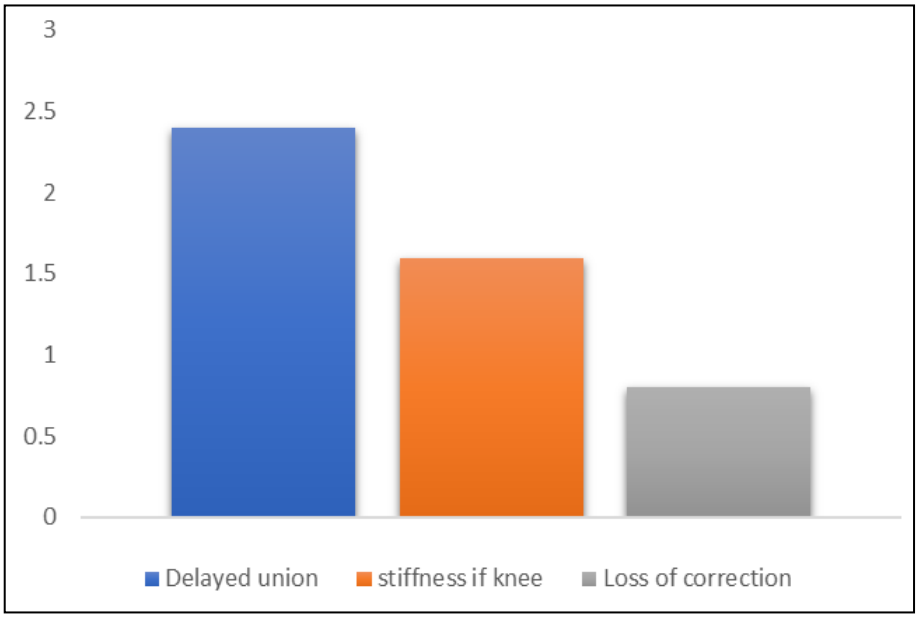


Graph 5: Distribution of Cases according to BMI

The mean BMI was 25.5, the minimum was 19.3 and the maximum was 30.1 out of which 47% of patients had normal BMI. 3% were under the overweight category and 3% were obese. According to a study conducted by Stephanie Floerkemeier, persons with high BMIs had somewhat worse functional outcomes than those with normal BMIs *et al.* [14].

Table 6: Distribution of Cases according to Complications

Complications	No. of cases	%
Delayed Union	12	2.4
Stiffness Of Knee	8	1.6
Loss of correction and progression of OA	4	0.8
Total	24	4.6



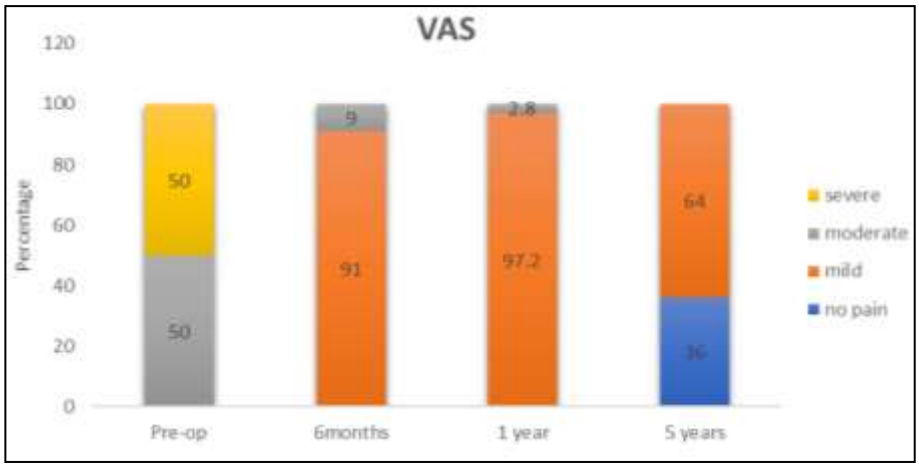
Graph 6: Distribution of Cases according to Complications

The overall complication rate was 4.6% in our study. These complications include Delayed Union (2.4%), Stiffness of the knee (1.6%), and Loss of correction and progression of OA which is comparable to Hunt *et al.* [15] who had an overall complication rate of 7.6% in their study. 4 patients who had a loss of progression and development of OA underwent Total knee replacement.

Table 7: Distribution of VAS according to follow-up

VAS	Preop		6 Months		1 Year		5 Year	
	N	%	N	%	N	%	N	%
No Pain	0	0	0	0	0	0	180	36
Mild	0	0	455	91	486	97.2	320	64
Moderate	250	50	45	9	14	2.8	0	0
Severe	250	50	0	0	0	0	0	0
Total	500	100	500	100	500	100	500	100

VAS	
O	NO PAIN
1 TO 3	MILD
4 TO 6	MODERATE
7 TO 10	SEVERE



Graph 7: Distribution of VAS according to follow-up

Table 8: Distribution of Mean VAS according to follow-up

Scores	Preop	6 Months	1 Year	5 Year	p-value		
					Preop & 6 Months	Preop & 1 Year	Preop & 5 Year
VAS	6.47±0.65	2.44±0.88	1.89±0.82	0.83±0.74	<0.001*	<0.001*	<0.001*

Note: p-value* significant at 5% level of significance (p<0.05)

Graph 8: Distribution of Mean VAS according to follow-up

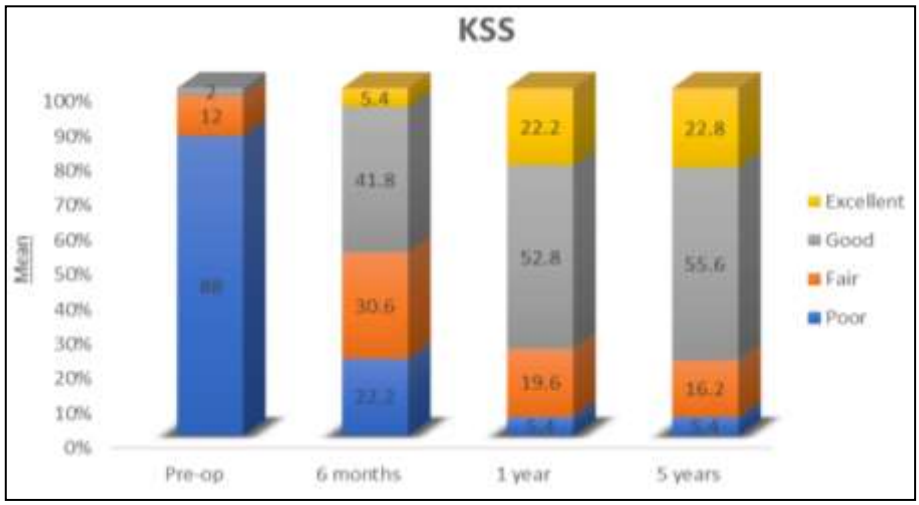
The Visual analogue scale (VAC) was used to assess the pain both preoperatively and postoperatively.

Most of the patients had a preoperative score of 7 (47.2 %) followed by 6 (44.4%), 5(5.6%), and 8(2.8%). Postoperatively majority of patients had a score of 1 (44.4%), followed by 0 (36.1%), and 2(19.4%).

The VAS score significantly improved after surgery (p<0.001).

Table 9: Distribution of KSS according to follow-up

KSS	Preop		6 Months		1 Year		5 Year	
	N	%	N	%	N	%	N	%
Poor (<120)	440	88	111	22.2	27	5.4	27	5.4
Fair (120-139)	60	12	153	30.6	98	19.6	81	16.2
Good (140-160)	0	0	209	41.8	264	52.8	278	55.6
Excellent (>160)	0	0	27	5.4	111	22.2	114	22.8
Total	500	100	500	100	500	100	500	100

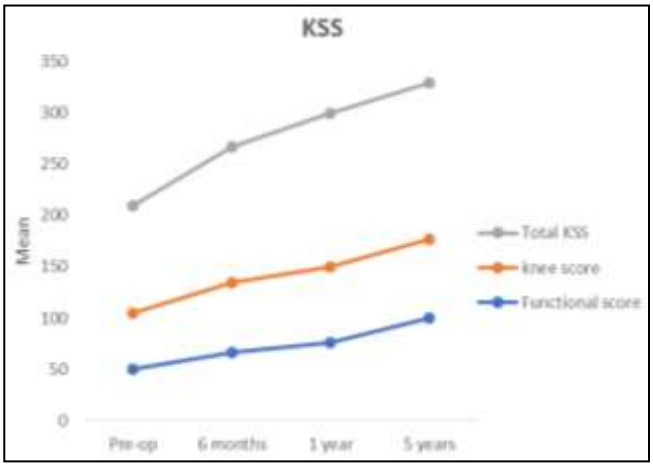


Graph 9: Distribution of KSS according to follow-up

Table 10: Distribution of Mean KSS according to followup

Scores	Preop	6 Months	1 Year	5 Year	p-value		
					Preop & 6 Months	Preop & 1 Year	Preop & 5 Year
Function Score	50.42±8.4	66.53±12.12	75.97±9.17	77.36±9.75	<0.001*	<0.001*	<0.001*
Knee Score	54.06±5.36	67.69±7.61	73.53±7.27	75.83±7.37	<0.001*	<0.001*	<0.001*
Total KSS	104.47±12.25	134.22±19.13	149.5±15.05	153.31±16.48	<0.001*	<0.001*	<0.001*

Note: p-value* significant at 5% level of significance (p<0.05)



Graph 10: Distribution of Mean KSS according to followup

The KSS score significantly improved after surgery (p<0.001). The Knee Society score at 2 years of follow-up was excellent in 22.8%, good in 55.6%, fair in 16.2% and poor in 5.4 %.

The pre-operative varus deformity mean was 10º and the mean correction of deformity in our study was 5.6º of valgus. Ivarsson *et al.* [16] recommended 3 to 5 degrees of valgus correction.

Table 11: Mean Knee ROM

Knee ROM	Mean
Pre-op	100º
Post-op	120º

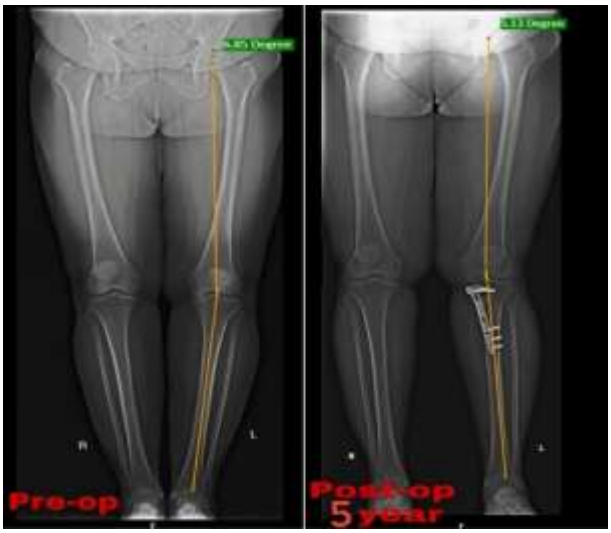


Fig 8: Pre-op varus 6.85 degrees corrected and it was maintained at 5.13 degrees of valgus at 5 years follow-up.

Fig 9: Clinical preop and post-op follow-up images

5-year follow-up x-ray

Fig 10: Preop and follow-up serial X-rays

Discussion

Age is not a definitive criterion for this procedure, but the patients should be active enough to undergo post-op rehabilitation, should have adequate bone quality and should be able to follow non-weight-bearing mobilization for 6 weeks. Patients above the age of 50 have a higher incidence of Osteoarthritis (Haq *et al.* 2003) [12]. In our study maximum i.e., 44.4% of the study population was above 50 years.

Srikanth *et al.* in 2005 [13] study results demonstrated the presence of sex differences in OA prevalence and incidence, with females generally at a higher risk. Females also tend to have more severe knee OA, particularly after menopausal age. Ivarsson *et al.* 1990 [16] recommended that significantly better results were found in a mean angulation of 3 degrees to 7 degrees of valgus had been achieved at operation. The best results were seen in knees with pre-operative grade I or grade II osteoarthritis and valgus deviation after osteotomy which we have followed in our study. A patient's chance of having failed surgery is ten times greater if their BMI is greater than 30. Therefore, a BMI of 25 to 27.5 is appropriate for HTO. However, the mechanical stability and load-bearing tolerance provided by newer, more modern plate fixators are sufficient to eliminate patient weight as a risk factor for fixation. No patient should be turned away from these operations solely because they are obese [Bonasia *et al.* [17] Stephanie Floerkemeier *et al.*] [14].

The open-wedge HTO approach produced better results in terms of functional scores than closed-wedge osteotomy in both early and late follow-up, requiring less time for full-weight bearing [Sanjay Agarwal *et al.*, Kolb *et al.*, Luites *et al.*, 2009] [18, 3, 19]. The successful outcome of HTO can be maintained for more than 8 to 10 years delaying the need for conversion to TKA (Lee and Byun, 2012)[20].

Conclusions

1. Medial open wedge osteotomy is a good option in unicompartmental symptomatic osteoarthritis and relieves pain and improves functional outcomes in patients.
2. The results are evident and are maximum at 5 years.
3. No hazardous complications were noted in any patients.
4. In future, if Total knee replacement is planned, it will not be a problem as the adequate bone stock is preserved.

References

1. Hunter DJ, Bierma-Zeinstra S. Osteoarthritis. The Lancet. 2019 Apr 27;393(10182):1745-1759.
2. Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015 - The Lancet [Internet]. [cited 2021 Aug 10]. Available from: https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(16)31678-6/fulltext
3. Kolb W, Guhlmann H, Windisch C, Kolb K. High Tibial Open-Wedge Osteotomy – New Techniques and Early Results. In: Chen Q, editor. Osteoarthritis - Diagnosis, Treatment and Surgery [Internet]. In Tech; c2012 [cited 2021 Sep 9]. Available from: http://www.intechopen.com/books/osteoarthritis-diagnosis-treatment-and-surgery/high-tibial-open-wedge-osteotomy
4. Siboni R, Beaufils P, Boisrenoult P, Steltzlen C, Pujol N. Opening-wedge high tibial osteotomy without bone grafting in severe varus osteoarthritic knee. Rate and risk factors of non-union in 41 cases. Orthop Traumatol Surg Res OTSR. 2018 Jun;104(4):473-476.
5. Costa Mendes L, Sauvigné T, Guiol J. [Morbidity of autologous bone harvesting in implantology: Literature review from 1990 to 2015]. Rev Stomatol Chir Maxillo-Faciale Chir Orale. 2016 Dec 1;117(6):388-402.
6. Fujisawa Y, Masuhara K, Shiomi S. The effect of high tibial osteotomy on osteoarthritis of the knee. An arthroscopic study of 54 knee joints. Orthop Clin North Am. 1979 Jul;10(3):585-608.
7. Liu X, Chen Z, Gao Y, Zhang J, Jin Z. High Tibial Osteotomy: Review of Techniques and Biomechanics. J Healthc Eng. 2019 May 2;2019:e8363128.
8. Sarman H, Isik C, Uslu M, Inanmaz ME. High Tibial Osteotomy Using a Locking Titanium Plate With Or Without Autografting. Acta Ortop Bras. 2019;27(2):80-84.
9. Kohn MD, Sassoon AA, Fernando ND. Classifications in Brief: Kellgren-Lawrence Classification of Osteoarthritis. Clin Orthop. 2016 Aug;474(8):1886-1893.
10. Lobenhoffer P, van Heerwaarden RJ, Staubli AE, Jakob RP. AO Osteotomies around the Knee [Internet]. AO

Publishing; p. 300. Available from: file:///D:/DR%20SAGAR/THESIS/AO_Osteotomies_around_the_Knee.pdf
11. Mhaskar V, Maheshwari J, Jain Y. Current Concepts in High Tibial Osteotomy; c2021 Mar 18.
12. Haq I, Murphy E, Dacre J. Osteoarthritis. Postgrad Med J. 2003 Jul 1;79(933):377-383.
13. Srikanth VK, Fryer JL, Zhai G, Winzenberg TM, Hosmer D, Jones G. A meta-analysis of sex differences prevalence, incidence and severity of osteoarthritis. Osteoarthritis Cartilage. 2005 Sep;13(9):769-781.
14. Floerkemeier S, Staubli AE, Schroeter S, Goldhahn S, Lobenhoffer P. Does obesity and nicotine abuse influence the outcome and complication rate after open-wedge high tibial osteotomy? A retrospective evaluation of five hundred and thirty three patients. Int Orthop. 2014 Jan;38(1):55-60.
15. Hunt N, Watts M, Hayes D, Owen J, McMeniman T, Amato D, *et al.* Closing wedge high tibial osteotomy: review of 374 cases. Orthop Proc. 2005 Sep 1;87-B(SUPP_III):346-346.
16. Ivarsson I, Myrnerts R, Gillquist J. High tibial osteotomy for medial osteoarthritis of the knee. A 5 to 7 and 11 year follow-up. J Bone Joint Surg Br. 1990 Mar;72(2):238-244.
17. Bonasia DE, Governale G, Spolaore S, Rossi R, Amendola A. High tibial osteotomy. Curr Rev Musculoskelet Med. 2014 Dec 1;7(4):292-301.
18. Agarwala S, Sobti A, Naik S, Chaudhari S. Comparison of closing-wedge and opening-wedge high tibial osteotomies for medial compartment osteoarthritis of knee in Asian population: Mid-term follow-up. J Clin Orthop Trauma. 2016;7(4):272-275.
19. Luites JWH, Brinkman JM, Wymenga AB, van Heerwaarden RJ. Fixation stability of opening- versus closing-wedge high tibial osteotomy: a randomised clinical trial using radiostereometry. J Bone Joint Surg Br. 2009 Nov;91(11):1459-1465.
20. Lee DC, Byun SJ. High tibial osteotomy. Knee Surg Relat Res. 2012 Jun;24(2):61-69.

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