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Indications and clinical outcomes of High Tibial Osteotomy: A literature review

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Abstract

Background: High Tibial osteotomy is a procedure with the goal of repositioning the mechanical axis of a varus malaligned knee into a slightly valgus one, in order to minimize joint tenderness, decrease the rate of cartilage degeneration and forestall or postpone joint replacement.

Methods: There is a great consensus among authors that this procedure's success depends on choosing the right patient: a moderately active individual with joint stability, between 40-65 years of age, with isolated joint line pain, body mass index <30, mal-alignment <15°, metaphyseal varus, good range of motion, high-demand patient, non-smoker, and with some degree of pain endurance capacity. Do a careful assessment of all patients with sagittal and coronal alignment.

Results: HTO is proven to possess a high success rate and low complication rate, with an incidence of non-union as low as 0-4.4%. More than 80% of patients restore their normal daily routine after one year, two-thirds of them at a level as demanding, or even greater than preoperative levels. Some studies outlined that the 10-year survival rate was anywhere between 51% and 93%, with a subsequent need for total knee replacement surgery.

Conclusion: HTO is an alternative procedure for knee arthroplasty in young, active patients with malaligned knee induced medial compartment degeneration. The purpose of this paper is to identify the evidence-based indications and up to date clinical outcomes of High Tibial Osteotomy by literature review.

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Introduction

High Tibial Osteotomy (HTO) is a common surgical technique for the treatment of varus deformity of the knee associated with medial compartment arthrosis/overload. It encompasses several procedures like an opening wedge, closing wedge, dome, and "en chevron" osteotomies. Closing (lateral) and opening (medial) wedge HTO are the most commonly used. However, opening wedge HTO was recently winning the spotlight for advantages of being easier to perform, no need for fibular osteotomy, and common peroneal nerve dissection, no disruption of the proximal tibiofibular joint, and without bone stock loss, when compared to closing wedge HTO.

Debeyre and Patte described Medial Opening Wedge (MOW) High Tibial Osteotomy (HTO) in 1951 [1]. HTO, initially intended to be the standard procedure for medial compartment knee OA, has now become the widespread use for uni-compartmental OA of the knee in young and active patients. The primary goal of HTO is to appropriately align the mechanical axis of the legs, transferring the load on the knee, so as to increase functionality, decrease the rate of osteoarthritis-induced degeneration, minimize joint tenderness and potentially reduce cartilage degeneration, as well as forestall or postpone joint replacement [2,3]. However, due to recent strides in total and unicompartmental knee replacement (TKR and UKR), the demand for HTO drastically reduced, especially for the elderly or less active patients [4]. That notwithstanding, the giant strides in cartilage healing surgery and meniscal transplantation in recent years has brought HTO back to the limelight as an additional procedure for axial malalignment management [5]. Synthes Inc., a swizz company in Bettlach, Switzerland, developed the internal fixator, TomoFixTM, to maintain the attained correction, as well as attain optimal stability, cutting the need for the additional bone graft to fill the gap produced by the osteotomy procedure [6,7]. Following OWHTO for elderly patients, the patient can walk unassistedly, with full weight, when given with sufficient postoperative rehabilitation. This then translates to avoid complications like osteoporosis or dementia.

In this study, patients are reported to walk unassistedly, with full weight bearing, 2 weeks after OWHTO treatment, provided sufficient rehabilitative care is begun early enough. In this particular case, TomoFix was inserted into the osteotomy gap, in combination with an artificial bone substitute. In the past, instability has deemed a contraindication to HTO. However, a current distinct indication for HTO is the need to rebalance the load in ligamentous insufficiency and substitute for any ligament reconstruction [3]. The aim of this review is to identify the correct indications for HTO and analyze the clinical outcomes.

Indications

Proper selection of patients for HTO is compulsory to attain satisfactory results [8,9]. Other determining factors include a correct indication, sufficient workup, preoperative management plan, and proper technique selection. Clinical indications for HTO include varus alignment of the knee associated with medial compartment arthrosis, unstable knee, post-meniscectomy medial compartment overload, and osteochondral lesions that require resurfacing procedures. HTO currently encompasses many procedures, either standalone or in combination with others. Conventionally, the typical HTO patient is a young, active individual (age <60 years), with normal weight, and radiographic single-compartment OA [10]. Other requirements include stable knee with a sufficient range of motion (ROM; flexion >120°), and pain should not extend beyond the tibiofemoral joint line.

Contraindications to HTO include more than 65-year-old patient, tri-compartmental OA, severe medial compartment OA (Ahlback grade III or higher). Relevant patellofemoral OA, ROM <120° (flexion less than 90° and a flexion contracture greater than 10°), unstable joint and ≥1 cm lateral tibial thrust, ≥20° of malalignment [11,12]. Other contraindications include axial deformity which can be assessed on stress radiographs and corrected by physiotherapy, diagnosed inflammatory arthritis, a large area of bone exposure on tibial and femoral joint surfaces (>15 cm × 15 mm), and heavy smokers [13,14]. The summaries of the included studies reporting relevant indication are shown in Table 1.

Indications for OWHTO and CWHTO

Each factor has been reviewed based on the most recent evidence available in the literature.

Age

Trieb et al. [15] found that the risk of HTO failure for patients older than 65 years was significantly higher (P=.046) than for those less than 65 (relative risk, 1.5). This is consistent with other research publications, which suggest that young patients, in particular, are best suited for HTO [16-18,13]. This thus confirms age as an influential factor for HTO patient selection.

99 OWHTOs cases were studied by Bonasia et al. [19], and it was found that age was of particular significance, as the likelihood of a failed operation was five times higher in patients aged >56 years, indicating there may be a need to reconsider the age range.

Of recent, 164 patients who underwent HTO were analyzed by Howells et al. [17], among which 95 were reviewed after a 10-year follow-up. Pre-operatively, with a Western Ontario and McMaster Universities osteoarthritis index (WOMAC) >45 points, age <55 years and BMI <30, they found the outcome was much better. However, in patients above 55 years, optimal pre-operative functional scores (greater than 66.7 for the Japanese Orthopedic Association Knee score and a WOMAC above 45 [20] were consistent with a quality prognosis for survival and functionality.

BMI

There is a distinct correlation between HTO prognosis and obesity. Akizuki et al [21] studied 159 knees CWHTOs and reported that pre-operative Body Mass Index (BMI) greater than 27.5 kg/m2 was consistent with a prognosis of early failure. Howells et al [17] however, used a BMI threshold of above 30 kg/m2 and found that the results for the obese group 5 years after HTO showed markedly reduced Knee Society Score (KSS) and Western Ontario and Mc- Master Universities Osteoarthritis Index (WOMAC).

The upper and lower limits of normal BMI are 18.5 and 24.9. Thus, a BMI higher than 27.4 is consistent with a poorer prognosis. In fact, survival analysis of 106 HTOs by Naudie et al. [22] indicated that individuals with a BMI lower than 25 have even poorer outcomes. However, there is currently no decisive conclusion on the correlation between BMI and OWHTO outcomes, according to Flecher et al [13].

Range of motion

Conventionally, a stable knee with a sufficient range of motion (ROM; flexion >120°), is a requirement to perform HTO surgery, in addition to pain being confined within the tibiofemoral joint line. Poor ROM has been consistently associated with poor prognosis by various authors, just as a flexion contracture is said to be contraindicated in OWHTO. In a retrospective study of 35 individuals who underwent a total of 39 OWHTOs, Berman et al. [23] found that a ROM <90° was associated with early failure. Akizuki et al. [21] showed that the threshold value distinguishing between a good and a bad outcome was preoperative ROM of 100°. Naudie et al. [22] showed that a flexion contracture of more than 5° correlated with early failure (p-value 0.042), especially with a preoperative ROM less than 120°. Bonasia et al. [19] found that both in multiple and single logistic regression models, a postoperative ROM of lower than 120° greatly influenced outcome negatively. We can, therefore, conclude, in line with other contemporary studies [24,8,22], that a preoperative ROM of less than 120° increases the chances for a poorer prognosis.

Grade of osteoarthritis

The degree of a medial compartment OA serves to predict the postoperative prognosis of HTO. In individuals with Ahlback Grade 0, Bonasia et al. [19] showed that they possess statistically significant prognostic potential. Floerkemeier [25] assessed 533 patients at an average of 3.6 years post-HTO; preoperatively, 85% of them had grade iii or iv OA. They also found favorable outcomes in individuals with severe mono-compartmental arthritis, with a local postoperative complication rate of 6%. However, there was no relationship between patient age and the Oxford Knee Score. Moreover, midterm results in OWHTO were found to be commendable, even in older patients who have significantly high medial cartilage degeneration. Like Majima et al., found no evidence in the literature that a shift of the weight-bearing line towards the lateral compartment aggravates the conditions of this compartment [26]. A neutral alignment proves better off in very young patients. Correcting the femorotibial angle to between 6° and 14° of the valgus provided optimal clinical outcome [13].

Instability

The unstable knee was once classified under the contraindications for HTO. But of late HTO, with or without combined ligamentous reconstruction, has gained the spotlight for correcting chronic knee instability, ligament reconstruction failure, and medial arthrosis associated with knee instability.

Some authors [27,28] portended unfavorable outcomes for HTO cases with unstable knee joints. However, multiple studies of late have debunked the claim that an unstable knee joint is contraindicated in OWHTO. For cases of combined instability and varus malalignment, a combined approach may be considered; for example, a combination of ligament procedures and OWHTO [29,9,30].

Above are the significant factors for selecting the best HTO patients and determining the postoperative prognosis.

Preoperative Planning

To perform a seamless yet predictable OWHTO starts with a sufficient preoperative management plan [31]. Conventionally standardized radiographs include the following: bilateral weight-bearing Anteroposterior (AP) images of a fully extended knee and in 30-45° of flexion (Rosenberg view), lateral, skyline and weight-bearing hip-to-ankle AP views [32]. The two AP views are indicated to evaluate the joint cavity, in extension and flexion. Severe patellar height deformity may indicate combined tibial tubercle osteotomy, or provide a clue for selecting either closing or opening wedge HTO. Lower extremity alignment measured on a weight-bearing hip-to-ankle AP view. MRI helps to identify other bony or soft-tissue defects (eg. osteonecrosis, meniscal tear, ligamentous lesion, osteochondral defect) and subchondral edema, which are typically seen in overloaded states. Usually, the mechanical axis is repositioned to 62.5% medial-lateral (medial edge=0%) across the tibial plateau [33] which is roughly equivalent to the midpoint of the downslope of the lateral tibial spine [34]. We most often employ the osteotomy technique as detailed by Dugdale et al [32]. This technique is built on identifying the weight-bearing line (i.e, the line running through the center of the femoral head to the center of the ankle). A thorough physical examination starts out with an evaluation of gait. A varus thrust strongly indicates the need for osteotomy. Compare the range of motion with that of the contralateral knee in order to identify any recurvatum, loss of flexion or extension. Ensure to completely test ligament stability. Identify any other ligamentous injury that should be factored into the operation. With sufficient preoperative schematics, there is neither a need for intraoperative radiographs nor a bovid cord to attempt to judge alignment. An unstable knee is typically an indication for opening wedge HTO, as this procedure helps to modify the tibial slope. Closing wedge HTO, on the other hand, would typically reduce the tibial slope. In cases where the ACL is deficient, decreasing the tibial slope can reduce the anterior tibial translation [35,36].

On the other hand, when the posterior cruciate ligament is deficient, the knee stabilized by increasing the slope [35], because of modified biomechanics and decreased posterior tibial translation in gait. The surgical plan for closing wedge HTO is the same. Although the angle (α) is computed just as in opening wedge osteotomy, the osteotomy proper, however, is different as it involves two cuts. The proximal osteotomy line placed horizontally, 2 to 2.5 cm distal to the joint line. The proximal and distal osteotomies typically define the angle of correction (α). Planning in the sagittal plane is less a requirement in HTO for medial compartment arthrosis than it is on an unstable knee. However, the tibial slope's anatomy must remain unaltered (Figure 1).

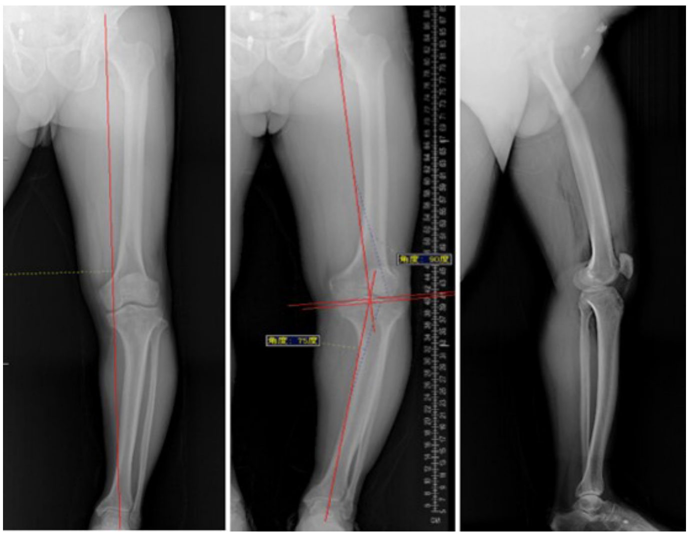

Figure 1: Preoperative weight bearing radiography of a 45years old man who underwent opening wedge high tibial osteotomy, showing proximal tibial varus deformity and medial narrowing.

OWHTO Surgical technique

The patient is reclined supinely on a radiolucent operating table, with a tourniquet positioned around the thigh. Beginning from 1 cm below the joint line, a longitudinal incisive cut is made, down to the midpoint between the medial border of the tibial tubercle and the posteromedial border of the tibia. A blunt retractor is used to retract the pes anserinus distally, to reveal the superficial medial collateral ligament. A Cobb elevator is then employed to partially separate the ligament distally, in order to prevent complete distal insertion detachment. Next, the medial border of the patellar tendon is identified and retracted. To guide against destroying the lateral cortex, a guidewire is inserted with the aid of fluoroscopy, starting from the anteromedial tibia at the level of the superior border of the tibial tubercle, about 4 cm distal to the joint line. The guidewire is pointed in the direction of the tip of the fibular head, 1 cm below the lateral articular surface. Using an oscillating saw for the medial cortex, the osteotomy is then carried out immediately distal to the guidewire. The osteotomy may then be finished within 1 cm of the lateral tibial cortex, using graduated thin flexible osteotomes. Three or four osteotomes can be stacked up at the osteotomy location to attain sufficient opening. To attain the desired degree of correction, calibrated wedges may be fitted into the osteotomy. Along alignment, the rod is used to ascertain the accuracy of the correction, with the aid of fluoroscopy. Place the rod at about 62.5% of the tibial width (just lateral to the lateral tibial spine). With four cancellous screws proximally, and four cortical screws distally, the opening of the osteotomy obtained is synthesized, with the TomoFix plate. Ensure bone grafting when the opening measures above 10 mm [9] (Figure 2).

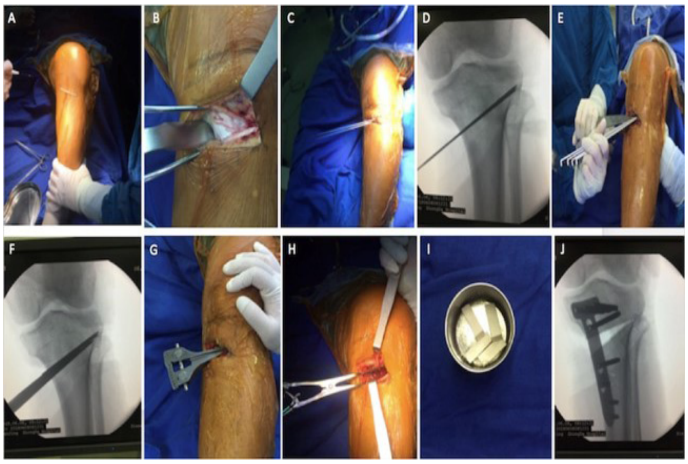

Figure 2: Intraoperative photographs and fluoroscopic images. A) Placement of the incision. B) The pes anserinus is retracted and superficial MCL is visualized. C) Guidewire is inserted from medial to lateral. D) Evaluate the position of guidewire with the help of fluoroscope. E) The osteotomy is carried out distal to guidewire with the osteotomes until the desired opening is achieved. F) The mechanical axis correction is verified with the fluoroscope. G) calibrated wedges fitted into the osteotomy. H) A blunt retractor has been placed to expose the posteromedial border of proximal tibia. I) Bone grafting. J) Fixation with the medial locking plate.

Postoperative Management

Multiple studies show that after opening wedge HTO, the knee is fixed in a ROM brace set at 0 to 90°, and the patient is kept touch weight bearing for 6 weeks. Bracing is then removed between weeks 6 to 12, while weight bearing advances steadily to full weight bearing. In 6 and 12 weeks, short leg radiographs are to be obtained to verify the stability of correction and healing, while long leg alignment films should be taken on the 6th month [37]. The standard postoperative management technique for closing wedge HTO represent a combination of hinged bracing for 6 weeks and partial weight bearing. However, if the radiograph substantiates healing after a 6-week follow-up, the patient is then progressed to weight bearing based on his or her degree of tolerance. Radiographic follow-up is the same as for opening wedge HTO [37].

The osteotomy is secured in a padded hinged knee brace for 6 weeks. The individual is to be educated on partial weight bearing with crutches. If the radiographs show signs of consolidation 6 weeks after the procedure, the patient continues full protected weight bearing (with crutches) 6 weeks more. Typically, the union is totally attained on or before week 12. Damage to the lateral cortex demands a more closely monitored management of the weight-bearing schedule. In the early postoperative phase, physiotherapy is centered on gait training, the range of motion exercises, pain management, and maintenance of surrounding joint strength and function. By week 6, physiotherapy is geared up to increase functionality. After week 12, therapy is then focused on maximizing muscular endurance and correcting any other functional defects identified (Figure 3).

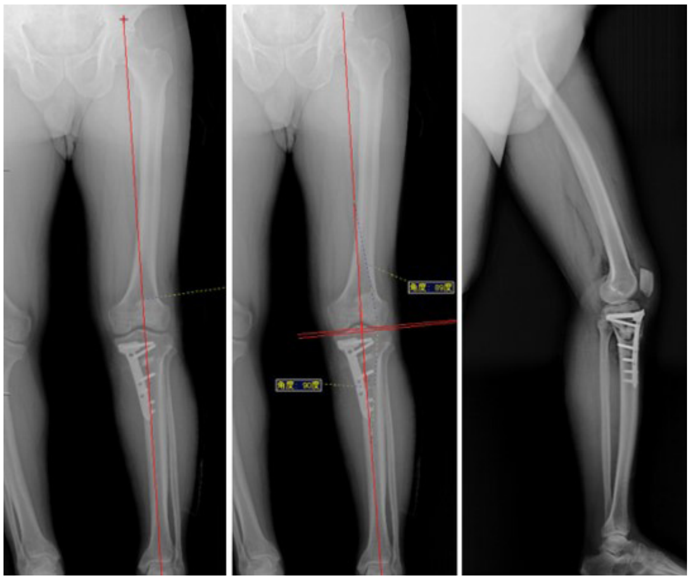

Figure 3: Postoperatively full weight bearing radiography evaluation of MOWHTO in the same patient of Figure 1. Tomo Fix Medial High Tibial Plate (synthes) was used for fixation.

Complications

Complications of OWHTO include a fracture through the lateral cortex or articular surface, damage of the posterior neurovascular structures, osteotomy failure, infection, and medical complications in line with the patient's comorbid conditions. Drilling a hinge pinhole may reduce the risk, as it allows the osteotomy to open through, thus, decentralizing the forces. With an extended lateral approach to the tibia, several authors have indicated damage of surrounding vessels. This may be avoided by using a posterior retractor and by flexing the knee as osteotomy is made, to minimize the tension on the vessels. However, the Balance has an implant guide with a built-in neurovascular sleeve that protects these structures. Osteotomy collapse is a complication unique to opening wedge osteotomy and has not been previously identified in closing wedge osteotomy. This is why weight bearing is guarded against for 6 weeks postoperatively, to give room for new bone formation to fill in the gap at the osteotomy location, thus preventing collapse.

Outcomes

The appreciable outcome, in the long run, is a direct result of proper patient selection, accurate surgical technique and fixation, and adequate postoperative management. A recent systematic review argues HTO is effective for pain reduction and knee function enhancement in patients with medial compartmental OA of the knee; however, no osteotomy technique appeared superior to others and no sufficient proof that HTO is more effective than either UKR or non-operative treatment [38].

Schallberger and colleagues [39] attempted a comparison between the survival rates of the various HTO techniques by conducting a retrospective study of OWHTOs and CWHTOs. Employing a median follow-up of 16.5 years, comparative survival rates indicated a progressive decline. Both approaches did not defer substantially in prognostic survival or functionality, however present data remains insufficient. A randomized clinical trial of late by Duivenvoorden and colleagues [40], with a follow-up average of 6 years, compared the mid-term results of these procedures. However, no significant clinical outcome was indicated. Yet, the OWHTO group failed with worse complications, while more conversions were noted, from the CWHTO group to TKA.

There is currently a shortage of documented research on the long-term results of HTO, with only a handful of those on OWHTO. More available, however, are those focused on the long-term outcome of CWHTO, as this technique precedes the former. Moreover, the debate is still ongoing as to which of the two techniques offer the best clinical outcome. In their study of 42 knees, Soleiman pours et al. [41], found a statistically relevant distinction between OWHTO and CWHTO, in favor of OWHTO, as regards length of operation, weight-bearing duration and return to normal daily functionality. While carrying out a systematic review of 4,557 patients in 69 studies, Harris et al. [42] analyzed the prognosis of isolated and combined HTO (with other procedures). The study revealed that after a two-year postoperative follow-up, prognostic survival was statistically in favor of OWHTO than CWHTO. Deie et al. [43] posited that OWHTO reduced varus movement and lateral thrust, whereas CWHTO does not significantly reduce lateral thrust. However, other authors, including Duivenvoorden et al. [40] and Brouwer et al. [44], did not find any differences.

There is a consensus across the board that slight valgus overcorrection produces the best results in HTO for medial knee arthrosis. However, the specific degree of valgus correction is yet to be agreed on. Dugdale et al [32] stand for a postoperative mechanical axis with a valgus correction of 3° to 5°, but some others recommend overcorrection of 3° to 6°, [45] 3° to 7°, [46] or even 7° to 9° [47].

For several years, lateral closing wedge HTO has remained the standard procedure for correcting medial knee osteoarthritis. However, its downsides include the need for fibular osteotomy or proximal tibiofibular joint disruption, peroneal nerve dissection, loss of bone stock, and a worse tibial slope control (with a likelihood to decrease it), apart from the fact that it ultimately demands TKA. All the above, in addition to a better implant technique, has paved the way for the current preference of opening wedge HTO, as an alternative. This procedure, however, is not without its own shortfalls, which includes the need for bone grafting and the chance of collapse or loss of correction [48].

The major positive prognostic factors include age <50 years, excellent preoperative Knee Society Score and Ahlback grade 0 arthritis of the medial plateau; negative prognostic factors include obesity, especially more than 1.3 times of the normal population weight, smokers, anatomical valgus alignment of. Five (at five weeks post-operation), postoperative flexion <120, and age >56 years old [49,19]. Coventry, Ilstrup, and Wallrichs found the survival rate to be lower in obese patients (51% *vs* 91%) [49]. Akizuki et al. showed that early osteotomy failure correlates with a BMI >27.5 [21]. On the other hand, patients with BMI <25 also had poor outcomes: the hypothesis is that lighter patients are often more active, impressing higher stress in the osteotomy site [22]. Hence, the outcome is best for BMI between 25 and 27.5.

Taking a mean estimate, more than 80% of all HTO patients were back to work 1-year post surgery; more active jobs required a longer break from work. Around two-thirds of patients went back to work at a level of physical demand equal to or greater than their preoperative level. Moreover, about 80% of patients returned to the sport at a level equal to or greater than their preoperative level [50].

The HTO results released in these reports substantiated the deteriorating trend: an expected 10-year survival of 75%. Evidence supporting the use of one surgical HTO technique over another is lacking, whether or not the most advanced implants and surgical approaches are employed.

The complications of HTO may be classified into two categories: problems arising from the specific procedure and general complications of surgery (infection, scar, deep vein thrombosis etc). The rate of grave HTO complications is low, but the rate of minor complications is comparatively higher. For all implant types employed, Woodacre described an overall complication rate of 31%, with an overall non-union rate of 4.3%, all subsequently revised, and successful union achieved. The infection rate needing hospitalization was 3.5%, just as another 9.5% were given outpatient oral antibiotic medications for minor wound infections. Nonunion rates seemed to be influenced by implant type with locking compression titanium plate group (3.6% *vs* 8.3%) recording a lower rate, although this also appeared insignificant [4]. Other authors report that the likelihood of non-union post HTO is between 0.7% and 4.4% [51]; the documented risk factors for non-union include an extensive correction in MOW HTO, smoking and poor fixation [48]. In the past, long-term cast immobilization was unavoidable after LCW HTO. As a result, patella baja secondary to patellar tendon contracture was documented to have a prevalence of 7.6-8.8%. During LCW HTO, the likelihood of nerve damage induced common peroneal nerve palsy was identified in 20-16% of cases. Such poor outcome can be minimized by fibular shaft osteotomy. The rate of external fixation associated infection is reported to be 2.3-54.5%, whereas that of internal fixation associated infection is reported as ≤4%. Other documented complications include fixation failure, loss of correction, pseudoarthrosis, deep venous thrombosis, pulmonary embolism, and compartment syndrome [11].

To improve long--term survival and minimize postoperative complications, correct patient choice as regards age, BMI, the range of motion, grade of osteoarthritis and knee instability is highly crucial. Other necessary factors include the appropriate surgical approach, proper implant selection, and preoperative management plan.

Conclusion

The goal of this technique is to unload the medial compartment of the knee to delay the progression of osteoarthritis. Moreover, according to available clinical evidence, HTO has consistently proven to be effective to reduce pain and improve knee function in individuals with a medial knee OA. Appreciable long-term outcomes are typically dependent on proper patient selection, appropriate surgical approach, and correct fixation.

From available evidence, the best patient for an OWHTO is a young (less than 56 years of age), normal weight or only slightly overweight (BMI 25-27.5), individuals with a range of motion of at least 120°, a flexion contracture of less than 5°, a low grade of the medial compartment OA (< Ahlback ii) without involvement of lateral compartment or patellofemoral compartment.

A comprehensive preoperative management plan is needful. Conventionally, a valgus overcorrection planned at 5° to 6° [9]. Overcorrection is not recommended in young patients and athletes, and the goal is to achieve a neutral alignment [52], avoiding lateral overload.

The documented 10-year survival rate of HTO is about 93%; moreover, there is a greatly significant tendency to resume work and sports activities post-HTO, at around 80%.

In conclusion, HTO qualifies to be deemed a safe and effective procedure. Its evergrowing acceptance is not unrelated to the consistent advancement in its techniques, as well as the improvement of its fixation devices, in conjunction with the advancement of sports medicine, soft tissue, and chondral surgery. In the light of the above, it is no surprise that HTO is currently widely employed in favor of knee arthroplasty in young patients with medial degenerative changes in a varus knee, particularly in the young active demographic or physically demanding workers.

Tables

Table 1: Result indication of different parameters.

Author	Year	Type of Study	Follow Up	Cases	Type	Age (years)	BMI	ROM	Grade of OA	Functional Score
Trieb K et al. [15]	2006	Retrospective	13±2 years	94	NOT STATED	<65	-	-	-	-
Bonasia DE et al. [19]	2014	Retrospective	9 years	99	OWHT Os	<56	-	>120°	Outer-bridge =0	-
Howells et al. [17]	2014	Prospective	10 years	95	CWHTOs	<55	<30	-	-	WOMAC>45 point
Akizuki S et al. [21]	2008	Prospective	10-20 years	159	CWHTOs	<65	<27.5	>100°		HSS>55 point
Naudie D et al. [22]	1999	Prospective	10-22 (mean=13) years	106	CWHTOs & DOMe	-	>25	>120°	-	-
Berman A et al. [23]	1991	Retrospective	3.8-15.1 (mean=8.5) years	39	NOT STATED	<60	-	>90°	-	-
Flecher X et al. [13]	2006	Retrospective	12-28 (mean=18) years	372	CWHTOs	<50	<30	-	Ahlbäck <3	-
Floerkemeier S at al. [25]	2013	Retrospective	2.4-4.7 (mean=3.6) years	533	NOT STATED	60 or above	-	-	Outer-bridge =iii,IV	OKS=43 point

WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index; HSS: Hospital for Special Surgery; BMI: Body Mass Index; YO: Years Old; ROM: Range of Motion, OKS: Oxford 12-item knee score

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