Proximal tibia medial Opening-wedge osteotomy using Puddu plate for treatment of medial compartment osteoarthritis with varus knee deformity in adolescent and young adult.

Mohamed S Singer MD, Mohammed Anter Meselhy MD and Osama M. Essawy. MD

Orthopedic department of Benha University, Banha

Corresponding author: Mohammed Salah Singer, MD
Ass. Professor orthopaedic surgery, Benha University, Egypt
Phone: +20 1227323479
Fax: +20 (13) 3227518
Address: Orthopedic department, Benha University, Banha, Qalyubia 13511, Egypt
Email: mhsedsharff@yahoo.com

The Egyptian Orthopedic Journal; 2017 supplement (1), July., 52: 106-111

Abstract

Background
Puddu had presented a special osteotomy plate in early 1990s, which had a spacer for internal support of the medial opening wedge osteotomy of variable heights (from 5mm to 17.5mm). In the current study, we present our results of opening wedge HTO using Puddu plate.

Patients and methods
Between June 2012 and August 2015, 30 knees in 29 patients were prospectively enrolled in the current study. Twenty patients were male and 9 were females. The average age of the patients was 21.5 years (range, 15-30). Two adolescent patients had open proximal tibial growth plate. The average follow-up period was 30 months (range, 24 to 40). All patients had opening wedge high tibial osteotomy using Puddu plate.

Results
Union was achieved in all patients with no need for bone grafts except in one patient. The average time to union was 16 weeks (range, 12 to 24). The mean pre-operative mechanical tibiofemoral (MTF) angle was 11.27 degrees varus (range, 5 to 16), while the mean post-operative MTF angle was 4.53 degrees valgus (range, 2 to 7). Overcorrection (MTF angle >6) occurred in 4 cases, while no under correction (MTF angle <0) was reported. The mean desired correction angle was 12.2 (range, 7 to 16). The mean medial osteotomy gap (as measured intraoperatively) was 10.77mm (range, 7.5 to 15). At final follow-up, pain VAS improved significantly from 3.3 (range 2 to 5) preoperatively to 1.2 (range, 0 to 2) postoperatively (p<0.001). The knee range of motion (ROM) did not show significant changes; knee flexion improved from average 125 (range 110 to 135) preoperatively to 128 (range 110 to 140) (p=0.023). The average Lysholm score improved significantly from 56.4 (range 50 to 70) to 88 (range 80 to 92) postoperatively (p<0.0001).

Conclusion
Opening wedge high tibial osteotomy with Puddu plate is effective in management of medial compartment knee arthritis with varus malalignment, with good functional outcome and low complication rates.

Key words
varus, Genu varus, High tibial osteotomy, Puddu plate.
Level of evidence: iv, prospective case series.

Introduction

High tibial osteotomy remains a corner stone in treatment of uni-compartamental knee arthritis with varus deformity in young active patients. Redistribution of mechanical loads by correcting the varus deformity relatively unload the medial knee compartment resulting in pain relief and delay of progression of arthritis. [1]

There are many types of high tibial osteotomies, opening wedge, closing wedge, and dome shape osteotomy with varying types of fixation including staples, plate and screws, external fixators as Ilizarov and Taylor spatial frame. [1,2] Recently, medial opening wedge have gained popularity with many advantages over closing wedge including; accuracy of correction and ability of intraoperative fine tuning the correction angle, preserving superior tibiofemoral joint, preserving leg length and preserving bone stock of the proximal tibia for future possible total knee replacement. [3]

Puddu had presented a special osteotomy plate in early 1990s, which had a spacer for internal support of the medial opening wedge osteotomy of variable heights (from 5mm to 17.5mm). [4] In the current study, we present our results of opening wedge HTO using Puddu plate.
Patients and methods

Between June 2012 and August 2015, 29 patients were prospectively included in the current study. Inclusion criteria included symptomatic medial compartment arthrosis with varus malalignment of the knee. Exclusion criteria included patients with inflammatory arthritis, age more than 50 years, lateral compartment arthrosis, patellofemoral arthritis or knee flexion contracture >10 degrees or flexion range <100 degrees. The study was approved by ethical committee of our university. All patients signed an informed consent after clear explanation of the surgical procedure.

Thirty knees (in 29 patients) were included. Twenty patients were male and 9 were females. The average age of the patients was 21.5 years (range, 15-30). Two adolescent patients had proximal tibial growth plate. The average follow up period was 30 months (range, 24 to 40). Associated injuries included posterior cruciate ligament injuries in 4 patients, and malunion of proximal tibial fracture in 2 patients.

Patient's assessment and preoperative planning

All patients had a standing long leg film to determine the amount of varus deformity and amount of correction required (Fig 1). The varus angle was measured by measuring the mechanical tibiofemoral (MTF) angle; which is the angle between the femoral mechanical axis and the tibial mechanical axis. The desired correction angle was measured according to Noyes [5] by drawing the desired mechanical axis of the femur passing from the centre of the head femur to Fujisawa [6] point (a point 62% of the tibial plateau width where 0% is most medial and 100% is most lateral), and the desired tibial mechanical axis from centre of talus to Fujisawa point. MRI were obtained in all patients to assess concomitant ligamentous and meniscus injuries. Pain was evaluated using visual analogue scale (VAS). Knee range of motion (ROM) were measured using goniometer. Knee function was evaluated using Lysholm score.

Surgical Technique

All operations were done under spinal anesthesia. Patients were positioned supine on translucent orthopaedic table with access to intraoperative fluoroscopy. A midtigh tourniquet was used. A medial longitudinal 5 cm incision midway between anterior and posteromedial borders of tibia was used. The superficial MCL was dissected with the periosteum posteriorly and a Homan retractor was placed over posterior border of the tibia to protect neurovascular structures. The medial border of patellar ligament was exposed, and the pes anserinus tendons were retracted.

A K-wire was placed along the planned osteotomy from above the pes anserinus insertion aiming to the superior tibio-fibular joint at least 1.5 cm below the tibial plateau. The osteotomy was performed with an oscillating saw along a K-wire under image intensification taking care not to reach the lateral cortex and making sure to cut the posterior cortex and the anterior cortex. Serial osteotomes were then used to open the wedge gently with preservation of the lateral hinge. The desired wedge height (as determined pre-
operatively) were maintained using a laminar spreader that was put posteriorly to avoid increasing the tibial slope (except in cases with PCL injuries where slope was intentionally increased to 5 degrees). The desired mechanical axis was then checked under image intensification using diathermy cable. The Puddu plate of appropriate size was then inserted and fixed with cancellous 6.5 screws at the proximal holes and cortical 4.5 screws at the distal holes. The tourniquet was deflated and hemostasis was ensured. A drain was used only in 3 cases. The wound was closed in layers and above knee fiberglass cast was applied. Figure one showed pre and postoperative photographs and radiographs of one case.

In the 2 cases with open physis, a fibulectomy was mandatory as the tibial osteotomy was done at a lower level (metaphyseo-diaphyseal) and the removed fibular segment was used as a graft (fig3).

**Figure 2:** A preoperative photograph showing varus rt knee, B: preoperative radiograph, C: postoperative photograph, D: postoperative radiograph after union.

**Fig 3:** A: preoperative photograph showing bilateral genu varum more severe in right side, B: Preoperative scanogram, C: intraoperative radiograph showing position of guide wire, D: intraoperative radiograph showing the plate, E: Immediate postoperative radiograph, Photograph after correction of left side, F: X-ray after 6 weeks, H: x-ray after 1 year.

**Postoperative follow-up and rehabilitation:**
Static Quadriceps exercises were started immediately postoperatively. Non-weight bearing above knee cast was removed after 4 weeks, and partial weight bearing and knee ROM exercises were allowed under supervision of physiotherapist. Radiographs were obtained every 2 weeks, and full weight bearing was allowed once union was reported. At final follow up, pain VAS score, knee ROM and Lysholm score were recorded. A weight bearing long film was used to measure postoperative MTF angle and mechanical
axis of the lower limb.

The clinical data were recorded on a report form. These data were tabulated and analyzed using the computer program SPSS version 16. *P* value <0.05 was considered statistically significant.

**Results**

Union was achieved in all patients with no need for iliac bone grafts except in only one patient. The average union time was 16 weeks (range, 12 to 24). The mean pre-operative MTF angle was 11.27 degrees varus (range, 5 to 16), while the mean post-operative MTF angle was 4.53 degrees’ valgus (range, 2 to 7). Overcorrection (MTF angle >6) occurred in 4 cases, while no under correction (MTF angle <0) was reported. The mean desired correction angle was 12.2 (range, 7 to 16). The mean osteotomy width (as measured intraoperatively) was 10.77mm (range, 7.5 to 15).

At final follow-up, pain VAS improved significantly from 3.3 (range 2 to 5) preoperatively to 1.2 (range, 0 to 2) postoperatively (*p*<0.001). The knee ROM didn’t show significant changes; knee flexion improved from average 125 (range 110 to 135) preoperatively to 128 (range 110 to 140) (*p*=0.023). The average Lysholm score improved significantly from 56.4 (range 50 to 70) to 88 (range 80 to 92) postoperatively (*p*<0.0001).

As regard complications, one patient developed superficial wound infection and it was treated by dressing and antibiotics. Delayed union was reported in one patient (40 years old, smoker) and was managed by autogenous iliac bone graft at 16th week and achieved union 8 weeks latter. There were no neurovascular complications in early or late follow-up period. Reoperation was indicated for one patient of delayed union, and in 5 patients to remove the implant after an average of 13 months due to soft tissue irritation.

**Discussion**

Medial opening wedge high tibial osteotomy for correction of varus knee mal-alignment in young active patients have become widely accepted alternative to closed wedge osteotomy. In 2009, Luites, et.al. compared fixation stability of opening versus closing wedge high tibial osteotomy and concluded that medial opening wedge osteotomy fixed by plates is equal in stability as the lateral closing wedge osteotomy. In addition, the medial opening wedge was superior than lateral closing wedge technique in liability to produce the desired angle of correction. [3]

In the current study, we presented results of open wedge osteotomy in 30 knees without bone graft. Union was achieved in all cases (one case showed delayed union and had bone graft). At final follow-up, pain VAS improved significantly from 3.3 (range 2 to 5) preoperatively to 1.2 (range, 0 to 2) postoperatively (*p*<0.001). The knee ROM didn’t show significant changes. The average Lysholm score improved significantly from 56.4 (range 50 to 70) to 88 (range 80 to 92) postoperatively (*p*<0.0001). Our results are similar to other studies [7-9] using the same plate (table1)

<table>
<thead>
<tr>
<th>Study</th>
<th>No patients</th>
<th>technique</th>
<th>Fixation</th>
<th>Bone graft</th>
<th>Union rate</th>
<th>Correction</th>
<th>Reoperation</th>
<th>Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asik [7] (2006)</td>
<td>65</td>
<td>Opening wedge</td>
<td>Puddu plate</td>
<td>Yes</td>
<td>100%</td>
<td>13 Under correction</td>
<td>Not mentioned</td>
<td>3 infection, 2 DVT, 1 lat plateau fracture</td>
</tr>
<tr>
<td>Haviv[8] (2012)</td>
<td>22</td>
<td>Opening wedge</td>
<td>Puddu plate</td>
<td>yes</td>
<td>100%</td>
<td>- Not mentioned</td>
<td>2 plate removal, 1 arthroscopic arthrolysis</td>
<td>-1 screw breakage</td>
</tr>
<tr>
<td>Babu[9] (2016)</td>
<td>13</td>
<td>Opening wedge</td>
<td>Puddu plate</td>
<td>No</td>
<td>100%</td>
<td>1 Under correction</td>
<td>1 plate removal</td>
<td>2 superficial infection</td>
</tr>
<tr>
<td>Current study</td>
<td>30</td>
<td>Opening wedge</td>
<td>Puddu plate</td>
<td>No</td>
<td>96%</td>
<td>4 Overcorrections</td>
<td>5 plate removal, 1 bone graft</td>
<td>1 sup infection</td>
</tr>
</tbody>
</table>

*Note: DVT: Deep Vein Thrombosis, TKR: Total Knee Replacement*
Rigid fixation in high tibial osteotomy ensures stability for healing of the osteotomy and allows early rehabilitation. The methods commonly used in fixation is either spacer plates like Puddu plate, or anatomical medial proximal tibial locked plates like Tomofix plates. [1] Many authors compare both methods and concluded that long plates with fixed angle locking screws achieved better stability. Stoffel et al., compared the biomechanical properties of Tomofix plates and Puddu plates. They concluded that both plates allowed good and secure stability in fixation of opening wedge HTO but Puddu plate required intact lateral cortex or additional lateral fixation. [10] Kim et al., in another biomechanical study using 48 fresh frozen specimens, found that both plates provided a suitable compressive and torsional stability to allow weight bearing with no significant difference between both plates. [11] Zhim et al., found that puddu plate yielded more stable fixation than uni-planner Hoffman external fixator.[12] In the current study, no implant failure or loss of correction were reported, and we think that sticking to the correct technique especially in gradual opening the wedge allowing for gradual deformation rather than complete fracture of the lateral cortex is mandatory.

The use of bone graft in opening wedge HTO is controversial. Advocates of using graft due to its osteoconductive and osteoinductive function claimed more stability and shorter healing time. On the other hand, autograft increases the operative time and donor site complications, where bone graft substitutes show lower biological properties and increased cost of the procedure. In a randomized controlled trial of HTO fixed by Puddu plate, Zorzi et al., reported no significant difference in patients who had bone graft and those without bone graft. [13] A recent meta-analysis included 25 studies failed to find significant differences in patients treated with or without graft in terms of union rate or stability. [14] El-Assal et al. reported union in 9 patients with opening wedge HTO without bone graft for wedges of up to 14 mm.[15] Similarly, Kolb et al. also performed opening wedges of up to 14 mm without bone grafts.[16] In the current study, we didn’t use grafts (except fibular in the 2 adolescent patients), and we achieved union in 96% of cases with wedges up to 15 mm.

The role of high tibial osteotomy in treatment of patients with varus mal-alignment and medial compartment arthrosis of the knee is decreasing the weight bearing stresses on the subchondral bone, of the medial knee compartment, that leads to decrease the intrasosseous venous hypertension that result in pain relief and improvement of joint function. [17] The aim of correction should be 3 to 5 degrees of mechanical valgus or the mechanical axis passing at a point 62% from tibial width (medial to lateral) as suggested by Fujisawa. [6] Recently, the degree of correction is individualized according to the degree of severity of the medial compartment pathology with the mechanical axis passing at appoint from 50% to 65%.

In a randomized controlled study, Mymerts treated 78 varus knees with high tibial osteotomy, randomly allocated patients in either normal correction group and 5 degrees over correction group. He concluded that the group of over correction had better functional outcome and less pain than the other group. [19] In the current study over correction was recorded postoperatively in 4 patients which is asymptomatic till the last follow-up.

This study had some limitations. First, the number of cases was small. Second, the study did not include comparison with other methods of fixation. Further comparative study with locked proximal tibial plates is recommended. The third limitation is the relatively short term follow up.

### Conclusion

Opening wedge high tibial osteotomy with Puddu plate is effective in management of medial compartment knee arthrosis with varus malalignment, with good functional outcome and low complication rates.

### Conflict of interest:

All authors have no conflict of interest to disclose and didn’t receive any fund or research grants.

### Ethical approval: The study was approved by ethical committee of Benha University and were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

### Informed consent: All patients signed an informed consent after clear explanation of the surgical procedure.

### References


