Benha Journal of Applied Sciences (BJAS) **print: ISSN 2356–9751**
Vol. (4) Issue (2) (2019), (95-100) **online: ISSN 2356–976x**
http://bjas.journals.ekb.eg

Medial Opening Wedge High Tibial Osteotomy using the Puddu Plate without Graft in Patients with Varus Deformity

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Abstract

A medial open wedge high tibial osteotomy (MOWHTO) is a precious surgical procedure that correct varus deformity related to Knee Osteoarthritis (OA). It consistently provides relief in knee pain and improves knee function. This performance is recommended for active, middle and old aged patients with isolated medial cityand hence is now a preferred choice of High tibial osteotomy (HTO). This study was conducted on 10 patients with HTO in unicompartmental osteoarthritis in the medial joint space with varus deformity. The youngest patient was 15 years and the oldest was 55 years old. The mean age was 35 years; using the Puddu plate fixation without graft. Mean follow-up period was 6 (range 5–7) months. Full consolidation was achieved at the osteotomy site. These include appearing of trabecular formation, bridging of bone ends, and corticalization of three of the four sides at least as seen on anteroposterior and lateral radiographs. Cartilagenous tissue in the lateral compartment was intact and of good quality. There was no observation of any plate failure at the end of third month. HSS score was obtained for each patient preoperative and monthly post-operative till the 6^{th} month.The Puddu plate fixation without graft approach is a procedure looked as a gold standard technique to many surgeons because of the small incision and the simple surgical steps. Open-wedge osteotomy of the tibia can be performed without bone grafting or bone substitution in most cases.

Keywords ; Puddu plate, High tibial osteotomy, Varus deformity**.**

1.Introduction

Varus deformity of the knee joint is fairly common and causes an abnormal distribution of the weight-bearing stresses within the joint. The stress is concentrated medially accelerating degenerative changes in the medial compartment of the joint. Genu varum is considered a predisposing factor for osteoarthritis of the medial femoro-tibial compartment [1]. Knee osteoarthritis with varus deformity presents a surgical challenge that must be solved during repairing operation. Unlike inflammatory diseases, deformity leading to varus gonarthrosis is thought to be a mechanical problem [2]. Among the etiological parameters resulting in mechanical troubles, tibial and femoral bone deformities, malalignments and malorientations due to the laxities of the lateral ligaments rank first [3]. It is considered that arthrosis develops as a natural consequence of this related mal-alignment [4].

High tibial ostetomy technique is belived to decide pain owing to its decompressive outcomes in early period, although this procedure leads to an enhancement in knee physiology because the translation of the mechanical axis onto reasonably intact lateral tibial plateau in long term, subsequently it prevents the progress of arthrosis [5]. Jackson and Waugh [6] first reported high tibial osteotomy and Coventry [5] popularized this method by publishing long-term results. Later various assessments of high tibial ostreotomies were described. Although in 1972 Debeyre [7] delineated medial open-wedge osteotomy performance, it has not been used widely. At the end of 2003 due to the introduction of fixation plate named Puddu into clinical practice, and relative simplicity of the technique [8] the procedure of medial open-wedge osteotomy gained popularity.

In this study we analyse the outcome of open wedge osteotomy in patients having uni-compartmental osteoarthritis with genu varum using the puddu plate.

2.Materials and methods

2.1Study population

This retrospective study evaluating 10 patients (6 males and 4 females, the age ranged from 15 to 55 years, six patients were within the age group between 40 and 50 years). They were taken from the attendants of the Outpatient and Inpatient Clinic of the Department of Orthopaedic Surgery, Benha University, Faculty of Medicine, Egypt, from the period between May 2017 and August 2018. A written informed consent was signed by the patients. The study was approved by the Research Ethics Committee of the Faculty of Medicine, Benha University.

The inclusion criteria of this study included patients with HTO in unicompartmental osteoarthritis in the medial joint space with 15 degrees or less of varus deformity [9]. Range of motion was 100 degrees flexion and flexion contracture not exceeding 20. Bone loss was less than 10 mm of the medial tibial plateau. Also, bone quality must be adequate to hold fixation and not undergo collapse. Patients who are employed as heavy laborers who wish to continue

participation in athletic activities are better suited for osteotomy than arthroplasty [10].

The exclusion criteria includes combined medial and lateral arthrosis inflammatory arthritis a specific contraindication for HTO, degree of varus deformity more than 15 degree [9], instability allowing the tibia to subluxate more than 1 cm, flexion contracture greater than 20 degrees, lack of flexion beyond 80 degrees [9], body weight more than 30% above ideal and if bone loss more than 10 mm of the medial tibial plateau. Another contraindications such as presence of neurological impairment, inflammatory arthritis, severe varicose veins, arterial insufficiency and/or any other physical disability that seriously hinders rehabilitation.

2.2Etiological diagnosis

Primary varus was detected in all patients (pain in the medial compartment not associated with injury of the central ligament and/or lateralcollateral injury). Patients were suffering from varus malalignment and medial compartment disease (i.e., localized cartilage damage in the medial compartment or subtotal resection of the medial meniscus in previous surgery, each with medial pain but good motion). Side of deformity was at left side in 5 patients and was at right side in 4 patients and bilateral in one patient.

2.3Laboratory and radiological investigations

All of patients were subjected to the routine labs which included complete blood count, prothrombin time and activity, fasting and post-prandial blood sugar, liver function tests, kidney function tests. Radiographic evaluation of the knee in the anterior-posterior profile and axial views of the patella, lateral view of the knee, panoramic radiography with full weight-bearing and magnetic resonance imaging (MRI) were involved.

2.4Surgical technique

After preoperative evaluation and preparation of the patients, the operation was done according to the following steps under general or spinal anesthesia:-

I-Step 1: patient position

A normal operating table was better with the patient in a supine position and the C-arm of an image intensifier set up opposite to the surgeon. The patient was draped as usual in knee surgery and also prepared the iliac wing and cover the foot using very fine stockinet and a transparent adhesive draped to minimize the bulging at the ankle so that it will be possible to better realized the femoro-tibial alignment after the correction. The tourniquet was inflated.

II-Step 2: arthroscopy

Arthroscopy of the knee was carried out before the osteotomy to assess the relative integrity of the controlateral tibiofemoral compartment and of the patellofemoral joint and to treat any intra articular pathology: appropriate joint surface debridement, partial meniscectomy or loose body removal was performed if needed [11].

III-Step 3: Incision and Exposure

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.1). The investing fascia was incised and the pes anserinus was identified. Superficial medial ligament was dissected from the bone proximally up to the level of osteotomy [9].

There was no risk of instability because the deepest and much more stabilizing tibio meniscal bundle of the ligament remains intact. A blunt retractor was placed dorsally, deep to the collateral ligament to protect the posterior vessels and expose the postero-medial corner of the tibia. Anteriorly, a second retractor was placed under the patellar tendon. The procedure was facilitated by flexion of the knee.

IV-Step 4: 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 [9] .

The lower half of the tibial tuberosity was osteotomised to prevent its fracture during tibial osteotomy, then 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 .

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. Fibular osteotomy was not necessary.

The opening should be medial and posterior . The bone at the site of the osteotomy was wedged open. The portion of the tibia distal to the osteotomy was then pushed into valgus, while the large osteotome maintains the proximal end of the tibia in place. The opening should advanced slowly to allow gradual opening of the osteotomy. It was supposed to avoid

flexion at the site of the osteotomy. The sagittal plane correction should also be assessed by looking carefully at the amount of opening of the osteotomy anteriorly and posteriorly. Since the tibia was a triangular bone in cross section with apex anterior, the opening must be greater at the postero-medial part of the osteotomy than at the anterior part in order to avoid increasing the posterior tibial slope and patella baja. If the gap anteriorly is equal to that at the postero-medial corner, the posterior slope of the tibia will be inadvertently increased. Positioning of the wedge and internal fixation were important. Then using 10, 25, and 35 mm width, long and thin osteotomies, osteotomy was performed under fluoroscopic control .

V-Step 5: Plate Fixation

After adequate exposure of the osteotomy line, the osteotomy guide was removed and an appropriate plate was placed inside the osteotomy line (Fig.3 a,b). 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. Positioning a symmetrical plate anteromedially will increase the slope, using a tapered plate directly medially should have no effect on slope, and positioning a tapered plate posteromedially should decrease tibial slope. Before fixing the plate, checking to the mechanical axis must be done, under fluoroscopic guidance, by means of the special guide rod, long enough to extend from the center of the femoral head through the knee to the center of the talus. When the rod crosses the knee at a lateral point about two thirds (63%) of the tibial plateau, planning to know the angular correction corresponds to that knee must be performed pre operative. But if the correction is under-or oversized, we can still change the plate with one having a thicker or thinner tooth as needed.

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.3 c,d). The proximally placed screws were not allowed to come in direct contact with the joints and should be parallel to the osteotomy.

Finally, the wound was closed by repairing the tendons and the superficial medial collateral ligament. After the closure of the layers and placement of a drain, the patient's knee was put into a hinged immobilizer [9].

2.5Postoperative rehabilitation

At approximately 6 weeks postoperatively, the patients were ambulated with knee-hinged immobilizers. Soon after the operation, the patient started isometric quadriceps exercises and used CPM (continuous passive motion) apparatus to ease his/her movements.

The patients were rehabilitated with quadriceps muscle and hamstring strengthening exercises. Partial weight bearing exercises were initiated promptly and with gradual increments full weight bearing exercises were assumed at approximately 3 months postoperatively. Short radiographs were taken at six and twelve weeks to ensure maintenance of position and healing, and long leg alignment films done at six months to assess the correction achieved.

3.Results

3.1Demographic characteristics

The mean age of patients was 35 years; six patients (60%) were within the age group between 40 and 50 years. There were 6 males (60%) and 4 females (40%). The left knee was affected in 5 patients (50%) while four patients (40%) complained of their right knee and there was bilateral affection in one patient (10%).

3.2Postoperative characteristics

Mean follow-up period was 6 (range 5–7) months. Full consolidation was achieved at the osteotomy site. Bone consolidation was evaluated according to Paley et al [1]. These include appearing of trabecular formation, bridging of bone ends, and corticalization of three of the four sides at least as seen on anteroposterior and lateral radiographs. On the other hand, we did not observe any plate failure at the end of third month even though we allowed patients to bear full weight.

During arthroscopic examination, in all of the patients, arthrosis was observed to 7 patients within the medial compartment and managed arthroscopically. Cartilagenous tissue in the lateral compartment was intact and of good quality. Besides, partial menisectomies were performed for instable ruptures of 3 medial menisci, HSS score was obtained for each patient preoperative and monthly post-operative till the 6^{th} month.

4.Complications

One patients developed superficial wound infection, which healed with antibiotic. A deeper wound infection was seen in one patient, which healed with open wound management, wound irrigation, debridement, and antibiotic.

Casting post-operative for 6 weeks was applied to 1 patients due to the plate was not fixed very rigid as we redirect the proximal screws twice intra operative to be away from the joint line.

5.Discussions

Varus gonarthrosis is one of the most frequently encountered abnormalities currently seen by orthopedic surgeons. Although morbidities (inflammatory diseases, traumas, disorders of the articular cartrilage) are responsible for this deformity, the mostly seen etiologic factors are genu varum or varus malalignment.

Varus malalignment could develop as a result of a dynamic factor due to lateral laxity, however it could occur more often because of a bony deformity.

The association between varus malalignment and gonarthrosis is not fully understood. An abnormal response of the cartilage to normal stresses or normal reaction of the cartilage against excessive stresses is suggested for this association.

Akamatsu et al in their series consisting 144 knees, detected that mineral densities and sclerosis of medial femoral condyles and tibial bone plateau are denser than those of the lateral compartment. They performed high tibial osteotomies for 23 patients and stated that the degree of bone mineral density and sclerosis decreased by distributing mechanical stress evenly and diminishing weight-bearing forces impinging on medial compartment [12].

In a study by Odenbring et al 189 knees with isolated medial compartment arthrosis were followed up for 16 years. HTO's and total knee prostheses were carried out for 85 and 33 of these knees, respectively [13]. After 16 years of follow-up of untreated cases, it was revealed that 23 knees were painful with restricted mobility, while in 20 knees arthrosis advanced as demonstrated with radiographic controls. Based on this study, we believed that the patients with isolated medial compartment arthrosis must be managed surgically and high tibial osteotomy is one of the surgical alternatives for these patients.

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 high tibial osteotomy using Puddu plate without graft procedures include presence of isolated medial compartment arthrosis, good patient motivation to comply with postoperative rehabilitation program, patients aged <65 years, absence of knee contractures and excessive patellofemoral arthrosis, range of motion being at least 90 to 100 degrees, varus gonarthrosis requiring <10 degrees correction, stable knees and the usage of rigid fixation material for osteosynthesis.

We selected patients complying with the above inclusion criteria. Successful outcomes found at the last follow-up visits suggest the meticulous concern for the selection of HTO candidates. Although the patient's age is an important criterion for classical high tibial osteotomy indication. Bone texture, daily activity level, and biological age have a greater impact on selection criteria.

With high tibial osteotomy, lesser weight bearing impact on subchondral bone, decrease of intraosseous venous hypertension and micro fractures involving subchondral bone and alleviation of clinical symptoms such as pain and consequently improvement in functional status of the patients are targeted.

Since the reports of Hernigou et al on open-wedge medial osteotomy published in 1951, both the technique and the implants used have undergone considerable modifications. In medial open-wedge osteotomy, fibular osteotomy is not performed, technique does not require a wide exposure and a stable fixation can be accomplished with a Puddu plate without loss of correction [14].

Medial opening wedge HTOs have become increasingly popular over the past 2 decades. The procedure is attractive because the peroneal nerve is not in jeopardy and disruption of the proximal tibiofibular joint and lateral ligaments is avoided [15]**.** The theoretical advantages of opening wedge over closing wedge include: restoration of anatomy with or without addition of bone to the diseased medial side, the ability to achieve predictable correction in both coronal and sagittal planes, the ability to adjust correction intraoperatively, the requirement for only one bone cut, avoidance of proximal tibiofibular joint disruption and invasion of the lateral compartment, and the relative ease of combining with other procedures such as ACL reconstruction. The disadvantages of this procedure include the creation of a defect that requires bone graft with attendant harvest morbidity, and a theoretical higher risk of non-union, as well as the longer period of restricted weight bearing postoperatively. Associated laxity of the ACL or posterolateral corner (PLC) is not uncommon in patients with medial gonarthrosis, and disruption of the proximal tibiofibular joint as commonly performed during lateral closing wedge HTOs may effectively lengthen the PLC and lead to increased instability [16].

It is reported that PTS increased by 2 to 5 degrees after open-wedge HTO and decreased by 2 to 5 degrees after closed wedge HTO. Besides, anterior cruciate ligament (ACL) reconstruction can be achieved using the same incision. Furthermore, this technique also reserves bone stock to be used for possible future total knee prosthesis and provides the desired degree of correction. In addition, it is perfectly comfortable for the patient. Hernigou et al 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 [14].

Success in medial open-wedge osteotomy depends largely on sound application of the technique. The determination of the exact localization of the osteotomy site accurately under a good fluoroscopic control, meticulous care not to fracture lateral cortex during opening of the osteotomy site, frequent assessment of the correction angle at every step of the operation, avoidance of overcorrection, the selection of an appropriate Puddu plate size fit for the osteotomy gap are important details increasing the success rate of this procedure. Based on median 34 month follow-up of the patients, mean improvements obtained in HSS scores was 26.72. According to this assessment scale, preoperative score was deemed ‘‘worse’’, and postoperative scores was ‘‘good’’.

In addition, the radiological examinations revealed that the mechanical axes on the average passed 5.09 mm laterally achieving an average of 5 genu valgum. I am in the opinion that early outcomes of the medial open-wedge osteotomies with Puddu plates are fairly successful and safe. Besides when compared with the results reported in the literature for high tibial osteotomies my success rates are found to be similar or slightly better.

One of the most important complications reported for either close or open wedge osteotomies is patella infra or alta. Based on postoperative Insall index we didn’t encounter neither patella infra nor patella alta in our patient group [17].

We attributed this outcome to meticulous selection of inclusion criteria, avoidance of postoperative casting and initiation of early rehabilitation program. Different complication rates ranging between 2 and 5.1% were reported for medial open-wedge osteotomy procedures. These include over or undercorrection, nonunion or delayed union on the osteotomy site, problems related to fibular nerve and vessels, traumatic injuries of anterior and posterior arteries, compartment syndrome, deep vein thrombosis, pulmonary embolism, infection, dysthesias around the incision line, fractures of the lateral cortex and tibial plateau and inadequate stabilization.

Coventry et al stated that they had obtained successful results in varus or neutral (64%) and in 4 to 6 degrees valgus (94%) positions [18]. In a study by Hernigou et al arthrosis did not deteriorate in patients maintained in 3 to 6 degrees valgus position [14].

In our study group, mechanical axes passed through 5.09 laterally, and we obtained a median 5 degrees valgus position. We believe that this approach had a favorable impact on the early improvement of functional status, and also thought that it might prevent the deterioration of arthrosis owing to the even distribution of mechanical weight bearing forces in the long run.

However, we did not observe poor functional results in patients who had under correction. We think that this result comes from my short follow-up period. In early postoperative period, most of patients are satisfied because osteotomy results in decompressive effect on bone.

Then this effect alleviates pain and consequently provides a good functional status in short term, while a good outcome after high tibial osteotomy depends on the distribution of overload to healthy compartment in long term. Therefore, this study should be supported by other studies with longer follow-up.

Shorter follow-up periods and lack of comparative results are shortcomings of this study. However, early results obtained indicate that medial open-wedge osteotomies using Puddu plates could be realized safely with considerable success with encouraging outcomes, and this technique could be a good alternative for unicompartemental total knee arthroplasty. Comparative studies with longer follow-up periods will be required to demonstrate its favorable effects on arthrosis in the long term.

Concerns and Future of This Technique

The treatment of unicompartmental OA of the knee remains a challenge to the orthopedic surgeon. The causes are varied and the therapeutic options are numerous. When non operative and arthroscopic procedures fail and the patient is considered too young for unicompartmental or total knee replacement, osteotomy is the standard operation in the orthopedic armamentarium to treat the axial deformities of the knee and subsequent unicompartmental OA [19].

The opening wedge technique we have presented here is relatively new. Also new are the dedicated instruments and plates. Some variations in the shape and dimension of the plate tooth are planned in the coming months.

Tibial plates with trapezoidal spacers will be available to permit the correction of the coronal and, eventually, the sagittal deformity, the so called tibial posterior slope, at one surgical session. The new femoral and tibial plates will have increasing tooth sizes in single-millimeter increments [8].

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