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■ INSTRUCTIONAL REVIEW: KNEE

Complications of closing wedge high tibial osteotomies for unicompartmental osteoarthritis of the knee

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We systematically reviewed the published literature on the complications of closing wedge high tibial osteotomy for the treatment of unicompartmental osteoarthritis of the knee. Publications were identified using the Cochrane Library, MEDLINE, EMBASE and CINAHL databases up to February 2012. We assessed randomised (RCTs), controlled group clinical (CCTs) trials, case series in publications associated with closing wedge osteotomy of the tibia in patients with osteoarthritis of the knee and finally a Cochrane review. Many of these trials included comparative studies (opening wedge *versus* closing wedge) and there was heterogeneity in the studies that prevented pooling of the results.

Keywords: High tibial osteotomy, Unicompartmental, Osteoarthritis, Complications, Closing-wedge, Review, Knee

Introduction

High tibial osteotomy (HTO) remains a popular treatment method in unicompartmental (medial) osteoarthritis of the knee. There are three main procedures for high tibial osteotomy (HTO); lateral closing wedge, medial opening wedge and dome osteotomy.[1] The HTO closing wedge was first described by Jackson and Waugh[2] in 1961 and then further popularised by Coventry in 1965.[3] The function of these osteotomies is to correct the mechanical axis and off-load force from the medial compartment onto the less affected, lateral part of the joint. In the closing wedge procedure, this is achieved by performing an osteotomy above the tibial tubercle and removing an appropriate wedge of bone. Mechanical axis is therefore shifted laterally, theoretically improving function and pain scores.

An in-depth comparison between both closing- and open-wedge osteotomy is beyond the remit of this paper, however, the advantages are thought to be a shorter time to begin weight-bearing and to healing, better control of maintaining posterior tibial slope and less patella baja. In addition there is no need for bone graft or synthetic bone substitute.

Of the papers reviewed, pooled complication rate ranges between 5%[4] and 34%[5] with a mean of 15.2%.[6-9] The complications are listed in Table I and discussed individually at greater length below.

Infection

Reported rates of infection range from 0.8% to 10.4%.[5,6,8-10] The majority of these are superficial wound infections that can be treated successfully with oral antibiotics. Deep infections are more problematic and may require irrigation and debridement with the use of intravenous antibiotics. Eradication of deep infection is possible by debridement, intravenous antibiotics and bone grafting.[5] Fixation devices should be left *in situ* if at all possible.

Thromboembolic events

The incidence of deep-vein thrombosis (DVT) ranges from 2% to 5%,[5-11] a similar rate to that of major joint replacement. A post-HTO venographic study indicated that the rate of DVT may be as high as 41%,[12] but that the vast majority of these thrombi are located distally in the calf with little chance of progression more proximally. Of those few in the proximal veins, only 15% were clinically detectable (with patients complaining of calf pain). Isolated fatal pulmonary emboli have been reported.[7,11] The use of a tourniquet did not seem to have any significant effect on the incidence of thromboembolic disease.[13]

With the above information, the use of a thromboprophylaxis regimen similar to that of a knee arthroplasty may be prudent.[12]

Fractures

An osteotomy is a controlled fracture. In HTO, a wedge of bone is resected, leaving a hinge

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Table I. Mean rates of complications from the reviewed articles

Complication	Rate (%)
Infection	4.7
Thromboembolic event	3.1
Fractures (opposite cortex and intra-articular)	63
Neurovascular complications	9.8
Under-correction/recurrence of deformity	N/A*
Conversion to total knee replacement	N/A*
Nonunion	2.2
Delayed union	6.6

* N/A, not available (the amount of correction depends on initial severity, and conversions are time-dependent). See text for further details

of bone on the opposite side that helps to maintain stability. Options for this include leaving the osteotomy 5 mm from the opposite cortex. Two things must occur in the process of angular correction. Plastic deformation occurs in the hinge and microfractures occur in this region of bone as the osteotomy is closed. Propagation of the fracture to the opposite cortex or the intra-articular region is to be avoided. In their series of 44 cases, van Raaij et al[14] reported opposite cortex fracture in 36 patients (82%) undergoing closing wedge HTO. The authors state that this complication is 'not entirely preventable'. The notion that a valgus osteotomy greater than 7° or 8° will inevitably cause an extension fracture is supported by other authors.[15-17] Importantly, van Raaij et al[14] noted in their cohort of 44 patients that despite the high numbers of medial cortical fractures at one year, they did not cause a recurrence in varus angulation or significant malunion in any case. Of the closing wedge group, the desired angular correction was maintained more often in those cases complicated by fracture than in those without fracture (seven of 18 (39%) *versus* six of 18 (33%)) than in those without fracture. They postulated that 'With the closing wedge technique, posteromedial bony remnants may act like a more lateral hinge when closing the wedge, and probably cause fracture and gaping at the medial osteotomy site with pronounced valgisation'.[14] Despite this, the majority of surgeon aim to leave the posteromedial hinge of bone, as described by Slocum et al.[18]

An option to maximise the amount of valgus deformation before fracture is to place a drill hole from anterior to posterior. This is positioned 1 cm from the media cortex and 2 cm below the articular cartilage. The authors report the stress relieving hole allows a further 3° of valgus deformation than without one.[15]

Intra-articular fractures during closing wedge osteotomies have a reported incidence of between 0% and 20%.[5,7,8,10] This occurs when the osteotomy is too shallow and the medial hinge is too wide, causing excessive resistance during closure of the osteotomy, which can direct the applied force into the joint resulting in an intra-articular fracture. Also, an osteotomy too close to the joint with a resultant thin proximal fragment will offer little resistance to fracture. In general, the width of the medial hinge should be less than the distance from the end of the osteotomy to the joint line.[18] It is critical to recognise the occurrence of this complication, as congruity of the articular surface must be preserved. Most intra-articular fractures remain reduced and require no additional fixation.[10,18] Assessment can be made with fluoroscopy and/or directly with arthroscopy. Displacement of an intra-articular fracture necessitates reduction and fixation, usually in the form of compression screws.

Nerve injury

The incidence of symptomatic peroneal nerve injury is reported between 3.3% and 11.9%; EMG demonstrates nerve damage in up to 27% of patients.[19-21] While many of these are temporary deficits, some report that 50% of those with early peroneal symptoms are left with some permanent deficit.[19]

Reasons for nerve injury following an HTO include neuropraxia secondarily to tourniquet use,[22] tight bandages/plaster casts,[3,23] compartment syndrome[21,24] and finally from iatrogenic peroneal nerve palsy.[25] While pressures in the compartment do increase (up to 50 mmHg – maximally between the six hour and 24 hour post-operative period) the use of a drain can significantly reduce this complication.[21,25]

Most authors agree the most frequent cause of nerve injury is iatrogenic damage to the peroneal nerve in particular with the inclusion and location of the fibular osteotomy.[19,26] The extensor hallucis longus is the most affected muscle after HTO. Anatomical studies have confirmed that there are two or three branches to this muscle.[26,27] However, in some instances there may only be the one branch from the deep peroneal nerve,[19] and injury to it may cause permanent palsy. This division is typically located 7 mm to 8 mm from the fibular styloid process. Another danger area is the close relationship between the common peroneal nerve and the neck of the fibula. The nerve is on average only 4 mm posterolateral to the fibular head.[19] Very proximal detachments of the fibular head may cause tractional pressure on the nerve as it adherent to the periosteum. Around 2.5 mm from the fibular styloid, the nerve divides into its deep and superficial parts and again is at jeopardy.[27]

As a result, the so-called safe zone of fibular osteotomy is suggested to be at the junction of the middle and distal thirds (around 16 cm distal to the fibular head).[19,20,25,27] Osteotomy at this level requires a separate incision.

Vascular injury

Vascular injuries during closing wedge osteotomies are rare occurrences, but case reports of direct damage to the posterior tibial artery (both complete transaction and pseudoaneurysm) are documented.[20,25,27] Damage to the anterior tibial artery by poorly placed retractors or osteotomy jigs is a more common occurrence due to its relatively proximal and unprotected origin. Careful use of these instruments is therefore suggested to avoid vascular complications.

Undercorrection/recurrence of deformity

The goal of any HTO for varus malalignment is to shift the load from the medial to the lateral compartment of the knee. Biomechanically, 70% of the load is borne by the medial compartment when the mechanical axis passes through the centre of the knee,[28] This load decreases to 50% in 4° of valgus with a further reduction to 40% in 6° of valgus.[29]

Given these data, most authors recommend an alignment range between 2° and 6° of mechanical valgus.[3,30-34] Coventry[3] recommended 8° of valgus. Hernigou et al[35] achieved best results at between 3° and 6° of mechanical valgus and showed deterioration when correction was > 6°. Fujisawa, Masuhara and Shiomi[36] used a different approach, aiming for the mechanical axis to pass through a point 30% to 40% lateral to the midpoint of the knee (the so-called Fujisawa point). Much controversy still remains regarding the ideal mechanical alignment. Many authors aim for an overcorrection of at least 5° with results showing better long-term outcomes.[4,37,38]

Regardless, pre-operative planning and adherence to that plan may be the key to a better outcome. Therefore the use of jigs and computer navigation may well be the more accurate way to attain the desired goal.[39-41] Ultimately, undercorrection of the HTO is related to higher rates of revision and conversion to total knee replacement (TKR).

Conversion to total knee replacement

Survivorship of the HTO procedure is often measured by the conversion to TKR. There are few large number prospective studies with substantial follow-up. The largest series so far followed a group of 301 knees for a mean of 18 years (minimum of 12 years) after a closing wedge HTO.[30] Survival was 85% at 20 years with revision as the endpoint. Knee function was considered satisfactory by 77% of patients. Their population was a younger group than other studies (mean age of 42 years), with an equal gender mix. Their multivariate analysis showed that an age > 50 years and a pre-operative Ahlback grade[42] for arthritis of ≥ 3 were predictors of poor outcomes.[30]

Another large series followed 118 knees for a mean of 16.4 years.[31] They reported survivorship of 97.6% (95% confidence interval (CI) 95.0 to 100) at ten years and 90.4% (95% CI 84.1 to 96.7) at 15 years. Their cohort had a mean age of 63, and the Cox's proportional hazards model gave a relative risk ratio of 1.196 for an age > 65 years. Excellent and good results, as assessed by the Hospital for Special Surgery (HSS) knee score,[43] were achieved in 87 knees (73.7%).[31] Of the 11 patients (9%) who required conversion to TKR, three had an inadequate angle of correction at one year, one had a hyper-valgus correction and seven had good correction despite poor HSS knee scores. In this study, a pre-operative body mass index > 27.5 kg/m^2 and range of movement < 100° were risk factors predicting early failure.[31] These results are similar to those from a smaller series also from Japan,[32] with a similar patient cohort (four times as many women as men, and a mean age of approximately 60 years).

Other studies demonstrate less successful survivorship. Tang and Henderson[33] described a cumulative survival probability of 89.5% at five years, 74.7% at ten years and 66.9% for both 15 and 20 years, based on a cohort of 67 knees with a follow-up between one and 21 years. A similar survivorship is reported by other studies in younger patient cohort.[5,34]

Most series report a deterioration in both functional outcome and conversion to TKR rates after ten years.[3,10,44]

The results of TKR after HTO are variable. Some studies have found poor results when compared with primary TKR[45-47] and others have found no difference.[48-50] Parvizi et al[50] have a large series of post-HTO arthroplasties with a 15-year follow-up and revision rate of 92%, but also report a high rate of radiological evidence of tibial loosening but without revision.

Most authors agree that the surgical approach to arthroplasty after any type of HTO is more complex, with time for careful dissection being paramount.[51] The presence of scars, patella baja, ligamentous laxity, remaining hardware and fibrosis are all issues that may have to be addressed. The use of a cruciate-sacrificing system is advocated after HTO, as ligamentous instability is thought to attribute to poorer outcomes in those with implants retaining the posterior cruciate ligament.[52]

Nonunion

The major benefit of the closing wedge over the opening wedge is the lower rates of non- or delayed union. This is because there is good bone apposition and the osteotomy is in compression.[2,10,14] Nonetheless, rates of nonunion have been reported between 1% and 5%, with a mean pooled rate of 2.2%.[5,8,10,31,32,53] The usual general risk factors for non- or delayed-union must be considered in patient selection i.e. smokers, diabetics, arteriopaths, and those that are non-compliant.

From a surgical point of view it is considered that an osteotomy distal to the tibial tubercle has a higher rate of delayed/ nonunion compared with those made proximal to it (14% *versus* 3%).[53] Treatment options include the use of adjuvants such as BMP, electrical stimulation and distraction osteogenesis.[54,55]

Summary

The closing wedge high tibial osteotomy remains a relevant treatment option in the option of unicompartmental osteoarthritis. While the criteria for patient choice remain contentious, most authors agree that in a younger patient with varus or flexion deformity of < 15°, no ligamentous instability and no other degenerative changes, a closed HTO may still be a suitable procedure. While the survivorship rates are variable, most authors agree that the levels of analgesia and failure increase after ten years.

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