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HIGH TIBIAL OSTEOTOMY

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ABSTRACT

The number of cases handled by PJI is projected to rise in the coming years. The diagnosis of PJI relies on evaluating microbiology, inflammatory response, and pathology. However, the accuracy of the diagnosis is compromised by previous exposure to antimicrobial agents, the possibility of contamination, and the lack of specificity of inflammatory markers. Although new testing methods, such as molecular techniques, hold the potential for a swift diagnosis, they are constrained by the risk of contamination and the absence of susceptibility results. Interestingly, emerging synovial fluid markers exhibit promise as an additional tool in diagnosing PJI. The management of each PJI case, both in terms of surgery and antimicrobial treatment, requires an individualized assessment. It is imperative to conduct high-quality studies that aim to determine the most effective route and duration of antimicrobial treatment for each surgical approach. This review provides an overview of the diagnostic tests and treatment options for prosthetic joint infection, offering a practical approach to managing this complex clinical condition.

Keywords: High tibial osteotomy; osteoarthritis; knee

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INTRODUCTION

Techniques of lower limb osteotomy to correct lower limb deformity first emerged in the sixteenth century (1). The first surgical osteotomy around the knee is attributed to John Rhea Barton from Pennsylvania, USA, who performed a supracondylar wedge femoral osteotomy for an ankylosed knee in 1835. Most osteotomies done in the 19th century and early 20th century were aimed to correct limb deformity not related to osteoarthritis (OA). High tibial osteotomy (HTO) for the treatment of medial compartment OA was first introduced by Jackson in 1958. This surgery was not popular until Coventry reported good results in 1973 (2).

The goals of osteotomy are to reduce knee pain by unloading medial compartment of the knee and to delay the need for knee replacement (3). With the advances and success of knee arthroplasty (total knee arthroplasty and unicompartmental knee arthroplasty) there has been relative neglect of osteotomy as one of treatment modality for OA in many healthcare services. However, less favorable results have been reported for knee arthroplasty in younger and active patients, causing some surgeons to search for another solution.

Osteotomy around the knee is appreciated as treatment choice for younger patients with unicompartmental OA, allowing for long term preservation of knee joint and reduce the need for knee arthroplasty (4). Recently, HTO is also performed in the context of cartilage injury. In regenerative treatment of the knee cartilage, alignment seems to be the essential part, therefore deformity correction is often recommended in combination with cartilage or meniscus repair (5). HTO has also been advocated to treat chronic knee instabilities and ligament reconstruction failure due to malalignment (6). With appropriate indications, careful planning, standardized operating technique and improved implant quality, HTO can be a highly effective procedure, reproducible and enduring functional and symptomatic improvement (4).

Patient selection is one of most important factors in successful HTO. One of the most common indications for HTO is primary or secondary medial unicompartmental osteoarthritis. ISAKOS (International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports medicine) in 2004 defined the ideal patient for HTO as young (40-60 years old), active high demand, with isolated medial unicompartmental OA, BMI <30, malalignment < 150, metaphyseal varus (ie TBVA > 50), full range of motion (ROM), near normal lateral and patellofemoral compartments, without ligamentous instability, non-smoker and with some level of pain tolerance (7).

Unfavorable patient factors are: Ahlback grade III or higher, age ≥65 years, advanced patellofemoral arthritis, ROM of less than 90° flexion, flexion contracture greater than 15°, joint instability, lateral tibial thrust equal to or more than 1 cm, the need of correction greater than 20°, and rheumatoid arthritis (3).

Most studies mention that HTO is more useful in overweight patients compared to Uncompartmental Knee Arthroplasty (UKA). Recent study, however, shows that the results of both procedures are quite comparable (3). HTO may provide better ROM, while UKA may provide better functional outcome and lesser complication (8). In recent years, there have been a shift in indications and contraindications of HTO. For example, some studies have explored the use of HTO in knee with ligamentous instability which was deemed as a contraindication in the past (6).

Differences in indication of HTO, UKA, and TKA there are many recommendations and debates regarding patient selection of HTO, UKA, and TKA from various authors. The author would like to summarize the common patient selection criteria from recent studies. Table 1 depicts the comparison of indications of HTO, UKA, and TKA (8–12).

Table 1. Comparison of Patient Selection in Choosing HTO, UKA, or TKA

	HTO	UKA	TKA
Age	Younger, <55 y.o.	Older, >55 y.o.	Any
Severity of Disease	Any with intact lateral compartment	Severe OA, with intact lateral compartment	End stage cartilage disease
Body Mass Index	BMI<30 kg/m^2	BMI<40 kg/m^2	Any, but weight loss is recommended
Alignment	Metaphyseal varus deformity greater than 5°	Deformity which reduces completely in 20° of flexion under valgus stress	Any
Ligamentous stability	Stable, newer studies do not consider instability as contraindication	Intact ligament, newer study suggests ACL deficiency is not contraindication	Any
Activity Demand	Active	Low demand	Low demand
Comorbidity	Preferably for non-smoker	No inflammatory disease	Any

One of the most important aspects of HTO preoperative planning is understanding normal anatomy of lower extremity and its normal/physiological axis and angles (13). There are two axis used to describe the lower limb: anatomical and mechanical axis. The anatomical axis of femur and tibia are obtained from a line centered in diaphysis of each bone. The mechanical axis of the femur is defined by a line from the center of femoral head to the center of the knee (14). The angle formed between anatomical and mechanical axis of the femur is defined as anatomical mechanical femoral angle (aMFA) or femoral mechanical anatomical angle (FMA) with normal value of 6±1° (15). The anatomical and mechanical axis of tibia are indistinguishable; both describe a line from the center of the knee to the center of ankle (14).

The mechanical axis of lower limb (Mikulicz line) is a line parallel to the centre of femoral head to the centre of the ankle through the patella (14). Mikulicz line normally lies 4±2 mm medial to the centre of the knee, and it creates an angle of 3° to perpendicular axis of the body. The deviation from this value is called mechanical axis deviation (MAD) (Figure 3.). MAD is considered clinically significant if it deviates >10 mm to the lateral (valgus) or >15 mm to the medial (varus) (13).

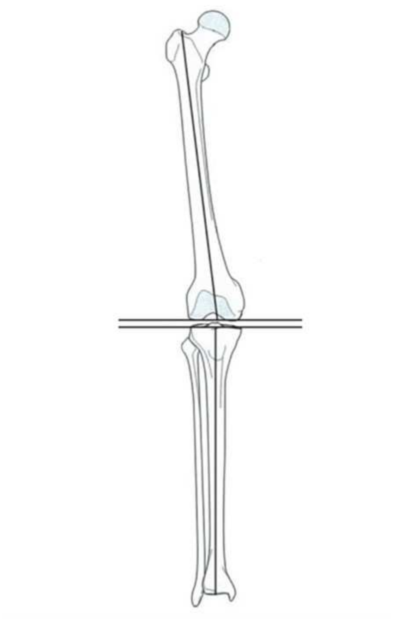

Figure.1. Anatomical axis

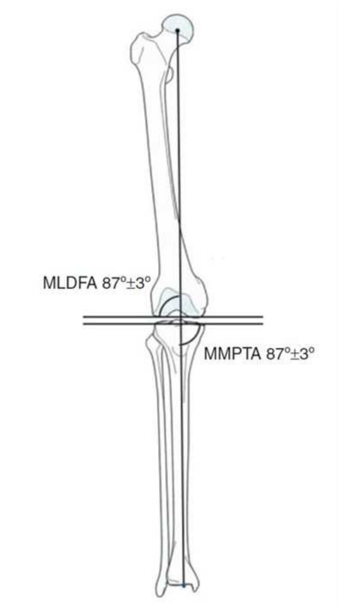

Figure 2. Mechanical axis of the femur, mMPTA, mMLDFA.

Two important parameters in evaluating femoral or tibial pathology are mechanical lateral distal femoral angle (mLDFA, normal = 87±3°) and the mechanical medial proximal tibial angle (mMPTA 87±3°) (Figure 2.). If the mLDFA is more than normal, the varus deformity is of femoral origin. If the mMPTA is less than normal, the varus deformity is of tibial origin. On the contrary, if the mLDFA is decreased, the valgus deformity is of femoral origin, and if the mMPTA is increased, the valgus is of tibial origin (16).

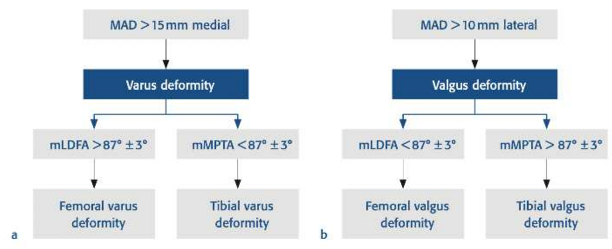

Figure 3. Evaluation of deformity based on 'malalignment test' (A). MAD> 15 mm medial. (B). MAD > 10mm medial.

Other parameter is posterior tibial slope, which is the tilt of tibial joint surface caudally in the sagittal plane (normally is about 10°) (13,16).

General patient preparation in performing HTO is quite similar with other operations. Several factors which should be assessed are age, occupation, BMI, level of activity, expectation, smoking history, knee surgery history, range of motion, degree of deformity, ligamentous stability, Leg Length Discrepancy (LLD), and patellofemoral problems (3,17).

Following radiographic examinations should be obtained prior to HTO for preoperative radiographic assessment18

1. Knee X-rays

- Anteroposterior (AP) weight-bearing view: to evaluate lower leg alignment, degree of OA, and planning the amount of correction.
- Lateral view: to evaluate tibial slope and patellar height.

- Rosenberg view (AP view in 45° flexion): to evaluate lateral compartment of knee.
- Merchant/skyline view: to evaluate patellofemoral joint (19).

2. Magnetic resonance imaging (MRI): evaluating ligamentous injuries, cartilage lesion, and meniscal injuries; planning concomitant procedure, and it may help the extent of lateral compartment and patellofemoral joint disorder (20).

Correction angle calculation the number of corrections has been a topic of debate since the 80s. There is no consensus about optimal alignment in HTO. In general, the ideal post operative lower limb alignment is considered as 3-5° in mechanical axis or 8-100 valgus in anatomical axis. Slight varus correction can lead to recurrence of deformity whereas overcorrection can cause lateral compartment OA (2,3) Fujisawa, in his paper, recommended axis correction bringing the weight-bearing line 30-40% from the midpoint of lateral compartment (weight bearing line should pass 62.5%) (Figure 4.) (21). Jakob and Jacobi suggested that correction of mechanical axis should be adjusted according to residual thickness of cartilage. The mechanical axis should pass 10-15% laterally from the center of tibial plateau when one third of medial cartilage is damaged, 20-25% when two third is damaged and 30-35% when all cartilage is impaired (Figure 5.) (3,22).

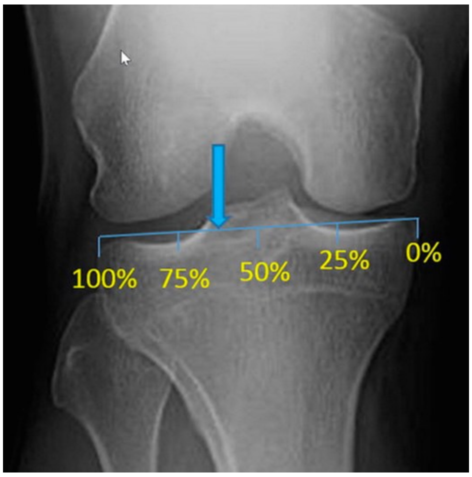

Figure 4. Fujisawa point

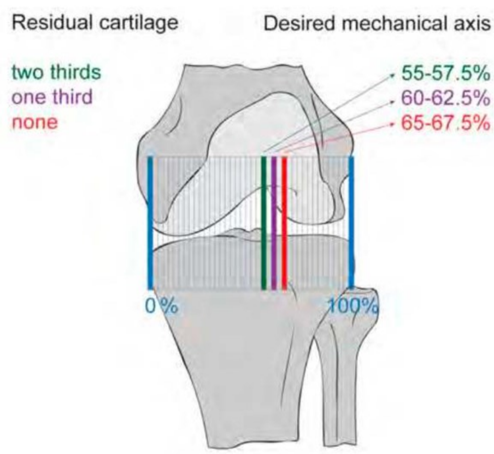

Figure 5. Correction of varus deformities

Recent studies have different opinion regarding valgus alignment. Atkinson reported that valgus alignment is not necessary, based on his finding that correction to near neutral alignment is sufficient to provide regenerative stimulation to cartilage of medial compartment without damaging the lateral compartment (24). Other studies reported that concomitant cartilage procedure (microfracture, autologous cartilage implantation and stem cell implantation) with medial opening wedge HTO have good clinical outcomes in cases with mechanical axis of 0-30 valgus (25).

There are several methods to calculate the amount of frontal plane correction in valgus producing osteotomy. The Miniaci and Dugdale methods are the commonly used methods to calculate the correction angle using weight bearing scanogram with calibration before operation. They can be applied to both closing and opening wedge HTO (22,26).

Miniaci method with the first step is to determine the Mikulicz line. The second step is to define the weight bearing point in tibial plateau (Fujisawa point). Draw the line from center of the hip joint to the predicted new center of ankle joint through Fujisawa point. Then draw a line from center of ankle joint to the hinge point of osteotomy and lastly draw the line from the hinge point of osteotomy to the new center of ankle joint. The angle between these 2 lines is the planned correction angle (Figure 6) (22,27). Lee et al reported that this method showed high inter and intra rater reliabilities in determining preoperative correction angle and osteotomy gap (28).

Dugdale method with the steps are as follows: a line is drawn from the hip center through the correction point at the knee joint line (Fujisawa point). Another line is drawn from the ankle center through the correction point, and the angle between those two lines is determined as the correction angle (Figure 7.) (3,22). However, a recent study suggests that Dugdale method might underestimate the degree of correction needed compared to Miniaci method (29).

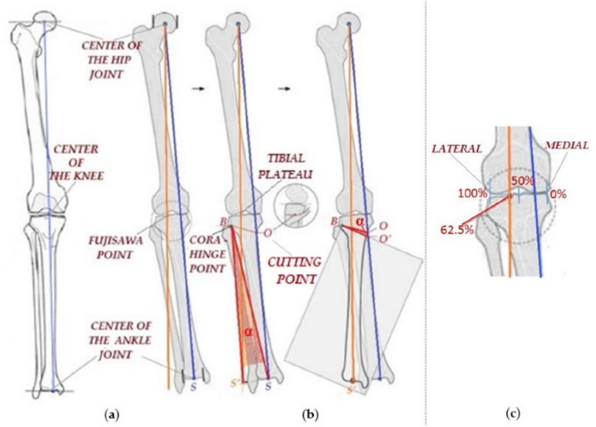

Figure 6. Miniaci method of amount of correction planning in high tibial osteotomy.

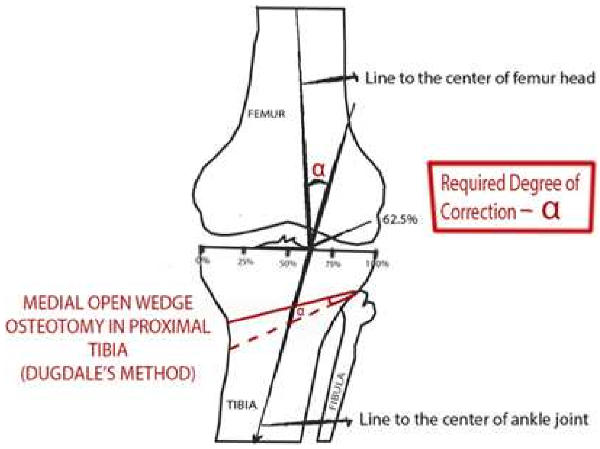

Figure 7. Correction Angle

For alternative, the correction could be measured intraoperatively using cable/rod method (Figure 8.). This method involves identification of center of the hip and ankle with fluoroscopy. Then, the hip and ankle centers were connected using an electrocautery cable or alignment rod under fluoroscopic guidance. The osteotomy site was spread until the electrocautery cable was placed at the target point on the medial-to-lateral tibial plateau of the knee joint. Then, the osteotomy site was fixed with plate. This method, however, has tendency to overcorrect/under correct the deformity as the estimation is done in non-weight-bearing setting, and there is relatively more radiation exposure to the patient (30).

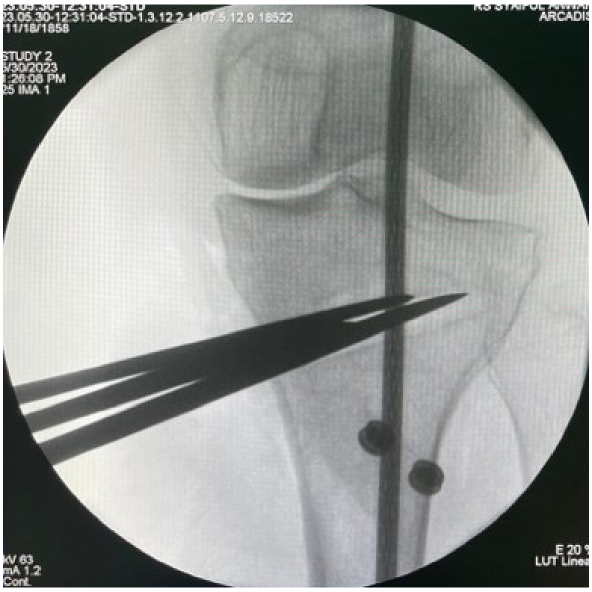

Figure 8. Cable/rod method to control the proper alignment intra operatively (images from author's personal documentation)

In sagittal plane, HTO affects tibial slope. Medial opening wedge HTO tends to increase the slope and overload the ACL. Conversely, lateral closed wedge HTO would decrease the slope and in turn overload the PCL. Thus, in ACL insufficiency the slope should be decreased, and in PCL insufficiency, the slope should be increased (3,31,32). There are several strategies to maintain the posterior tibial slope: creating anterior gap 67% of the posterior one, controlling the direction of wedge insertion, utilization of a sagittal oriented hinge, placement of a trapezoidal plate posteriorly, and fixation with knee hyperextension (33,34). Moreover, HTO may also change patellar height. In lateral closed wedge HTO, the result usually yields patella alta due to elevation of tibial tuberosity after shortening of proximal tibia. The inverse applies to medial opening wedge HTO. Although, a meta-analysis concludes lateral closed wedge HTO do not yield any change in patellar height (35).

In mild or moderate correction, patellar height changes do not have significant influence in clinical outcome. A level IV study reveals that medial opening wedge HTO does not worsen patellofemoral joint condition despite the decrease of patellar height it caused. However, in larger correction (>15°) prevention of patellar change could be considered (36).

This is the first technique popularized by Coventry (18). In the lateral closing wedge technique, a valgus producing osteotomy is achieved by removing a wedge of bone with the base on the lateral side is removed from the upper end of tibia. If necessary, release of the proximal tibiofibular joint or fibular osteotomy could be performed. This technique may produce lateral tibial metaphyseal bone loss and can lead to considerable lateral overhang of the tibial plateau, producing changes in tibiocondylar offset (37).

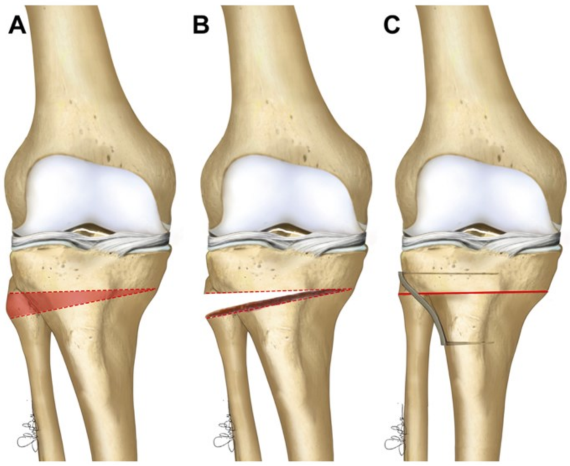

Figure 9. Lateral closing wedge osteotomy

The skin incision is anterior, from the joint line to 8-10 cm along the tibial crest. After dissecting the subcutaneous tissue, the fascia of anterolateral compartment is incised. The lateral tibial cortex is exposed (by detaching the anterior muscles) along with the fibular head.

The fibula could be osteotomized on the level of the neck proximally or on the middle third of diaphysis distally. Care should be given so peroneal nerve is not injured. After that, two K-wires are inserted anteriorly to prevent rotation one superior and the other inferior to the osteotomy site. The osteotomy site is level with tibial tuberosity, perpendicular to tibial or slightly oblique from lower lateral to upper medial. Two other K-wires are placed from lateral to medial on each side of osteotomy site to guide correction angle.

The osteotomy is initiated by drilling 3.2 holes in the lateral cortex. The cut then is extended with oscillating saw or chisel, with medial cortex left intact. This osteotomy line is parallel to the first K-wire. A second cut parallel to the second K-wire is made, then the wedge is removed. The gap formed is then closed and fixated with either L-shaped AO plate, LPT TomoFix plate, angled plates, or staples. The anterior muscles then re-inserted and the wound closed.

Medial opening wedge HTO in contrast to the closing lateral wedge osteotomy, a valgus alignment is achieved by performing an oblique osteotomy on the medial side of proximal tibia. The patient is placed on radiolucent operating table with lateral support and tourniquet applied. An arthroscopy can be performed prior to osteotomy to diagnose and treat intra articular lesions. With the knee held in 900 of flexion, a 5-6 cm vertical incision is made over the centre between the medial tibial tuberosity and medial border of tibia. The incision begins 1-2 cm below the joint line, continuing caudally to pes anserinus. The pes anserinus is detached from tibia to expose the superficial medial collateral ligament (MCL). The distal portion of the exposed ligament is separated from the bone and a retractor inserted posterior to MCL and the tibia to protect neurovascular structures. Identify the medial border of patellar tendon and then perform subperiosteal dissection from tibial tuberosity to posteromedial aspect of tibia. The knee is then extended and two 2.5 mm Kirschner wires are inserted at a point of 3.5 to 4 cm below the medial joint line and pass obliquely to the tip of fibula. After checking the appropriate position of the K wire with fluoroscopy, the tibial osteotomy can be started (Figure 10.).

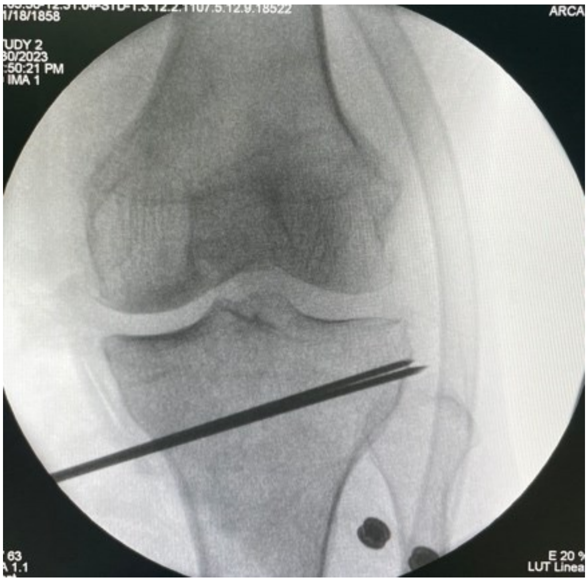

Figure 10. Guide wire placement (image from author's personal documentation)

The knee is flexed again, and a V-shaped osteotomy is then performed using an oscillating saw below the guide wires. The oblique osteotomy is performed in the posterior two thirds of the tibia while leaving a 10 mm lateral bone bridge intact. Also ensure that the line of osteotomy is parallel with posterior tibial slope on the sagittal plane. The second osteotomy is then performed, beginning at anterior one third tibia at an angle of 1350 while leaving the tibial tuberosity intact (Figure 11.). mm. The mobility of the osteotomy site is checked, and the osteotomy site is gently opened with a valgus force. Use 2 or 3 stack osteotomes to open the osteotomy site, do it carefully and gently to reduce the risk of intraarticular fracture (Figure 12.). Subsequently, a calibrated wedge is inserted until the osteotomy is opened to desired degree of correction. Ensure the new mechanical axis by placing an alignment rod or electrocautery cable from the center of the hip to the center of ankle, it should lie at 62.5 % of the width of tibial plateau (Fujisawa point). After the desired degree of correction is achieved, the osteotomy is fixed with a metal plate (3,23).

Figure 11. V-shaped open wedge HTO (23)

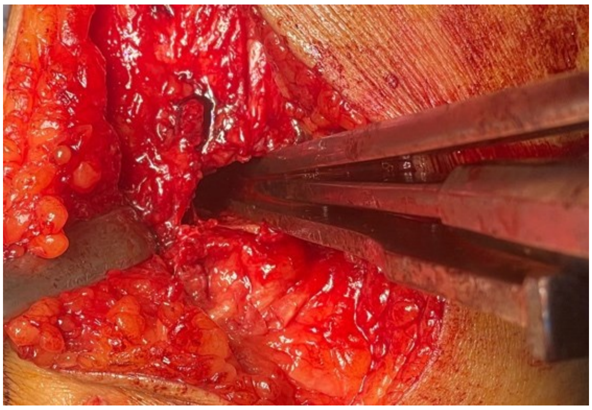

Figure 12. Stacked osteotomes to open the osteotomy site.

Proximal tuberosity osteotomy (PTO) in the classic opening wedge medial osteotomy, the osteotomy line parallel to the anterior tibial cortex begins posterior to the patellar tendon insertion, as previously described above (Figure 13.). After that, the tibial osteotomy is made behind the tuberosity, which is protected by an angular blade. Widening of the tibial osteotomy causes the tuberosity to move distally and the patella to move inferiorly (39).

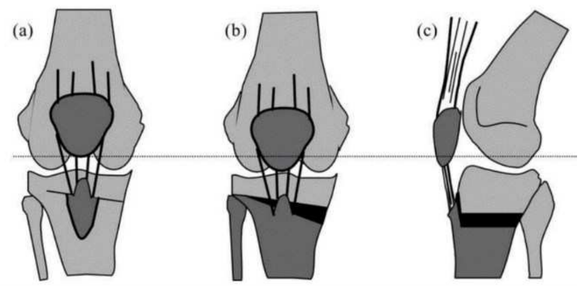

Figure 13. Proximal tuberosity osteotomy (39)

Distal tuberosity osteotomy (DTO) Patellar height reduction commonly occurs after medial opening wedge osteotomy. This prompts a technique modification by performing the osteotomy below the tibial tuberosity for patients requiring a significant degree of valgus correction. This technique consists of a triplane osteotomy comprising transverse, descending, and arc incisions (Figure 14.). The fist osteotomy line (descending) begins 15 mm posterior to the tibial tubercle and parallel to the tibial shaft in the coronal plane; careful to avoid posterolateral direction. Two guidewires placed parallel to the direction of fibular head and the arc of drilled holes permit fluoroscopic guidance of this descending osteotomy easily and accurately. Thereafter, the arc osteotomy is performed using a small bone saw along the arc of drill holes. The end of the arc cut relates to the descending cut. Finally, the transverse osteotomy is performed along and below the guidewires. The disadvantage of this technique is that it is more extensive of bone loss and lacks anterior cortical support, compromising the biomechanical environment. This requires additional biocritical screw fixation to stabilize the distal part of the tuberosity of the tibia (39,40).

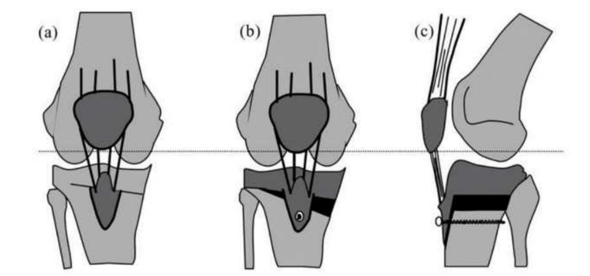

Figure 14. Distal tuberosity osteotomy

Dome shaped osteotomy is proposed to preserve the natural anatomy of proximal tibia, the lower limb length, improving bone healing, and preserving bone stock for future TKA. This osteotomy generates rotational effect by only removing enough amount of bone. This osteotomy also maintains the height of patella better, because it does not alter the distance of tibial tubercle and joint line by large margin. Unfortunately, this technique is quite technically demanding, limiting its popularity (41)

Double level osteotomy is recommended in cases of severe varus deformity. In this kind of deformity both femur and tibia are usually involved in the deformity. HTO alone may result in excessive joint line obliquity, thus increasing the shear stress at the joint surface and risking the development of new bony deformity (42) Other potential problem associated with correction of severe varus deformity is leg length discrepancy (43). The indication of DLO as reported by several authors was based on preoperative simulation using digital planning software. If in the simulation, an open wedge HTO resulted a mMPTA of more than 940, the DLO was considered, or if there was deformity analysis of mMPTA < 870, combined with a mLDFA > 900 (42–44) DLO is a combination of distal femoral osteotomy (DFO) and HTO. It is always started with lateral closing wedge DFO and then followed by medial opening wedge HTO. The advantage of this procedure is to unload the affected joint compartment by normalizing the knee joint angles and their orientation. Elbardesy et al. performed a systematic review on DLO and found out that this procedure had a low complication rate and showed satisfactory short term KOOS and IKDC score (45).

HTO for valgus knee with historically, HTO is more commonly used and developed for medial compartment arthritis (varus knee). Likewise, unicompartmental OA is less frequent in the lateral compartment. Lateral compartment OA is more commonly managed with distal femoral osteotomy. Several authors, however, have explored the use of HTO in valgus knee.

Figure 15. Double level osteotomy

There are still a few publications regarding this topic; a recent systematic review only found 17 publications of this topic. Unfortunately, from these papers do not report the degree of correction achieved. Moreover, due to the mixed quality of the studies, it is still difficult to draw a conclusion or recommendation. The patient satisfaction reported is mixed, ranging from 47-78%. The number of patients requiring TKR ranges from 10-70%. Thus, more good quality studies are required to build a recommendation. Fortunately, most studies indicate HTO can delay TKA in the patients for 5 to 10 years (46).

Role of arthroscopy prior to HTO was advocated by many surgeons. Muller, in his study found out that from 340 cases planned for osteotomy of the knees, arthroscopy procedure prior to osteotomy had changed the treatment for the patients. Ten patients received endoprosthetic treatment, 37 patients only arthroscopic therapy and modification of degree of correction in 157 cases (47). Rozkydal showed that arthroscopy prior to osteotomy improves post operative results in 52 patients in a total 92 patients with corrective osteotomy (48). Friemart stated that arthroscopy cannot be replaced by magnetic resonance imaging. An asymptomatic mediopatellaris plica for example, would receive stronger tension after valgisation and therefore has to be resected prophylactically to prevent plica shelf syndrome after surgery.49 Arthroscopic cartilage repair could be combined with high tibial osteotomy in treating unicompartmental knee osteoarthritis (50,51). One study mentions that combination of HTO with autologous chondrocyte implantation (ACI) yields superior outcome in 11-year-follow up compared to HTO alone (50). HTO is thought to promote cartilage regeneration by offloading the cartilage, and arthroscopic cartilage repair is proven to further promote cartilage repair, marked by increased collagen mRNA expression (51). Clinically, combination of HTO with arthroscopy could lessen length of stay (LOS) other than alleviating pain (52).

Patellar Height and Posterior Tibial Slope after High Tibial Osteotomy with historically, closed wedge HTO precedes open wedge HTO significantly. The risk of decreasing bone stock and neurovascular injury are primary concerns of this procedure. However, closed wedge HTO avoids osteotomy proximal to tibial tubercle, preserving patellar height. A study which compares patellar height of patients who underwent closed and open wedge HTO found that after one-year-follow-up, there is a significant decrease of patellar height of the patients who underwent open wedge HTO (53).

Previous studies agree that medial open wedge HTO causes significant decrease of patellar height. Gooi et al. found that proximal tubercle osteotomy significantly reduced patellar height.54 Recent systematic review of 11 retrospective studies mentioned similar conclusion; there is statistically significant reduction of patellar height, measure both by Catton-Deschamp index (CDI) and Blackburn-Peel index (BPI) (55). The concern of decreasing patellar height is its effect on patellofemoral degeneration. The change of patellar height after proximal tubercle open wedge HTO would increase patellofemoral pressure during knee flexion. The pressure may increase up to 7%, accelerating patellofemoral degeneration (53).

It is agreed that open wedge HTO would increase posterior tibial slope (PTS), and closed wedge HTO would decrease it. This change is observable in measurements from various reference points (anterior tibial cortex (ATC), tibial proximal anatomic axis (TPAA), and posterior tibial cortex (PTC)). PTS is thought to affect the tension of the cruciate ligaments. Increased posterior tibial slope would increase ACL's tension due to increased anterior translation of tibia. Vice versa, decreased tibial slope would increase PCL's tension due to more posterior translation of tibia.56

One case report mentions that increased tibial slope after open wedge HTO may cause degenerative changes in the patient's ACL.57 Moreover, a retrospective cohort by Kwon et al. found that the degree of degeneration in ACL following open wedge HTO is proportional to the magnitude of slope difference (58,59). On the other hand, the effect of closed wedge HTO to PCL degeneration is still rarely elaborated.

Rehabilitation after HTO with new plate fixators have improved stability of HTO construct which allows earlier mobilisation and weight-bearing. Some centers propose simple active mobilisation including initiation of active mobilisation on first postoperative day accompanied by strengthening exercise. Weight-bearing of 15-25 kg is allowed on the operated side in the first 6 weeks after operation. The limit is increased to 30-35 kg with good clinical and radiological control. Crutch-free mobilisation may be initiated after 8-10 weeks. Cycling exercise is allowed if flexion of 1100 is reached.

The details of the rehabilitation phases are as follows (60):

1. Phase I: week 0-2 Patients are fixed with hinged braces in full extension. The brace is always locked except during continuous passive motion (CPM) in the hospital. CPM maybe continued at 4-6 hours/day to reduce swelling and restore ROM.

The target is to achieve 900 knee flexion by the end of the second week. If extension is limited, prone hangs and extension bridging is recommended. Strengthening exercises include isometric quadriceps contraction in full extension. Weight bearing is prohibited with the aid of dual crutch. Icing and elevation could be done to reduce swelling.

2. Phase II: week 2-6 (NWB strengthening) Strengthening of the hip

could be done by doing leg raises while maintaining NWB. Quads should be strengthened further by performing terminal extension exercises.

3. Phase III: week 6-12 (Advanced strengthening and activity progression) The important benchmark in this phase is the initiation of WB. The goal is the patient able to ambulate without crutches in week 6-8. However, if the osteotomy is unstable, crutch could be maintained until 10th week. The strengthening exercise could be delayed likewise.

4. Phase IV: 3-9 months (return to activity) Low impact activity may be resumed in 3-4 months, and high impact activity may be resumed after 6 months or more. The patient should pay attention to any pain on the osteotomy site or any effusion.

Outcome and complication in general, the survivorship of both lateral closing wedge and medial opening wedge HuTO is excellent. Most good quality studies show that the 10-year survival rate of this procedure reaches 80%, even 90% in some studies. This outcome is directly affected by some preoperative factors: age>65 years is associated with worse outcome, more severe OA is associated with worse clinical outcome after the procedure, and poor correction is also associated with worse outcome. One recent study found that opening wedge HTO with fast rehabilitation protocol would yield superior functional outcome compared to UKA in patients older than 50 years old. Moreover, this superior result is observed as early as 6 months after surgery and maintained for the next 4 years.61

In the end, failure of HTO would demand TKA for correcting the deformity. Generally, TKA after failed HTO is challenging owing to several factors: intraoperative exposure, decreased patellar height, excessive joint line change on the tibia and/or malalignment due to overcorrected HTO.62 Moreover, medial opening wedge HTO is proven to induce biological improvement in osteoarthritic joint. Two years after HTO, the inflammatory biomarker of knee degenerative changes decreased significantly.63

Nevertheless, HTO is not free of complications. Some of complications frequently mentioned in publications are: hardware initiation, displaced lateral hinge, fracture of lateral tibial plateau, non-union, loss of correction, infection, peroneal nerve injury (especially in lateral opening wedge HTO), and vascular injury.64

CONCLUSION

Recent papers focus on the development of HTO technique which have been mentioned throughout this paper. The recent trend of studies is including surgical technology, cartilage repair and new fixation devices.65 In conclusion, HTO is a reliable procedure in treating unicompartmental OA, especially in younger active patients. It should be remembered that careful preoperative planning and meticulous surgical technique are mandatory in achieving satisfactory results.

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