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The Results of High Tibial Open-Wedge Osteotomy and Fixation with Puddu Plate for Treatment of Genu Varum in Adults

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ABSTRACT

Background:*High tibial osteotomy remains one of the important options for the treatment of knee malalignment and angular deformity about the knee. This study aimed to evaluate the efficacy and safety of medial open-wedge high tibial osteotomy using Puddu plate for treatment of genu varum in adults*. ***Patients and Methods****: This is a retrospective study evaluating 18 knees in 18 patients who had undergone medial open-wedge osteotomies with Puddu plates at Zagazig University Hospitals and El-HELAL Hospital between January 2019 and June 2020 for varusmalalignment. Our study population consisted of 11 male, 7 female, with a mean age of 24.556 ± 7.326 (17-40) years at surgery time. For the clinical evaluation of the patients Hospital of Special Surgery (HSS) score, and for the radiological assessment mechanical axis deviation (MAD), Tibio-femoral angle, medialproximal tibial angle (MPTA) Follow-up averaged six months.* ***Results****:In this study, the average varusangleto be corrected was 10.278 ± 3.427, with 13 patients left knee and 5 patient right knee, the preoperative HSS score was78.722±6.918, based on median 6 months follow up of the patients, mean improvements obtained in HSS score was 24.706±9.967. There were 4 (22.2%) patients who had post-operative complications, two (50%) of them had under correction, one (25%) had delayed union and the 4th one had superfacial wound infection that was successfully managed without surgical intervention.****Conclusion*** *:Therefore, we believe that HTO using Puddu plate could be realized safely with considerable success and encouraging outcomes.*

Keywords*: Gonarthrosis, Open-wedge osteotomy, Puddu plate.*

I. INTRODUCTION

High tibial osteotomy remains one of the important options for the treatment of knee malalignment and angular deformity about the knee. The overall principle is to adjust the mechanical access of the lower limb such that

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the load is redistributed from one compartment to the other. High tibial osteotomy principally is indicated to correct varus alignment into valgus alignment, but it also can be used for the opposite correction. Indications for surgery fall into two main groups: (a) for unloading a compartment suffering from early degenerative change, and (b) for controlling instability of the knee resulting from specific ligamentous laxities [1].

High tibialostetomy procedure is thought to resolve pain owing to its decompressive effect in early period, while this effect leads to an improvement in knee functions due to the translation of the mechanical axis onto relatively intact lateral tibial plateau in long term, subsequently it prevents the development of arthrosis. Jackson and Waugh[2], first described high tibial osteotomy and Coventry[3], popularized this technique by publishing long-term results. Later various modifications of high tibial osteotomies were described.Although in 1951 Debeyre[4], delineated medial open wedge osteotomy technique, it has not been used widely. At the end of 1990s due to the introduction of fixation plate named Puddu into clinical practice, and relative simplicity of the technique the procedure of medial open-wedge osteotomy gained popularity[5].

Opening-wedge high tibial valgus osteotomy with Puddu plate fixation can be a reliable procedure for the treatment of medial-compartment osteoarthritis of the knee associated with varusdeformity[6].

The lateral closed wedge high tibial osteotomy (HTO) described by Jackson and Coventry is a classical operation to treat osteoarthritis of the medial compartment and varus deformity, but it has some problems such as peroneal nerve palsy, nonunion of fibula, and loss of the bone. Medial opening HTO hadbeen developed, because it had some advantages over the closed wedge technique. However, suitable bone substitutes to fill the opened defect and suitable fixation plates to fix the osteotomized site in the medial opening procedure have not been identified[7].

Normally, the tibiofemoral angle progresses from pronounced varus before the age of 1 year to valgus between ages from 1.5 to 3 years[8].

Varus instability might be caused by 1) rupture and/or elongation of thelateral soft tissues, or 2) a loss of bone medially, or both. If the knee was to be compressed axially (as on bearing weight or during muscular contraction), aknee with normal bones would tend to be stabilized in normal alignment, whereas the knee with bone loss would tend to be driven into the position of deformity. Lateral collateral ligament elongation or rupture may also play a part in the genesis of varus instability (elongation of lateral collateral ligament- as against rupture-seems to be a more likely possibility[9].This study aimed to evaluate the efficacy and safety of medial open-wedge high tibial osteotomy using Puddu plate for treatment of genu varum in adults.

II. PATIENTS AND METHODS

This is a retrospective study evaluating 18 knees in 18 patients who had undergone medial open-wedge osteotomies with Pudduplates atZagazig University Hospitals and El-HELAL Hospital between January 2019 and June 2020 for varusmalalignment. There were 11 male, 7 female, with a mean age of 24.556 ± 7.326 (17-40) years at surgery time. The average varus angle to be corrected was 10.278 ± 3.427degrees, with 13 patients left knee and 5 patient right knee. Approval taking Institutional Review Board (IRB)approval and also informed written consent was taken from patients and/or their caregivers. This Work was performed according to the code

of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.**Inclusion criteria**: Range of motion being at least 90-100, Varus mal- alignment across the knee, Varus deformity < 20 degree, After closure of physis and less than 60 years old, Compliant patient that will be able to follow postop protocol, Absence of knee contractures

Stable knee with good collaterals. **Exclusion criteria**: Before closure of physis and more than 60 years, Combined medial and lateral arthrosis, Severe articular destruction (≥ Alback grade 3), Flexion contracture greater than 20 degrees, Lack of flexion beyond 80 degrees,Instability allowing the tibia to subluxate more than 1cm, Significant patellofemoral disease, Varus deformity > 20 degree, Obese patient BMI > 35, Prior lateral menisectomy or lateral tibiofemoral cartilage damage.

Pre-operative:

Pre operative assessments of our patients were performed using Demographic data taking, HSSS (Hospital for Special Surgery Knee Rating Scale) to assess the functional outcome pre and post-operatively, all patients were examined clinically for evaluation of the type of the deformity, degree of deformity, range of knee motion, stability of the knee, painful or not, whether it is unilateral or bilateral.Radiograph was done for the deformed knee AP and lateral views, Long standing scanogram of both lower limbs to assess, Mechanical axis deviation (MAD), Tibio-femoral angle, Medial proximal tibial angle (MPTA) .

Deformity is present when there is mechanical axis deviation which is the perpendicular distance from the center of the knee to the mechanical axis of the lower limb. Our measurements assume that the knee is seen in full extension and neutral rotation [10][(56)].

Surgical technique:

After preoperative evaluation and preparation of our patients, firstly arthroscopic examination was performed with the patient in the supine position under general anesthesia. We used exposure to the anteromedial aspect of the tibia through a vertical skin incision centered between the medial border of the anterior tibial tubercle and the anterior edge of the medial collateral ligament (at line of medial border of patella) and extending 6–8 cm distally to the joint line (Fig. 1a). The investing fascia was incised and the pesanserinus was identified. Superficial medial ligament was dissected from the bone proximally up to the level of osteotomy. Then under the guidance of fluoroscopy, with the knee in extension, 2 K-wires (3 mm) were advanced medially from 1–2 cm distal to the level of the joint up to the lateral cortex and parallel to the joint line to ensure maintenance of the original tibial slope and prevent extention of the fracture to the tibial condyles.Afterwards other K-wire (2.4 mm) was introduced at an appropriate angle up to the lateral cortex.The osteotomy was performed, keeping the oscillating saw blade below and parallel to the guide pin to prevent an intra articular fracture. The saw was used to cut the medial cortex only (Fig. 1b).Then a sharp osteotome was used to finish the osteotomy, making certain that the all the cancellous metaphysis and especially the anterior and posterior cortices were completely interrupted, but preserving a lateral hinge of approximately 0.5 cm of intact bone.Then using 10, 25, and 35 mm width, long and thin osteotomies, osteotomy was performed under fluoroscopic control. Osteotomy line was opened and widened with a special wedge shaped spreader. Meanwhile the mechanical axis of the lower extremity was measured with special probes.After adequate exposure of the osteotomy line, the osteotomy guide was removed and an appropriate plate was placed inside the osteotomy line. The plate was placed just on the

anterior aspect of the medial ligament to hold the proximal end of the tibia and the tibial shaft. The plate was fixed proximally with two 6.5mm cancellous screws parallel to osteotomy and distally with two 4.5-mm cortical screws or two 6.5mm cancellous screws (Fig. 1c).The proximally placed screws were not allowed to come in direct contact with the joints. Finally, using tricortical grafts taken from the Iliac bone graft used to fill osteotomy gab. The wound was closed by repairing the tendons and the superficial medial collateral ligament (Fig. 1d). After the closure of the layers and placement of a drain, the patient's knee was put into a hinged knee brace for 12 weeks.

Figure 1.Intraoperative photographs of a medial open-wedge osteotomy procedure with Puddu plate. a- Incision and exposure.b- Osteotomy.c- Plate Fixation d- Drainage and closure.

Post-operative care and follow up:

Soon after the operation, the patient started isometric quadriceps exercises and postoperative x-ray knee A-P and lateral view was done. 1st visit after 2 weeks, new x-ray was done and assessment of the wound and removal of the surgical stitches. 2nd visit after 1month, a new x-ray was done to assess bone union at the osteotomy site. 3rd visit after one and half month, a new x-ray was done to assess bone union and if there is a good callus the patient is allowed partial weight bearing and flexion and extension exercises. 4th visit 2 months after the operation, a new x-ray was done to assess bone healing, quadriceps strength and range of motion. 5th visit 3 months after the operation to ensure the patient is full weight bearing with full knee range of motion and removal of the hinged knee brace. The patient was followed up regularily every month till the 6th month.

Statistical analysis

Data analysis was performed using the software SPSS (Statistical Package for the Social Sciences) version 20. Quantitative variables were described using their means and standard deviations. Categorical variables were described using their absolute frequencies and were compared using Chi square test and fisher exact test when appropriate. Kolmogorov-Smirnov (distribution-type) and Levene (homogeneity of variances) tests were used to verify assumptions for use in parametric tests. To compare the same parameters at two points of time, paired sample t test (for normally distributed data) was used. To assess correlation between two continuous variables of not normally distributed data, spearman rank correlation coefficient was used. Percent change was calculated by subtracting postoperative value from preoperative value then divided it by preoperative value*100, The level statistical significance was set at 5% ($P<0.05$). Highly significant difference was present if $p\leq0.001$.

III. RESULTS

Age of the studied patients ranged from17 to 40 years with mean 24.556 years. About 83% of them presented with deformity. Larger percentage (72.2%) had left side deformity. Varus angle ranged from 7 to 20 degrees with mean 10.278 degree. Angle correction ranged from 10 to 18 with mean 11.333 degree. Size of plate ranged from 8 to 14 with mean 9.889. (Table 1).

Preoperative HSS ranged from 68 to 100 with mean 78.722 while postoperatively, it ranged from 90 to 100 with mean 97.556.There is statistically significant increase in HSS postoperatively. Regarding percent change in HSS, it ranged from -7.955% to 39.706% with median 26.582% (Table 2).

About 22% of patients had postoperative complications. Out of the four patients, two had under correction, one had delayed union and the last one had superficial infection (Table 3).

There is statistically non-significant correlation between percent change in posterior tibial slope and either age, varus angle, angle correction, size of plate, percent change in HSS or time to bear weight (Table 4).

Table (1): Distribution of the studied patients according to demographic and clinical data and orthopedic measurements.

Parameters	**N=18**	**%**
Age:		
Mean ± SD	**24.556** ± 7.326	
Range	17 – 40	
Presenting symptoms:		
Deformity	15	83.3%
Pain	3	16.7%
Side of deformity:		
Left	13	72.2%
Right	5	27.8%
	N=18 (%)	
Varus angle:		
Mean ± SD	10.278 ± 3.427	
Range	7 – 20	
Angle correction:		
Mean ± SD	11.333 ± 2.169	
Range	10 – 18	
Size of plate:		
Mean ± SD	9.889 ± 2.422	
Range	8 – 14	

Table (2): HSSS pre and six months postoperatively among the studied patients.

HSSS	**Time**		**Test**	
	Preoperatively	**6 months postoperatively**	**t**	**p**

Mean ± SD **Range**	78.722 ± 6.918 68 – 100	97.556 ± 3.053 90 – 100	-12.483	<0.001**
Percent change: Mean ± SD Median (Range)	24.706 ± 9.967 26.582 (7.955 – 39.706)			

t Paired sample t test p>0.05 is statistically non-significant

Table (3): Distribution of the studied patients according to complication:

Complications:	**N=18**	**%**
Non-Complicated **complicated**	**14** **4**	**77.8%** **22.2%**
Delayed union Superficial infection Under correction	1 1 2	25 25 50

Table (4): Correlation between percent change in posterior tibial slope and both age and clinical variables among the studied patients.

Variables	**Percent change in posterior tibial slope**	
	r	**p**
Age (years)	0.168	0.504
Varus angle	0.107	0.672
Angle correction	-0.077	0.762
Size of plate	0.1	0.693
% change in HSS	0.238	0.341
Time to bear weight	0.144	0.569

r Spearman rank correlation coefficient

IV. DISCUSSION

The clinical goals of osteotomy are pain relief, functional improvement, allowance of heavy functional demands, and extension of the functional life of the natural knee [11]. The surgical goal is to transfer the weight-bearing forces from the arthritic portion of the knee to a healthier part of the joint[12]. To obtain successful results in HTO not only requires the application of a good surgical technique but also depends on appropriate patient selection. The factors which will increase the rate of success obtained from hightibial osteotomy using**Puddu plate** with graft procedures include presence of isolated medial compartment arthrosis, good patient compliance for the postoperative rehabilitation program, patients aged < 60 years, absence of knee contractures and excessive patellofemoralarthrosis, range of motion being at least 90 to 100 degrees, varus angle <20 degrees, stable knees and the usage of rigid fixation material for osteosynthesis[13].

This study consist of 18 knees in 18 consecutive patients complying with the inclusion criteria, they had performed open-wedge HTO between January 2019 and June 2020 for varusmalalignement. There were 11 males and 7 females, with a mean age of 24.556±7.326 years at time of surgery. The average varusangleto be corrected was 10.278 ± 3.427, with 13 patients left knee and 5 patient right knee, the preoperative HSS score was 78.722±6.918, based on median 6 months follow up of the patients, mean improvements obtained in HSS score was 24.706±9.967. According to this assessment scale, the preoperative score was bad and postoperative was good.

Hernigou et al.[14] followed 93 cases with arthrosis of the medial compartment that had undergone open-wedge osteotomies for a median of 11.5 years and reported that the results obtained were satisfactory up to 7 years postoperatively.

Several studies report that younger patients respond better and longer to realignement osteotomy, although others did not show a clear relationship between age of the patient and results of the osteotomy, nowadayschronological age per se is not accepted as a criterion for eligibility. Bone texture, daily activity level and biological age have a greater impact on selection criteria[3].

Most authors recommend overcorrection in HTO in middle-aged patients, to effectively unload the medial compartment. It was found that these patients did not have poor results[15,16].

Coventry et al. [3]stated that they had obtained successful results in varus or neutral (64%) and in 4-6 valgus (94%) positions. In a study by **Hernigou et al.**[14]arthrosis did not deteriorate in patients maintained in 3-6 valgus position.

A study found that the average loss of correction at 10 years post-operatively was 2.4. explaining why patients experience good results only in the medium term[17].

In this study, the goal was set to restore a neutral alignement. Setting this goal is one advantage of an earlier osteotomy, such that overcorrection is not necessary to achieve enough off-loading and pain relief and saves the young patient from the unappealing cosmesis of valgus lower extremities. It also avoids shifting the load all the way to the lateral compartment, setting the stage for lateral gonarthrosis[15].

In this study, an average of neutral alignement was achieved, but some patients had alittle error of corrections. However, we did not observe poor functional results in patients who had under-correction. we think

that this result comes from my short folloe-up period. In early postoperative period, most of patients are satisfied because osteotomy results in decompressive effect on bone.

Bombaci and colleagues[18]**.**showed that the tibio-femoral range of motion decreased by 5-10 degrees in some knees post-operatively. Most of these patients complain of pain or limitation of the patella-femoral joint were observed. They also showed that the posterior tibial slope had a significant increase of 3.5 degrees.

In this study, the knee range of motion and posterior tibial slope were not affected and none of the patients complained of major symptoms related to the patelo-femoral joint.

One of the most important complications reported for either closed or open wedge osteotomies is patella infra or alta. Concerns regarding patellar height have been raised by some like **Wright**[19]. Based on **Insall-salvati index** we did not find neither patella infra nor patella alta in our patient group.

Spahn[20]**,** reported a complication rate as high as 43.6% related to the use of Puddu plate. These included implant failure (16.4%), fractures of lateral tibial plateau (14.6%)

Infection (7.3 %), hematoma (3.6%), and deep venous thrombosis (1.8%). They recommended immediate revision in case of infection. Other complications include neurological injury (mainly; peroneal nerve palsy), and non-union of the osteotomy.

In this study, there were 4 patients who had post-operative complications, two of them had undercorrection, one had delayed union and the 4th one had superfacial wound infection that was successfully managed without surgical intervention.

Our study is limited by short follow-up period and small number of patients. A large group of subjects with long-term follow-up is needed to evaluate the long-lasting effects of HTO in this age group. However, early results obtained indicate that medial open-wedge osteotomies using **Puddu plate** could be done safely with considerable success with encouraging outcomes, and this technique could be a good alternative for unicompartmentaltotal knee arthroplasty. Comparative studies with longer follow-up periods will be required to demonstrate its favorable effects on arthrosis in the long term.

V. CONCLUSION

Early results obtained from this study indicate that HTO using Puddu plate could be realized safely with considerable success and encouraging outcomes and this technique could be a good alternative for unicompartmental total knee arthroplatsy but this needs a longer follow up periods. Comparative studies with longer follow up periods will be required to demonstrate its real effect on arthrosis in the long term.

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