



Arthritis and osteotomies in anterior cruciate ligament reconstruction

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Anterior cruciate ligament (ACL) injuries in the young athletic population are extremely common [1]. Arthroscopic ACL reconstruction is a proven method of treating anterior knee instability [2]. Surgical reconstruction is recommended in patients who present with symptoms of instability secondary to their ACL injury. More advanced surgical techniques and accelerated rehabilitation protocols have significantly decreased the morbidity associated with ACL reconstruction, enabling many young athletes to continue participating in their preinjury sports without limitations. However, the young patient with an ACL deficient knee, symptoms of instability, and unicompartmental arthritis continues to be extremely difficult to manage, however, even with the many advances in orthopaedic science [3,4].

Jackson first described using an osteotomy of the knee in treating patients with varus malalignment in 1958 [5]. Many studies have since shown this to be a reliable treatment option for the patient with isolated medial or lateral compartment arthritis, who wishes to continue to participate in high-demand sports or activities [6–9]. Long-term outcome studies have reported up to 90% satisfaction at 5 years and up to 70% at 10 years [7,10,11]. Holden et al described the results of tibial osteotomies for unicompartmental arthritis in patients under 50 years old [8]. The primary pathology in their group was medial compartment osteoarthritis (OA); however, within the group was a subset of young, active patients, whose

primary problem appeared to be knee joint instability, secondary to ACL insufficiency. The medial compartment arthritis had developed in the setting of a previous medial meniscectomy and ACL deficient knee [8].

Symptomatic patients with ACL deficient knees complain of a feeling of instability, often described as a sense of “giving way.” Often, these episodes of instability lead to swelling, inflammation, and further injury to the knee. The incidence of acute meniscal tear with ACL rupture is 52%, and it increases to 83% in cases of chronic instability [12]. Though the relationship between meniscal injury, meniscectomy, and OA is clear, the relationship between the ACL deficient knee and the development of arthritis remains a topic of debate [3,13,14].

Clinical dilemma

Although ACL reconstruction is a well-accepted method of treatment for the ACL-deficient knee, and realignment osteotomies have shown good results in patients with unicompartmental OA, the most appropriate management of the young patient with the combined pathology of instability and isolated medial or lateral compartment arthritis is still unclear. Often, patients present with complaints of pain many years after the initial knee injury. On exam, patients may have malalignment as well as underlying clinical instability. This article will review the current science and help to clear up the confusion in the treatment of the patient with chronic instability secondary to ACL insufficiency and unicompartmental osteoarthritis.

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Background

Though the exact cause of OA is still unknown, conditions that predispose patients to the development of OA are clear. Bony abnormalities and malalignment, ligamentous injuries, meniscal injuries, meniscectomies, and articular cartilage injury all place the patient at an increased risk for the development of arthritis [15]. Some studies report that more than half of patients treated for ACL injury gave a history of medial meniscectomy [16–18].

The altered biomechanics of an ACL deficient knee may also place the patient at an increased risk of developing OA. Several authors have studied the characteristic injury pattern that takes place in patients with acute ACL tears [19–22]. The characteristic lateral bone bruise that typically accompanies an acute ACL injury is often seen in patients with recurrent episodes of instability because of the increased loads seen by the articular surfaces [20,22]. The bone bruise seen on magnetic resonance (MR) imaging is characterized histologically as microfractures in the cancellous bone and fragmentation of the overlying articular cartilage [21].

The chronic instability associated with ACL insufficiency has been implicated as a risk factor for degenerative joint disease. In addition to the mechanical changes that take place with ACL injuries, important biochemical changes take place as well. Acute injury to the ACL causes a rapid inflammatory response in the knee. Several authors have studied this response to injury and found that the concentrations of inflammatory cell markers were higher after knee injury, compared with the control group of uninjured patients [23,24]. These increased levels of inflammatory cells cause a shift in the balance of cartilage maintenance toward cartilage catabolism after an acute injury. The authors concluded that persistent changes in inflammatory cell markers after joint injury may be associated with cartilage destruction and the development of post-traumatic OA in this group of patients [25].

Patients with altered joint mechanics are also at an increased risk for developing early arthritis. In a normal knee, approximately 60% of the weight-bearing forces are through the medial compartment, and 40% of the forces are transmitted through the lateral compartment [26]. In a knee with isolated unicompartmental OA, this line is shifted with more of the load distributed to the diseased compartment, resulting in further deformity and degeneration [26–30]. The altered mechanics associated with the varus (or valgus) knee are treated in most young, active patients with knee osteotomies. The goal of an

osteotomy, valgus or varus-producing, is not only to relieve pain, but to redistribute the weight-bearing forces to facilitate healing and, hopefully, increase the life span of the knee joint.

The subset of patients who have both chronic instability, secondary to ACL insufficiency, and malalignment are particularly at risk for the development of early arthritis. Thus, both problems need to be addressed to alter the natural history of progressive OA significantly.

Mechanism of injury

The most common mechanism of ACL rupture is a noncontact injury [31,32]. Once the acute injury has resolved, patients generally will begin to sense the instability associated with the ACL tear. Most patients will complain of “giving-way” episodes, with activity caused by anterior subluxation of the tibia on the femur. This is especially true in patients who attempt to return to sports that require cutting or pivoting movements.

Patients presenting with combined instability and unicompartmental arthritis will often give a history of meniscal injury or meniscectomy [33]. In some studies, more than 50% of the patients treated for ACL injury had undergone medial meniscectomies as well [16–18]. The most common presenting complaint is medial knee joint pain with activity. These patients have medial joint line tenderness on exam, varus alignment of the knee, and radiographic changes of medial compartment arthritis [3]. These changes can also occur on the lateral side of the knee, though this presentation is much less common. These patients will present with lateral joint line tenderness, a valgus knee, and lateral compartment changes on radiographic examination.

Patient evaluation

The initial evaluation of the patient with combined ACL insufficiency and unicompartmental arthritis should focus on differentiating between symptoms of instability and symptoms of arthritis. The examination should include a thorough history, assessment of gait pattern, range of motion, and stability. Knee alignment, localized tenderness, and a careful neurologic examination should all be included in the initial examination.

A detailed history can help to distinguish early degenerative disease from late-stage arthritis [34]. It is important to determine the nature, location, and duration of pain symptoms. Patients with early OA will often complain of pain associated with exces-

sive activity and high-demand sports, but not with activities of daily living. These patients may benefit from the addition of a nonsteroidal anti-inflammatory medication [35]. Patients who complain of more chronic pain associated with light activities such as walking are likely to have more severe cartilage damage [34].

Exam findings such as isolated medial or lateral joint line tenderness, crepitus, and malalignment (varus or valgus) are indicative of unicompartamental arthritis. Knee stability is tested in both the coronal and sagittal planes. The collateral ligaments are tested in the coronal plane at 30° of flexion and full extension. The examiner should not be misled by “pseudolaxity” of the collateral ligaments [34]. The observed joint space opening may be caused by the isolated joint space narrowing (from the unicompartamental arthritis) and does not necessarily indicate collateral ligament incompetence. The examiner should bring the knee into a normal alignment and then apply the appropriate force to test the collateral ligaments.

Anterior instability is elicited using specific clinical tests such as the anterior drawer, lachman, and pivot shift test. These tests are considered to be a reproducible and reliable means to determine anterior instability [36]. Some patients with combined ACL insufficiency and arthritis may not exhibit the classic positive findings on pivot shift examination because of osteophyte formation. These patients should still have a positive lachman test revealing their underlying instability.

Imaging studies

All patients suspected of having ACL insufficiency and unicompartamental arthritis should have full-length standing radiographs (including hip, knee, and ankle) of both legs. Using these full-length radiographs, calculate the mechanical axis of both the affected and normal limb. These measurements are very important in determining the need for intervention, as well as the preoperative planning of the osteotomy [6,9]. In addition, all patients should have a standing posteroanterior (PA in 40° of flexion), standing anteroposterior (AP), a lateral, and a merchant view of the symptomatic knee in order to define clearly the degree and location of any degenerative changes [37,38].

A bone scan may be useful in detecting arthritis early, before radiographic evidence of degeneration becomes visible. MR imaging is useful in evaluating any intra-articular pathology. Loose bodies, meniscal tears, and ligamentous injuries are all well visualized using MR. In addition, MR is able to detect signal

changes within the subchondral bone and articular cartilage in the very early stages of OA.

Nonoperative treatment

Nonsteroidal anti-inflammatory medication will often reduce the symptoms associated with arthritis. The newer classes of cyclooxygenase-2 selective inhibitors have fewer gastrointestinal (GI) side effects and, thus, are better tolerated for long-term daily use [39]. Physical therapy directed at quadriceps strengthening and the use of braces are other potential nonoperative treatment modalities. Braces for ACL-deficient patients have been used in the attempt to reduce the number of instability episodes. The improvement in knee stability probably represents an increase in proprioceptive feedback from the brace and not a mechanical effect [40]. In cases of unicompartamental OA, unloading braces have yielded good results in relieving some of the pain associated with arthritis [41]. The braces can also be used by clinicians as a diagnostic tool. Patients who get symptomatic relief from the use of an unloader brace will be more likely to benefit from an osteotomy than those who get no relief from the brace.

Surgical indications

When nonoperative therapy fails to control the symptoms of instability and arthritis, surgical options must be considered. Patients with combined instability secondary to ACL insufficiency and unicompartamental arthritis can be divided into three groups. Group 1 consists of patients whose chief complaint is instability; and group 2 is made up of patients whose chief complaint is knee pain. Finally, group 3 includes those patients whose primary problem is both pain and instability [16,17].

In deciding on the best surgical approach, several important factors are considered: pain, instability, and alignment. We have devised two separate algorithms for the surgical treatment of these patients. One algorithm deals with patients whose primary problem is instability, and the second algorithm deals with patients who present mainly because of pain (Tables 1 and 2).

Patients whose main complaint is instability are considered under the first algorithm. All of the surgical options for these patients include an ACL reconstruction. Patients in this group who have instability, but a normal alignment, are indicated for ACL reconstruction alone. Patients who complain of instability and pain, and have a varus or valgus knee alignment, are treated with a combined ACL recon-

Table 1
Algorithm #1—patients in whom instability is the primary symptom

Pain only	→	ACLR
Malalignment only	→	ACLR, Osteotomy
No pain and no malalignment	→	ACLR
Pain and malalignment	→	ACLR, Osteotomy

Abbreviation: ACLR, anterior cruciate ligament reconstruction.

struction to address the instability and a knee osteotomy to address the unicompartmental arthritis. This combined approach is designed to give the patient a less painful and more functional knee.

In the second group of patients, the predominant complaint is pain. The pain may be caused by arthritis alone, or it may be caused by underlying instability [42]. This group of patients falls into the second algorithm. The primary goal of surgery in this group of patients is to relieve their symptoms of pain. Patients in this group who have instability but normal alignment are treated with an ACL reconstruction to stabilize their knee and alleviate their pain. This group may benefit from a meniscal transplant if indicated. Patients with pain, instability, and a varus or valgus alignment require an ACL reconstruction and a knee osteotomy to treat their pathology. Those patients who have only pain and malalignment without symptoms of instability will benefit from an osteotomy. These patients may also get some pain relief with an arthroscopic debridement [4,8]. In those patients who have no symptoms of instability or malalignment and whose only complaint is pain, an arthroscopic debridement is recommended if nonoperative therapy fails.

Preoperative planning

The preoperative planning in patients with malalignment requiring knee osteotomies is critical. The goal of an osteotomy is to shift the weight-bearing forces into the asymptomatic compartment (which contains healthier cartilage surfaces), thus relieving the symptomatic compartment of excessive contact pressures.

There are a variety of techniques described in order to help guide the clinician in the preoperative planning for a high tibial osteotomy [9,17,43,44]. For isolated medial compartment OA, some authors suggest guidelines in terms of degrees of anatomic valgus. Coventry [43] suggests a goal of 10° of valgus, whereas Kettlekamp et al [45] describe

achieving 3° more valgus than is present in the normal or contralateral knee. Still others suggest correcting the alignment so that the mechanical axis falls through the medial third of the lateral compartment [44,46]. The method of preoperative planning may vary depending on the preferences of the treating surgeon. Regardless of which method is used, however, the goal should be to overcorrect the alignment of the knee. Undercorrection of the deformity remains the most common reason for persistent symptoms and failure of high tibial osteotomy (HTO).

We use the mechanical weight-bearing line to determine the degree of correction required (Fig. 1). The centers of the femoral head and tibiotalar joint are identified on the full-length radiograph, and the desired tibial plateau coordinate is marked (for a varus knee, we use the 62% coordinate described by Dugdale et al) [44]. The first line is drawn from the center of the femoral head to the 62% coordinate, and then the second line is drawn from the 62% coordinate to the center of the tibiotalar joint. The angle formed by the intersection of these two lines is the angular correction needed to redirect the weight-bearing axis through the 62% coordinate. Trigonometric analysis has shown that each millimeter of bone resection corresponds with approximately 1° of angular correction [44]. In the case of a valgus knee, we select a neutral tibial plateau coordinate (50%) rather than the 62% described for the varus knee. The lines are then drawn as previously described. Correction of a valgus knee can be achieved by several methods; distal femoral osteotomy (DFO), or a proximal tibial osteotomy (opening lateral or closing medial).

In choosing the type of osteotomy, the surgeon should be sure that the medial structures are intact. If the medial collateral ligament (MCL) is incompetent, a medial opening-wedge osteotomy is the preferred method of correction (Fig. 2). Using a medial opening-wedge osteotomy eliminates the medial-sided lax-

Table 2
Algorithm #2—patients in whom pain is the the primary symptom

Instability only	→	ACLR
Malalignment only	→	Osteotomy
No instability	→	Debridement ^a
No malalignment		
Instability, Malalignment	→	ACLR, Osteotomy

Abbreviation: ACLR, anterior cruciate ligament reconstruction

^a consider a meniscal transplant

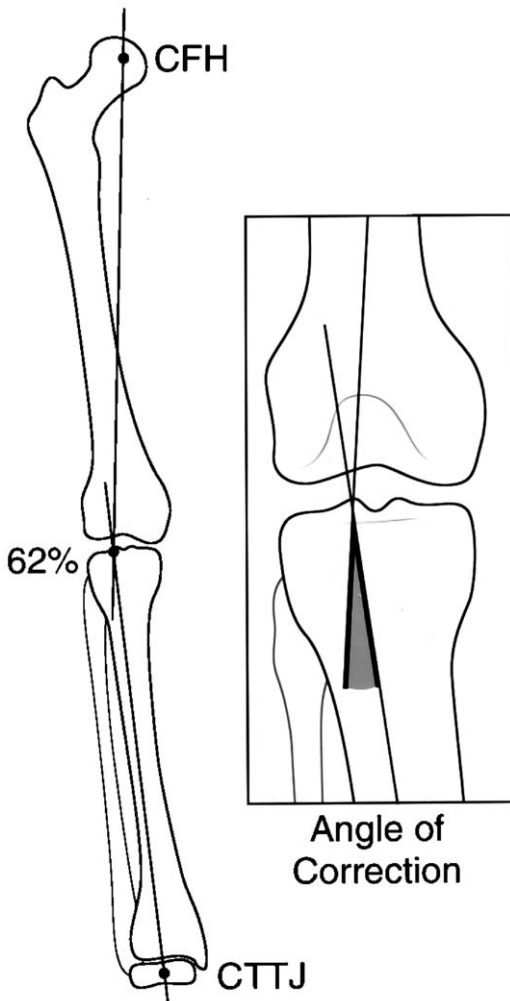


Fig. 1. Preoperative planning. The angle formed by the intersection of these two lines is the angular correction needed to redirect the weight-bearing axis through the 62% coordinate.

ity, at the same time treating the varus deformity of the knee [47,48]. Using a lateral closing-wedge osteotomy in the setting of an incompetent MCL with ACL insufficiency may lead to progressive genu valgum.

Surgical technique

Many consider diagnostic arthroscopy and arthroscopic debridement useful in the evaluation and treatment of the patient with combined ACL insufficiency and unicompartmental arthritis [49–51]. We routinely perform a diagnostic arthroscopy before all knee osteotomies. Cartilage surfaces are assessed and

graded using the Outerbridge classification system [52]; intra-articular ligaments are evaluated; menisci are inspected; and any pathology is addressed. Though healthier cartilage (grades I and II) is preferred in the compartment to which the weight-bearing line is being transferred, good results have been shown even in compartments with grades III and IV articular changes [53]. Cartilage defects seen at the time of arthroscopy have not necessarily been shown to correlate with clinical symptoms. Patients with varus alignment who do not give a history of lateral-sided knee pain may undergo high tibial osteotomy with expected good results, even in the presence of lateral compartment cartilage lesions noted during arthroscopy. Knee osteotomies should be avoided, however, if there is radiographic evidence, or clinical symptoms, of OA in the compartment to which the weight-bearing line is being shifted.

The varus knee

A lateral closing-wedge or medial opening-wedge osteotomy may be performed in order to achieve correction in the varus knee. Similarly, a medial closing-wedge or lateral opening-wedge osteotomy may be used to correct a valgus deformity. We describe our preferred method of achieving correction in the more common deformity, the varus knee, with isolated medial compartment arthritis, using a lateral closing-wedge osteotomy. We feel we can achieve rigid fixation, more rapid healing, and earlier weight-bearing with the closing-wedge osteotomy. The desired alignment can also be achieved using a medial opening-wedge osteotomy. This procedure is specifically recommended in cases of MCL insufficiency or posterolateral laxity. These osteotomies can be achieved with an opening-wedge plate (Fig. 3) or external fixation device [54].

A tourniquet is applied about the thigh. A lateral closing-wedge osteotomy is performed via an oblique or “L” shaped incision exposing the lateral aspect of the proximal tibia. The muscles of the anterior compartment are elevated subperiosteally to expose the tibia. The tibiofibular joint is exposed and disrupted to allow for closure of the osteotomy. Alternatively, if the surgeon prefers, a proximal third fibular osteotomy may be performed to preserve the tibiofibular joint. Under fluoroscopic guidance, the surgeon places a guidewire parallel to the articular surface and approximately 2 cm distal to the joint line. A second wire is then placed in a converging fashion with the first wire, beginning at the lateral cortex of the tibial metaphysis. The amount of bone resected depends on the degree of correction desired

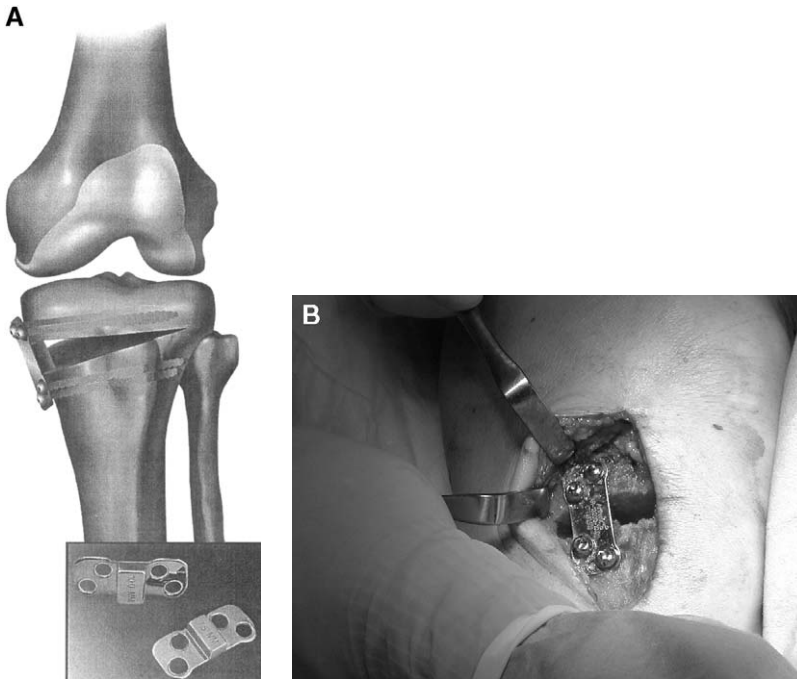


Fig. 2. (A) Illustration and (B) postoperative photograph of a medial opening wedge osteotomy. The plate pictured above is inserted above the distal insertion of the medial collateral ligament. (From Arthrex, Naples, FL; with permission.)

(based on preoperative planning). Approximately 1 mm of lateral cortex will yield 1° of angular correction (Fig. 4). An oscillating saw is used to perform the osteotomy, using the wires as cutting guides. The medial cortical periosteum is preserved. Osteotomes are used to complete the cuts and controlled osteoclasts results in apposition of the bony surfaces at the osteotomy site. A plate is used for fixation and stabilization of the osteotomy (Fig. 5). We like the precision and accuracy of the commercially available HTO systems and the stability that is achieved with the plate fixation provided by many of these systems (ie, Zimmer, Nexgen, Warsaw). This stability is especially important in cases where the HTO is combined with simultaneous ACL reconstruction; allowing these patients to participate in the postoperative rehabilitation program necessary for early motion and successful outcome. If ACL reconstruction is to be performed, it is important to place the proximal screws for the osteotomy plate in a diverging fashion in the subchondral bone to allow for proper tibial tunnel placement. The anterior screw should be short enough so as not to impinge on the tibial tunnel (Fig. 6).

At the completion of the osteotomy, fluoroscopy or intraoperative radiographs are used to ensure that the appropriate amount of correction has been obtained.

The valgus knee

Arthritis of the lateral compartment with a valgus deformity can be treated by either a proximal tibial osteotomy or a DFO. Coventry recommends using a varus-producing DFO if the valgus deformity exceeds 12° or if there is more than 10° of tibiofemoral joint surface tilt [6]. High tibial osteotomies are recommended only in cases of limited valgus deformity because correction of 15° or more on the tibial side may result in excessive joint line obliquity [26]. Most valgus deformities are localized to the distal femur and should be corrected with a DFO. In select cases where the deformity is equally distributed between the femur and the tibia, a double osteotomy may be considered [26]. When the valgus is caused, however, by a deformity of the proximal tibia in a limb with a normally aligned distal femur, a proximal tibial osteotomy is a logical option [26].

Anterior cruciate ligament reconstruction

ACL reconstruction should be performed following correction of the malalignment. There are many graft options for the ACL reconstruction. We recommend using a bone-tendon-bone allograft. Though ipsilateral bone-tendon-bone autograft is generally an

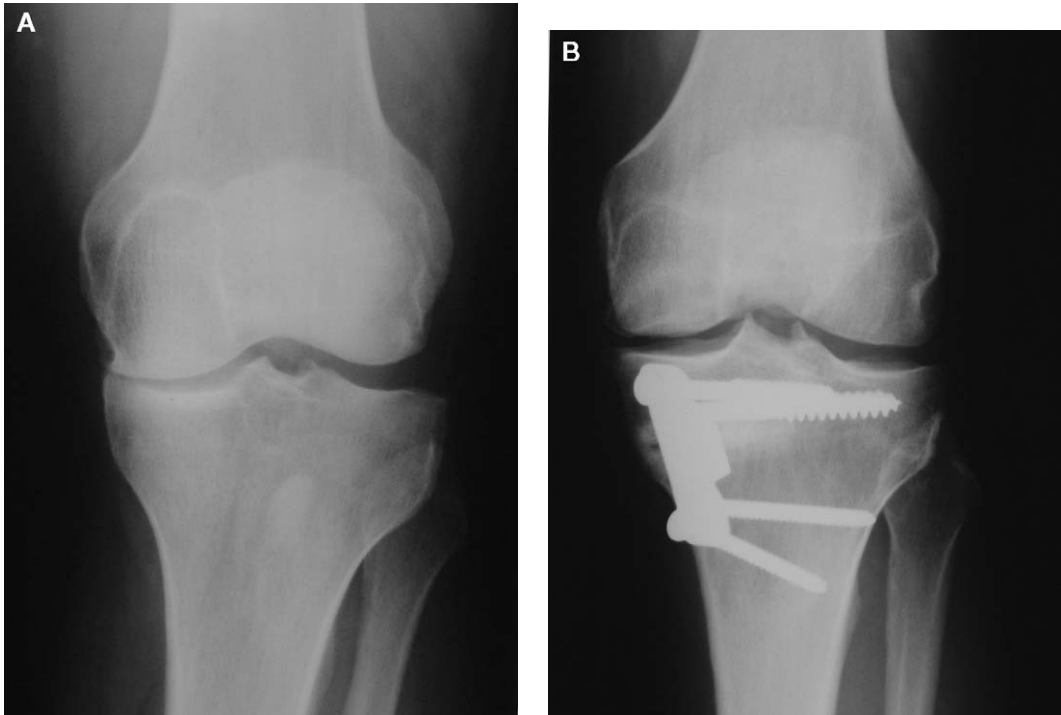


Fig. 3. (A) Preoperative and (B) postoperative anteroposterior (AP) radiographs of a patient with a varus deformity and MCL insufficiency. This patient underwent a medial opening wedge osteotomy to correct the malalignment.

excellent graft source for ACL reconstruction, in cases of simultaneous reconstructions with proximal tibial osteotomies there have been reported complications [16]. The use of allograft tissue decreases the postoperative morbidity and pain. Though the risk of disease transmission with allograft tissue is extremely low, some patients may object to its use. In these cases, the use of the quadrupled hamstring-tendon autograft is a good option for this procedure [55].

Commercially available guides and reamers are used to create tibial and femoral tunnels. The size of the tunnels is determined based on the size of the graft during graft preparation. The femoral tunnel is made with the knee flexed to approximately 80° leaving between 1–2 mm or posterior cortex at the back wall. Both tunnel edges are smoothed down to prevent chafing of the graft. Under arthroscopic guidance, the graft is passed into the knee, and tensioned and fixed—first proximally, then distally.

For patients undergoing staged HTO and ACL reconstruction, the ACL reconstruction may be performed 6 months or more after the HTO. At the time of the ACL reconstruction, all tibial hardware should be removed to prevent the possibility of having to come back at a later time for a third operative procedure.

Rehabilitation

Patients undergoing simultaneous high tibial osteotomies and ACL reconstructions are placed into a hinged knee brace during the immediate postoperative period. Toe-touch weight-bearing is allowed for a minimum of 4 weeks to avoid loss of the correction at the osteotomy site. Continuous passive motion is started immediately. Physical therapy is aimed at establishing full range of motion in addition to muscle strengthening and gait training. Weight-bearing is advanced at approximately 4 weeks. The brace is continued for a total of 8 weeks, or until the osteotomy site is clinically healed (stable and non-tender). An accelerated ACL reconstruction protocol is implemented following satisfactory bony healing at the osteotomy site. Radiographs are obtained at 2 and 8 weeks after surgery.

Results

Various studies have shown that the results of simultaneous HTO and ACL reconstruction are satisfactory [16–18,56–58]. Some authors have sug-

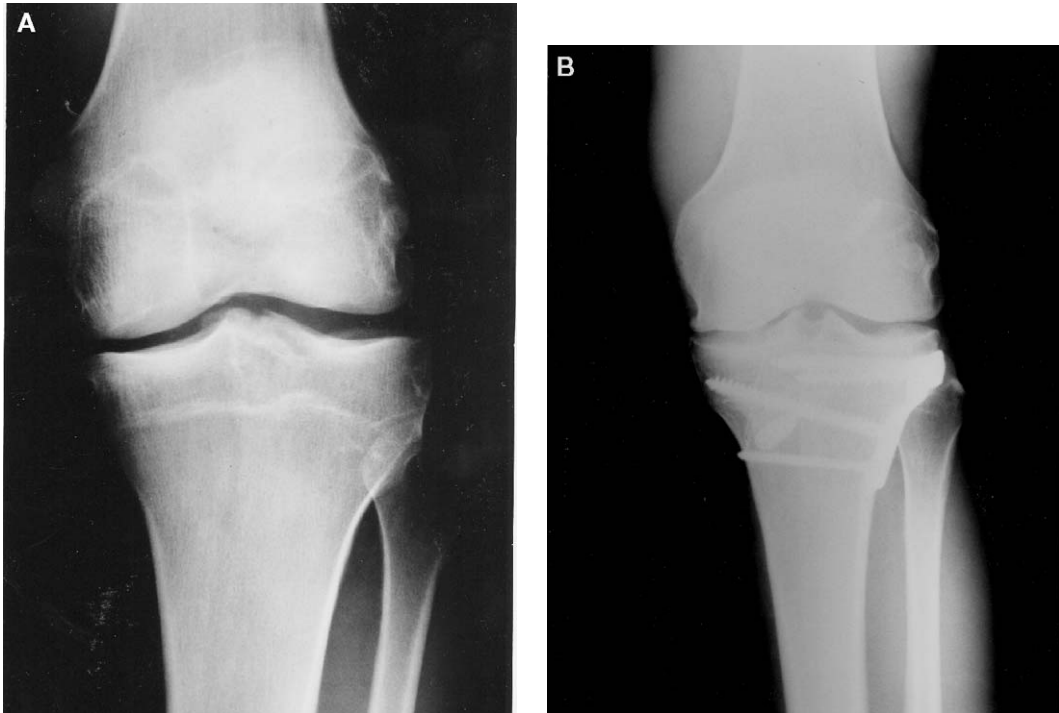


Fig. 4. (A) Preoperative and (B) postoperative AP radiographs of a patient with a symptomatic varus deformity and ACL insufficiency. The patient underwent a simultaneous lateral closing wedge osteotomy and ACL reconstruction.

gested that the simultaneous approach is technically demanding and carries an increased risk of complications compared with staged procedures [16,17]. There are no long-term results available yet for simultaneous HTO and ACL reconstructions. Most studies are retrospective and review only small numbers of patients, making them difficult to interpret.

O'Neil et al were the first to review the results of patients undergoing valgus osteotomy of the proximal tibia and ACL reconstruction [18]. They reported on 10 patients (mean age 32, average follow-up 3 years) who had failed nonoperative treatment with anti-inflammatory medication, physical therapy, and bracing and had been treated with combined HTO and ACL reconstruction. All patients showed improvement in subjective and objective scoring questionnaires; however, only one patient was able to return to full activity. The authors concluded from their review that this technique of combined HTO and ACL reconstruction should be used as a salvage procedure only.

Neuschwander and colleagues [58] published their results in 1993 on simultaneous HTO and ACL reconstruction in 5 patients (average age 27, average follow-up 2.5 years). All patients in their series

exhibited symptomatic anterior instability, genu varum, and medial compartment pain. All patients were evaluated using the Lysholm knee score, the Hospital for Special Surgery Knee Ligament Rating Form, and the Tegner Activity Scale. Four of the five patients had good and excellent results, and the fifth had a fair result. There were no complications reported. The authors concluded that the combined procedure yielded functional improvement, but they cautioned that high levels of activity should not be expected.

Dejour et al reported one of the largest series in a retrospective review of 43 patients treated with combined HTO and ACL reconstruction [56]. These patients had symptomatic ACL insufficiency and varus malalignment. Patients were evaluated at a mean follow-up of 3.5 years. Radiologic evaluation of these patients failed to demonstrate progression of their arthritis. Thirty-seven of forty-three patients were satisfied or very satisfied with the results of their surgery. Only 27 of the 43, however, were able to return to sports at a leisure level, and only 1 patient was able to return to competitive sports. In light of these results, the authors recommended this combined procedure be used for the young, symptomatic

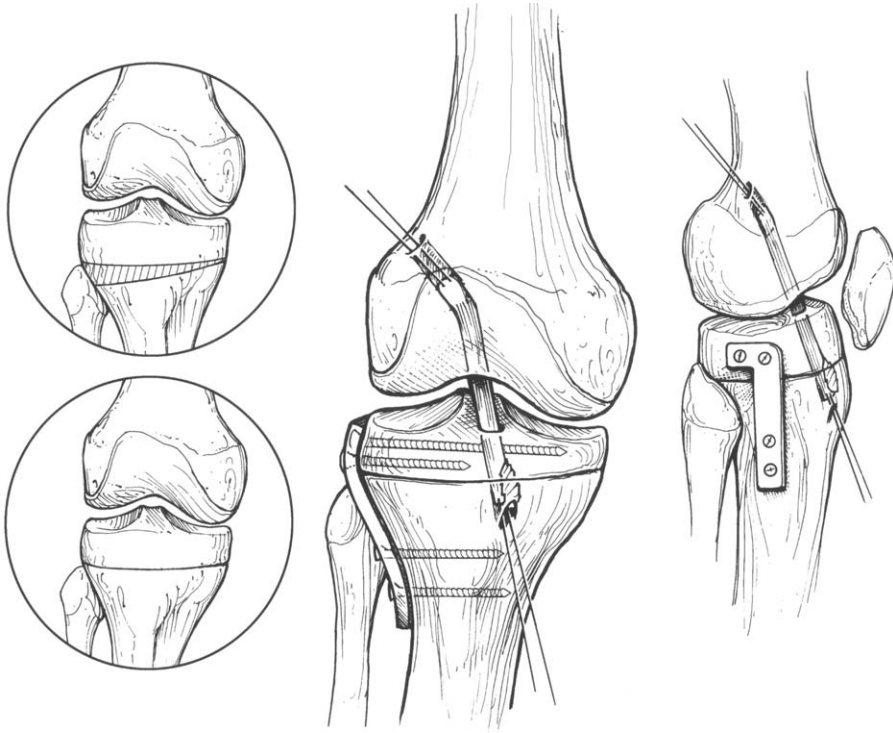


Fig. 5. Surgical technique for combined high tibial osteotomy and ACL reconstruction. High tibial osteotomy was performed first, followed by ACL reconstruction. (From Williams RJ, Wickiewicz TL, Warren RF. Management of unicompartmental arthritis in the anterior cruciate ligament-deficient knee. *AJSM* 2000;28:5; with permission.)

patient who wished to return to a leisure level of sporting activity.

Noyes et al reviewed their experience in 41 patients who were treated with either (1) HTO alone, (2) combined HTO with extra-articular ACL reconstruction, or (3) combined HTO with intra-articular ACL reconstruction [17]. Patients who were treated with the HTO and extra-articular ACL reconstruction had significantly increased anterior laxity as compared with the group treated with HTO and intra-articular ACL reconstruction. The knee rating scores improved in all patients, and there were no statistically significant differences between the three groups with respect to functional outcomes or symptoms. Seventy-eight percent of patients were able to return to light sports, but the majority of patients reported a modified activity level, and no patients were able to return to high-demand sports. Interestingly, patients who underwent HTO alone did show improvement in their symptoms even without an ACL reconstruction.

Latterman and Jakob reported their series of patients treated for ACL insufficiency with unicompartmental arthritis [16]. Patients were divided into three groups based on symptoms. Patients in group 1

were treated with HTO alone; group 2 was treated with staged HTO and ACL reconstruction; and group 3 underwent simultaneous HTO and ACL reconstruction. No significant differences in functional scores, pain, or instability were noted between the three groups. The combined HTO and ACL reconstruction group had, however, a very high morbidity rate, leading the authors to conclude that HTO alone should be the first line of treatment followed by an ACL reconstruction at a later time if the patients complained of persistent instability.

Our institution retrospectively reviewed our experience with HTO and ACL reconstruction [64]. All patients had symptoms of medial joint arthritis and varus knee alignment. Twenty-five patients (mean age 35, average follow-up 46 months) were included in this study. Ninety-six percent of the patients reported a history of medial meniscectomy. Twelve patients received a high tibial osteotomy alone (group I), and 13 patients were treated with a combined HTO and ACL reconstruction. Twenty-five patients were available for follow-up. All patients showed significant improvement in the knee scoring questionnaires (HSS knee score, Tegner and Lysholm), but group II

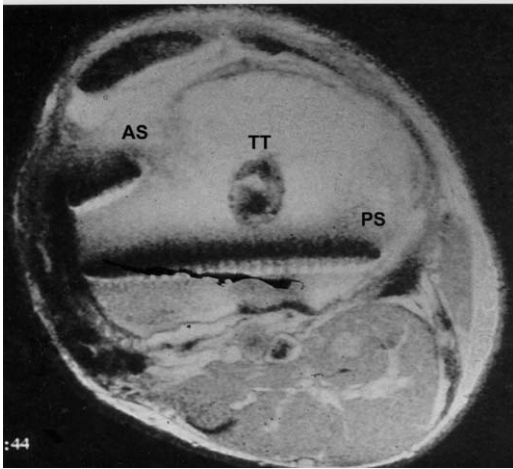


Fig. 6. Axial MR image of the proximal tibia from a patient who underwent combined HTO and ACL reconstruction. The screws are placed in a divergent fashion and the anterior screws are short to allow proper placement of the tibial tunnel for the ACL reconstruction. (From Williams RJ, Wickiewicz TL, Warren RF. Management of unicompartmental arthritis in the anterior cruciate ligament-deficient knee. *AJSM* 2000;28:5; with permission.)

had more patients reporting good and excellent results. Patients treated with HTO alone reported decreased symptoms of instability, despite the persistence of objective signs of laxity. Radiographs demonstrated osteoarthritic progression in both groups of patients. There was one major complication (failure of fixation). Patient satisfaction was high (92%), and 23 of 25 patients were able to return to recreational sports. The results of this study suggest that both HTO and combined HTO and ACL reconstruction are effective in the surgical treatment of varus, ACL-deficient knees with symptomatic medial compartment arthritis. However, good and excellent results were seen more often after the combined procedure.

Shelbourne et al evaluated their series of patients with combined ACL insufficiency and arthritis treated with ACL reconstruction alone [42]. Their series included 33 young patients with chronic ACL-deficient knees (average age 29.5 years, average follow-up 45 months, range 18–105). All patients had radiographic evidence of post-traumatic arthritis with documented grade 3 or 4 changes in at least 1 compartment. Lower extremity alignment was not measured. Patients underwent an ACL reconstruction using autogenous central third of patellar tendon and an accelerated postoperative rehabilitation protocol. At follow-up examination, all patients reported subjective improvement in their pain and function. Stability

significantly improved based on KT-1000 arthrometer measurements. The authors concluded that isolated ACL reconstruction did improve patients' pain and subjective function. They cautioned patients, however, against high-demand and contact sports in light of their underlying arthritic process.

More recently, Noyes et al reported their experience with high tibial osteotomy and ligament reconstruction for patients with varus deformities and ACL-deficient knees [59]. Of the 41 patients included in the study, 73% had a history of a previous medial meniscectomy. All patients in this series were treated with a HTO, and 83% underwent an ACL reconstruction a mean of 8 months later. Patients were evaluated at a mean of 4.5 years after the HTO. Pain was improved in 71% of patients, instability was eliminated in 85%, and 66% were able to return to light recreational activities. Five knees (12%) had a varus alignment at the time of follow-up. They concluded that, for the unique group of severely affected knees that exhibit chronic ACL insufficiency, varus deformity, a history of medial meniscectomy, and partial or complete posterolateral ligament insufficiency, early correction of the varus deformity in addition to ligament reconstruction yields a less symptomatic, more functional knee.

Although HTO has proved to be an effective treatment for painful arthritis of the medial compartment of the knee, the role of a varus-producing HTO in the treatment of painful arthritis of the lateral compartment remains controversial. Marti et al reviewed their experience with proximal tibial varus osteotomies for isolated lateral compartment arthritis [26]. Thirty-four patients were evaluated at a mean of eleven years postoperatively from an opening-wedge HTO performed with iliac crest bone graft. None of the patients in this series had severe progression of the arthritis after the osteotomy, and none had any significant loss of motion. Lysholm scores were good and excellent in 88% of patients, and the mean Insall knee score was 84 points. There were 3 patients (9%) who had transient peroneal nerve palsies postoperatively, which is comparable with that reported in the literature [60,61]. Their goal for correction was based on Coventry's study, showing a desirable anatomic axial alignment of 0° as the goal for correcting the deformity [6]. They concluded that lateral opening-wedge HTO is a good alternative treatment for isolated lateral compartment arthritis.

Complications

There is a high degree of variability in the literature regarding complications associated with

HTO and ACL reconstructions. Latterman and Jakob [16] reported a complication rate as high as 37% in their series, whereas Noyes [17] and Dejour [56] reported only 7% and 5%, respectively. Most of the complications in these studies were caused by technical errors in performing the osteotomy. We did not observe the high complication rates associated with combined HTO and ACL reconstruction. Only 1 of 13 patients had a complication related to loss of fixation. This patient had the osteotomy fixed with a staple, a method of fixation we no longer use. It is difficult to compare the groups in the above studies of HTO alone with combined HTO and ACL reconstructions. There does appear to be a possible correlation between the combined deep-plane tibial osteotomy and ACL reconstruction and the development of major complications [16]. In light of the potential risks associated the simultaneous HTO and ACL reconstruction, and the clinical improvements noted with HTO alone, the staged procedure may be the optimal surgical approach.

Meniscal transplantation

Meniscal allograft transplantation may be indicated in a select group of young patients with a history of meniscectomy, pain, and early osteoarthritis [62]. Thus, in cases of early unicompartmental arthritis in which the malalignment is corrected via an HTO, a meniscal allograft may be considered in a patient with a history of total or subtotal meniscectomy [63]. The early and intermediate results of combined ACL and meniscal transplant are promising [62,63].

Summary

Unfortunately, young patients with active lifestyles who present with an ACL-deficient knee and early evidence of arthritis remain a very difficult population to treat. Arthroscopic ACL reconstruction is a proven and effective way to treat patients with anterior knee instability [2]. In addition, numerous authors have demonstrated that knee osteotomies are effective in addressing isolated medial or lateral compartment degenerative disease, even in the presence of anterior knee instability [7,9,22,43]. A comprehensive evaluation of pain, alignment, and stability are necessary in order to formulate the best treatment plan for each patient. Patients with combined chronic instability secondary to ACL insufficiency and unicompartmental arthritis will generally benefit from arthroscopic debridement, ACL recon-

struction, knee osteotomy, or any combination thereof. Expectations of patients should be managed according to their underlying pathology, and this is a critical component for the success of the surgery. Most patients will get some degree of symptomatic relief and functional improvement. A return to competitive or high-level sports is an unrealistic goal, however, and should be discouraged.

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