Degenerative Meniscal Tears and High Tibial Osteotomy

Do Current Treatment Algorithms Need to Be Realigned?

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KEYWORDS

• Degenerative meniscal tear • Knee osteoarthritis • Varus gonarthrosis • Osteotomy • Limb realignment • Prevention • Treatment algorithms

KEY POINTS

- Recurring medial knee symptoms in the presence of varus alignment and a degenerative medial meniscal tear signify medial compartment overload and early knee osteoarthritis (OA) even if joint damage is not evident on plain knee radiographs.
- Arthroscopic partial medial meniscectomy is routinely performed for these patients in areas around the world, but does not address the underlying biomechanical problem.
- As varus alignment is a strong risk factor for medial joint degeneration, we propose limb realignment surgery should be considered earlier in the treatment algorithm at a time when biomechanical intervention is more likely to modify disease.
- The rationale and low-level proof of principle exist to encourage future investigations, including randomized trials, to evaluate HTO as a disease-modifying intervention in early knee OA.

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INTRODUCTION

Knee osteoarthritis (OA) is the most common chronic joint disease, affecting all joint tissues and structures by the time the disease is well established. Degenerative meniscal tears frequently appear before changes occur in the articular cartilage and subchondral bone, and should be considered early knee OA.[1–3]

A strong body of evidence suggests that varus alignment increases the risk for degenerative meniscal tears[4–7] and radiographic knee OA.[8–11] Despite the long history of limb realignment procedures, varus alignment is seldom considered to be a modifiable risk factor in knee OA by many health care providers, including orthopedic surgeons. Moreover, surgical realignment procedures that could address the underlying varus alignment, such as high tibial osteotomy (HTO), are rarely considered until much later in the course of the disease, after substantial degenerative changes have occurred and are clearly evident on plain radiographs.

The purpose of this article was to propose that medial-opening wedge HTO be considered as a treatment option for secondary prevention in patients with frequent knee symptoms, varus alignment, and degenerative meniscal tears, in the absence of radiographic OA. We provide rationale and low-level proof of principle using specific case examples. Last, we discuss caveats and challenges, along with proposed future directions for research in the area.

DEGENERATIVE MENISCAL TEARS

The menisci are fibrocartilaginous structures in the tibiofemoral joint that are vital for dynamic joint stability and load transfer. Repetitive trauma and excess loading to the knee can disrupt mechanical and biological processes, leading to meniscal degeneration, and jeopardizing the protective functions of the menisci for the joint. Degenerative meniscal tears often involve horizontal cleavage of the meniscus in middle-aged or older persons. These lesions are particularly common in persons *(with or without symptoms)* older than 50.[2,12] Although degenerative meniscal tears often exist without symptoms, many patients do seek care for episodic knee pain, catching, synovitis, effusions, and disability *(*ie, *symptoms of knee OA)*. Indeed, the symptoms attributed to degenerative meniscal tears may be the first indications that the OA disease process has begun to alter knee joint structures. Furthermore, numerous studies suggest meniscal pathology is associated with an increased risk for further knee joint degeneration evident on plain radiographs *(*ie, *incident radiographic knee OA)*.[13–18] Given the tremendous burden of knee OA and the high prevalence of degenerative meniscal tears, we believe it is crucial to explore potential disease-modifying interventions for these patients.

LOWER LIMB ALIGNMENT AND GAIT BIOMECHANICS

Numerous observational cohort studies demonstrate that varus alignment is a potent predictor of OA in the medial knee compartment, including meniscal pathology,[4–7] and incident[8,11] and progressive[5,8–11] tibiofemoral joint degeneration. For example, evidence has existed for almost 20 years that varus alignment results in a fourfold increased risk of progression in medial radiographic knee OA over as little as 18 months (adjusted odds ratio [OR] 4.09, 95% confidence interval [CI] 2.20–7.62).[10] More recently, MRI studies suggest that knees with varus alignment are twice as likely to develop medial meniscal pathology *(*ie, tear, destruction, or maceration) within 30 months compared with knees without varus alignment (adjusted OR 2.00, 95% CI 1.18, 3.40).[6] In addition, varus alignment is associated with almost 4 times

the risk of developing medial articular cartilage damage in the tibiofemoral joint, evident through MRI (adjusted OR 3.59, 95% CI 1.59–8.10).[5] Several studies also show that varus alignment is associated with high rates of developing symptomatic and radiographic knee OA.[8,11] Therefore, the depth of evidence suggests varus alignment can play a critical role in both the onset and progression of medial knee OA.

Biomechanical studies also demonstrate the potent effects of lower limb alignment. Gait studies, including instrumented knee implant[19] and motion capture[20] data, show that even small changes in frontal plane alignment cause substantial shifts in the mediolateral distribution of load on the knee during walking. Most commonly quantified as the external knee adduction moment, increased medial loading during walking is positively associated with varus alignment[19,21,22] and structural OA progression.[23–26] In addition, the presence of a varus thrust (ie, bowing out of knee during gait), seen in many patients with varus alignment, is associated with increased risk of OA progression.[27–29]

CURRENT MANAGEMENT FOR DEGENERATIVE MENISCAL TEAR

Current guidelines for treatment of knee OA suggest exhausting all nonoperative forms of treatment (eg, topical or oral analgesics, physiotherapy, lifestyle modification including regular exercise and weight reduction, intra-articular corticosteroid, braces, and orthotics) before considering surgery.[30,31] Generally, clinicians will wait until a patient presents with definitive radiographic knee OA (ie, KL$\geq$2 and American College of Rheumatology Classification Criteria fulfilled) before realignment surgery is even considered as a viable treatment option. However, there is a growing body of literature that contends the disease process is well-advanced before signs of joint damage on radiographs.[32–34] It therefore stands to reason that if pre-radiographic OA can be identified by the existence of a symptomatic degenerative meniscal tear, then interventions should be started. These should include nonoperative treatments intended to alter disease progression, such as diet (ie, weight loss) and exercise, understanding that their effects can be difficult to sustain over time and knee joint degeneration may continue. Importantly, this may be particularly true in patients with varus alignment and a degenerative meniscal tear who are at increased risk of OA progression.

Arthroscopic partial meniscectomy has long been considered the treatment of choice for symptomatic degenerative meniscal tears by surgeons around the globe.[35–37] However, the continued use of this procedure for the treatment of degenerative meniscal tears (with[38–43] or without[44–47] radiographic knee OA) is not supported by a large, well-established body of evidence from numerous high-quality randomized trials, including sham-controlled[42,45,46] and comparative effectiveness studies.[38–41,43,44,47] For degenerative medial meniscal tears (DMMTs) in the presence of varus alignment, we suggest arthroscopic treatment is directed at excising torn meniscal tissue without addressing the surrounding joint environment, nor the fundamental risk factors for persistent disease activity, which evidently include biomechanical drivers such as varus alignment.

HIGH TIBIAL OSTEOTOMY

Although varus alignment is consistently identified in prospective studies to be a strong predictor of medial knee OA progression, it is seldom considered a modifiable risk factor. Medial-opening wedge HTO corrects varus alignment to reduce aberrant loading of the medial tibiofemoral compartment. Gait studies evaluating medial-opening or lateral-closing wedge HTO suggest the procedure can produce long-term (ie, 5 years) and large (ie, 50%) reductions in the magnitude of the peak knee

adduction moment, a proxy measure for medial compartment loading,[48–50] and the amount of varus thrust.[51] The size of the sustained reduction in the knee adduction moment achieved with HTO deserves emphasis, as it appears to be much larger than reductions achieved when using other biomechanical interventions, such as unloader knee braces or lateral heel wedges.[52,53]

Unfortunately, HTO is a scarcely performed operation compared with other surgical procedures for the degenerative knee.[54] Moreover, data suggest the rates of HTO are decreasing,[55,56] especially in the treatment of knee OA, perhaps because of the small number of surgeons performing the procedure and the limited emphasis in current North American training programs, as well as increased indication for unicompartmental knee arthroplasty. Importantly, HTO is rarely recommended in clinical practice guidelines for knee OA because limited high-level evidence exists to support its inclusion.[57–61] When HTO is incorporated in guidelines, it is generally reserved for more active patients (eg, those with physically demanding jobs) after more advanced joint damage has occurred (defined as medial compartment joint space narrowing, osteophytes, and sclerosis) and conservative interventions have failed.[62]

We agree with the importance of nonoperative interventions shown to improve patients' symptoms as first-line treatments for early knee OA, including degenerative meniscal tears. However, we believe there is strong rationale for also performing realignment surgery before the establishment of definitive radiographic OA. By the time most patients are referred to an orthopedic surgeon for HTO, multiple active biological and physical processes have already been in play and resulted in substantial medial joint damage. We may be waiting too long to intervene with HTO to achieve its greatest benefit. Correcting alignment and thereby lessening aberrant loads on the medial tibiofemoral compartment may be most effective in altering joint disease processes before structural changes can be viewed on radiographs.

It is unfortunate that many of the patients who seek potential surgical treatment options, in addition to nonoperative care, are generally offered arthroscopic meniscectomy and/or debridement without any consideration for realignment surgery. Other patients may be told to persist with nonoperative treatment until their symptoms and radiographic OA severity have progressed enough to be considered candidates for early joint replacement surgery. We believe those treatment strategies represent missed opportunities for potential secondary prevention achieved with HTO.

CLINICAL CASES

Case 1

A 30-year-old male computer programmer was seen in clinic with a history of consistent bilateral medial knee pain over a 5-year period. The patient was quite physically active, having previously played collegiate hockey and national-level baseball. Varus alignment was confirmed for both knees through full-standing hip-to-ankle radiographs, seen in **Fig. 1**A. An MRI of the patient's right knee also confirmed an increased signal of the meniscus, suggesting meniscal degeneration. Therefore, the patient was deemed a suitable candidate for HTO. The patient underwent bilateral HTOs with arthroscopy at a 1-year interval between procedures. Arthroscopy confirmed the presence of a small DMMT during both procedures, which were subsequently resected (**Fig. 1**B, right knee). At 12 years following the second HTO, the patient continued to show good alignment with no evidence of medial compartment damage in either knee joint (see **Fig. 1**A). The patient then suffered a twisting mechanism injury that resulted in a lateral meniscal injury to the right knee. A lateral meniscal repair was

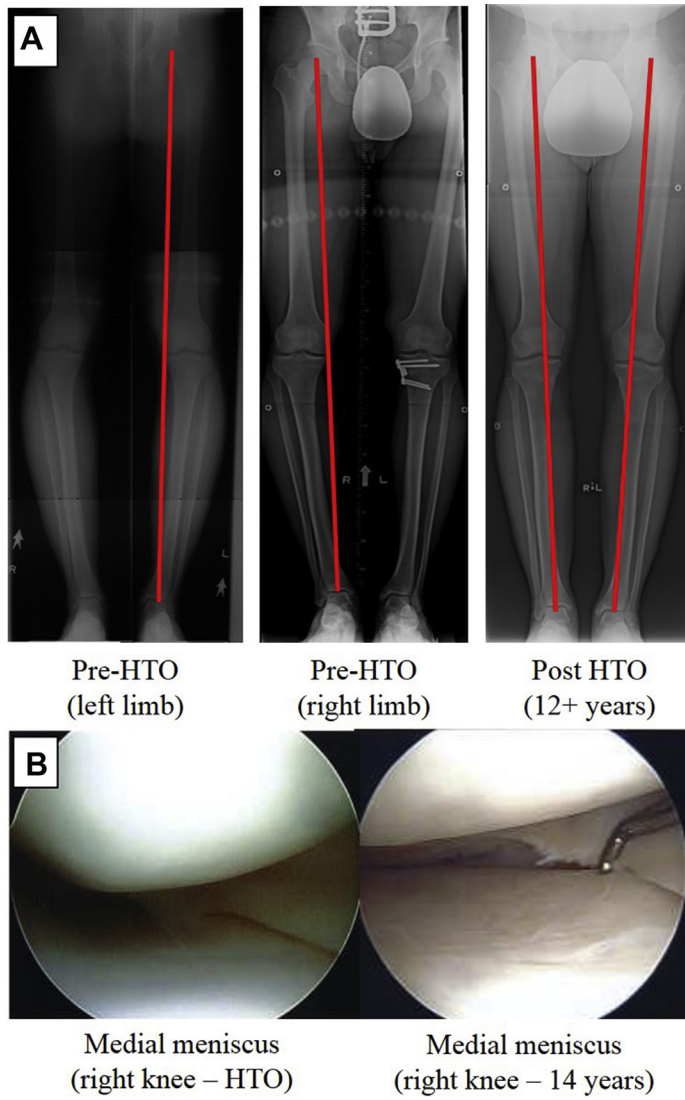

Fig. 1. (*A*) Patient radiographs before and after bilateral HTO surgery. An estimate of the limb weight distribution through the knee is shown with the vertical red line. (*B*) Arthroscopic view of the medial meniscus during HTO and arthroscopy and 14 years after the initial surgery.

then performed on the patient, and it was confirmed that there was still no evidence of further medial meniscal damage 14 years after the initial HTO.

Case 2

A 40-year-old male lawyer and high-performance triathlete was seen in clinic with a 3-year history of persistent bilateral medial compartment pain with physical activity and joint effusion. Three years prior, the patient had undergone a medial arthroscopic

partial meniscectomy of the right knee at a different tertiary care center. A full-standing hip-to-ankle radiograph (Fig. 2A) showed the patient had definitive varus alignment in both limbs. On physical examination, the patient was diagnosed with a DMMT and subsequently was deemed a candidate for HTO surgery with varus alignment and persistent knee symptoms. The patient underwent bilateral HTOs with arthroscopy at a 1-year interval between procedures. A DMMT was confirmed during arthroscopy for both knees with relatively intact articular cartilage (Fig. 2B, right knee). As seen in Fig. 2A, the patient did not undergo noticeable radiographic changes in either knee from baseline to 1 year after the second HTO (2 years after first HTO). Fortunately, the patient was able to return to full activities, including rigorous activity (ie, triathlons), after his bilateral HTOs with resolution of his persistent knee pain and without indication of joint effusion.

The presented case studies provide anecdotal proof of principle that a patient with varus alignment and early knee OA (ie, degenerative meniscal tear, knee symptoms, and no evidence of radiographic OA) can undergo HTO and show little-to-no signs of progressed medial meniscal degeneration or radiographic OA even at 12 years after initial surgery, as well as go on to return to preoperative level of rigorous activity.

CAVEATS AND CHALLENGES

We acknowledge that we are, perhaps controversially, suggesting a more aggressive approach than the current standard of care for treating a subset of patients with early knee OA, defined by frequent medial knee symptoms, the presence of a degenerative meniscal tear, and varus alignment. HTO realignment surgery should not be offered by surgeons in a cavalier manner nor be taken lightly by patients who need to be fully informed of its risk and benefits. It is an invasive procedure that involves a prolonged rehabilitation period (ie, progressive weight bearing on crutches) compared with some other surgeries and has a number of well-known potential complications (eg, hardware failure, delayed union, nonunion, loss of correction).

Randomized trials have led to changes in clinical practice guidelines and funding models to limit arthroscopic meniscectomy and/or debridement in patients with radiographic knee OA. However, increasing rates of knee arthroscopy use show the continued willingness of surgeons to perform the procedure on patients with degenerative meniscal tear, despite having been repeatedly shown to provide minimal, if any clinically meaningful benefit, especially long-term. Also, current nonoperative treatments have not been shown to slow structural disease progression. There is a dire need for additional options that can alter the rate of knee joint degeneration.

Unfortunately, decreasing rates of HTO suggest an inability or reluctance of surgeons to perform the procedure or a lack of HTO surgical procedure training. In fact, most orthopedic residents receive little or no experience with HTO during their training, leaving techniques to be learned during fellowships or other continuing medical education courses. To warrant further training, stronger evidence (eg, randomized controlled trials) to support to use of HTO is required.

ADVANCEMENTS IN HIGH TIBIAL OSTEOTOMY TECHNIQUE

Improvements in HTO plate technology and surgical technique have resulted in faster return to weight bearing after surgery[63] and fewer complications[64] than previously reported. For example, development of locking plate designs for osteotomy fixation has allowed patients to begin progressive weight bearing as early as 2 weeks after surgery,[65] much sooner than previous nonlocking plate designs which required a much longer period of non–weight bearing.[66] In addition, studies from orthopedic centers

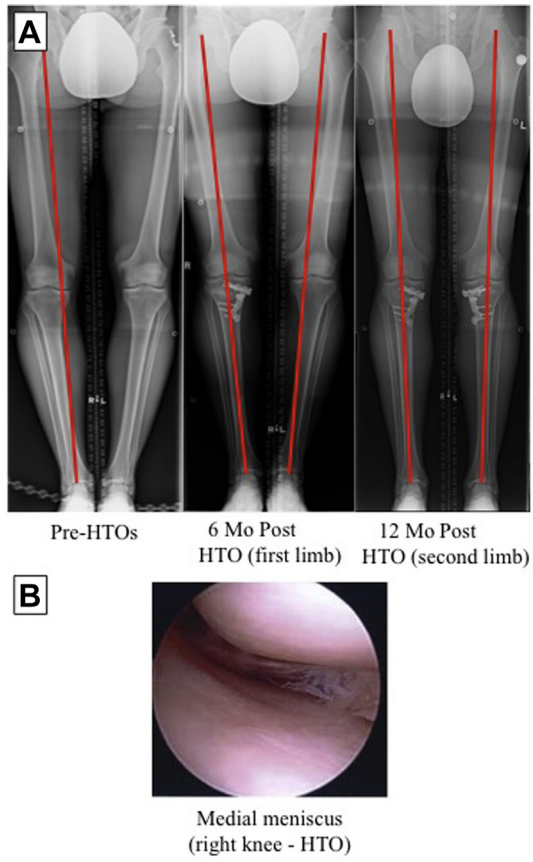

Fig. 2. (*A*) Patient radiographs before and after bilateral HTO surgery. An estimate of the limb weight distribution through the knee is shown with the vertical red line. (*B*) Arthroscopic view of the medial meniscus during HTO.

that perform high volumes of HTO surgery annually have reported complication rates as low as 7%.[64] Moreover, correcting alignment earlier in the disease process in patients who tend to be younger, with less acquired varus and less comorbidities, may enable smaller corrections, faster rehabilitation and fewer complications.

Comparatively, anterior cruciate ligament (ACL) reconstruction and total knee arthroplasty (TKA) are performed very frequently; more than 100,000 per year[67,68] and 1,000,000 per year,[69] respectively, in the United States alone. Studies have reported periods of recovery as long as 6 to 12 months for ACL reconstruction,[70] often longer than rates reported for HTO. Although return to weight bearing is generally faster after TKA, reported complication rates are much higher with TKA[71,72] and TKA places a number of other functional limitations on patients (eg, activity limitations). Still, surgeons continue to perform these surgeries on patients in high volumes to improve symptoms and joint stability. Furthermore, the goals of HTO may vary among surgeons and for specific patient characteristics. We have observed considerable success in improving gait biomechanics and clinical outcomes by correcting alignment to approximately neutral, rather than overcorrecting into substantial

valgus.[20,50,73] Yet, despite the reported clinical benefits of HTO and comparable risks to other procedures, the volume of HTO procedures performed annually continues to decline, likely as a result of limited high-quality evidence and a lack of surgeons trained to perform HTO.

FUTURE RESEARCH

We acknowledge that this article provides the lowest form of evidence.[74] Our goal is rather to stimulate discussion and encourage research. Currently, no studies have explored the potential role of realignment surgery for symptomatic patients early in the OA disease process (eg, with degenerative meniscal tear and no radiographic knee OA). We suggest that combined interventions that target individualized risk factors for knee OA progression, including varus alignment, need to be studied and that patients presenting with degenerative meniscal tears are appropriate participants for such studies.

SUMMARY

We propose that HTO is not currently being used to its full potential and warrants future research. The procedure may be particularly useful in patients with recurrent symptoms, varus alignment, and a DMMT, before radiographic damage is evident. HTO in patients with degenerative meniscal tear may present an excellent opportunity for early intervention in patients with varus alignment and symptomatic early knee OA for secondary prevention of radiographic knee OA.

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