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The influence of tibial slope on the graft in combined high tibial osteotomy and anterior cruciate ligament reconstruction

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ABSTRACT

Background: Young patients with severe medial osteoarthritis, varus malalignment and insufficiency of the anterior cruciate ligament (ACL) are difficult to treat. The tibial slope has gained attention with regard to osteotomies and ligamentous instability. The purpose was to evaluate the outcome of combined high tibial osteotomy (HTO), ACL reconstruction and chondral resurfacing (CR, abrasion plus microfracture), and to analyse graft failure rates with regard to the tibial slope.
Methods: Fifty cases (48.9 ± 5.4 years) of combined HTO, ACLR and CR were retrospectively analysed with regard to survival, functional outcome (subjective International Knee Documentation Committee (IKDC) examination form) and subjective satisfaction. The tibial slope was determined on lateral radiographs and analysed with regard to its influence on graft functionality at the time of hardware removal.
Results: Follow-up rate was 100% after 5.6 ± 1.6 years. No arthroplasties were performed. Subjective IKDC score was 70 ± 18, and 94% were satisfied with the result. The graft was intact in 39 cases (78%), and non-functional in 11 cases (22%). No significant changes were present in pre- and postoperative tibial slope ($P = 0.811$). Graft insufficiency was strongly dependent on tibial slope, with a failure rate of seven percent in cases of postoperative tibial slope <7.5°, 24% in cases of 7.5–12.5°, and 36% in cases of >12.5°.
Conclusion: Combined HTO, ACLR and CR is an effective treatment in these cases. The graft failure rate increases with an increase in tibial slope, in particular when exceeding 12.5°.
Level of evidence: Case series, Level 4.

1. Introduction

It is well known that chronic anterior cruciate ligament (ACL) deficiency and subsequent medial meniscus loss lead to degenerative medial osteoarthritis, especially in the setting of varus malalignment [1–7]. The treatment of young and active patients with a high degree of osteoarthritis based on instability and varus malalignment is challenging: arthroplasties are generally not desirable in younger patients of around 50 years of age, and have shown undesirable high rates of revision within the first years after surgery [8].

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In the absence of instability, high tibial osteotomy (HTO) has become a widely accepted treatment option, especially for younger patients [9–11]. Excellent results have been reported, also and in particular in severe osteoarthritis — which was often seen as a contraindication for these joint-preserving procedures in the past [9,11–13].

A number of smaller case series have reported on satisfactory results with combined approaches of HTO and ACL reconstruction (ACLR) [4,7,14–20]. However, in some studies, distinct graft failure rates have been reported [21,22]. The tibial slope has been extensively investigated within the last years, especially in terms of sustaining and treating injuries of the cruciate ligaments, and its role in tibial osteotomies [23–30]. Only very limited data exists on combined procedures of osteotomy and ligament reconstruction in severe osteoarthritis. Further, only a few studies investigated the reasons for graft failure in these cases, and no study has so far analysed graft failure rate with regard to the tibial slope [21,22].

Therefore, the purpose of this retrospective study was to evaluate survivorship and clinical function of a combined joint-preserving procedure of HTO, ACLR and a chondral resurfacing procedure (CR) in cases of severe osteoarthritis, varus malalignment and chronic anterior instability. Further, the tibial slope was evaluated with regard to its influence on graft integrity.

2. Materials and methods

2.1. Study design

All cases of combined HTO and ACLR (index procedure) at our institution between 2005 and 2015 were retrospectively identified, giving a 10-year period with a minimum follow-up of two years. Indications for the index operation were medial-sided knee pain and symptomatic insufficiency of the ACL, varus malalignment of more than four degrees (angulation between mechanical femoral and tibial axis), and severe osteoarthritis of the medial compartment (Kellgren–Lawrence 3 and 4 on weight-bearing radiographs) with full-thickness cartilage defects. Contraindications were significant loss of lateral meniscus and cartilage lesions grades 3 and 4 in the lateral compartment. Patellofemoral osteoarthritis was not seen as a contraindication when clinically not symptomatic. Patients without chondral resurfacing procedure within the index operation were excluded.

Medical charts and surgical reports were reviewed with regard to performed procedures, postoperative course (including complications) and especially function and status of the ACL graft. Patients were regularly seen in scheduled follow-up examinations after six weeks, six months, one year, and based on individual decision. In these examinations the status of the ACLR was standardized evaluated by the Lachman-test and KT-1000-measurement (side-to-side difference, SSD) [31].

With a minimum follow-up of two years all patients were contacted by telephone and postal questionnaire. Survival was defined as not requiring arthroplasty. The subjective International Knee Documentation Committee (IKDC) knee examination form was used for subjective outcome measurement. Patients were asked if they were satisfied, and if they would retrospectively undergo the operation again.

Hardware removal was usually recommended after consolidation of the osteotomy after one to two years, and was performed in the majority of cases. A diagnostic arthroscopy was usually performed within this procedure for evaluation of the graft and cartilage repair. Patients were grouped into ACL intact (Lachman negative, KT-1000 SSD ≤3 mm, intact graft on arthroscopy) or ACL not intact (Lachman positive or KT-1000 SSD >3 mm, insufficient or substantially degraded graft on arthroscopy) at this time of follow-up. In cases that did not undergo arthroscopy, the evaluation of the graft function was based on clinical evaluation as described above. Cases without clear classification of the ACL were excluded from further analysis.

In all cases, weight-bearing posterior–anterior (Rosenberg), standard lateral, and hip-to-ankle standing anteroposterior radiographs were available pre- and postoperatively (Figure 1). Radiologic evaluation was performed by two independent sports orthopedic specialists with regard to the mechanical tibiofemoral axis and the tibial slope. The tibial slope was measured on lateral radiographs, defined as the angle between a line perpendicular to the proximal tibial anatomical axis and a tangent along the medial tibial plateau (Figure 2). The proximal tibial anatomic axis is the bisecting line between tangents to the anterior and posterior tibial cortices. Alternatively, two circles can be drawn in the proximal tibia at different heights: the diameter of each is adjusted to the anteroposterior distance of the tibia in a way such that the anterior and posterior tibial cortices are tangents to the circles. The connecting line of the two circle centres is then the proximal tibial axis. Values of $10^\circ \pm 3^\circ$ measured in this way have been reported to be physiological [25,32,33]. It is known that the medial and lateral tibial slopes differ [34]. The lateral slope is difficult to measure on lateral radiographs, and therefore measurement with magnetic resonance imaging (MRI) is usually recommended [35,36]. Evaluation was performed if the tibial slope influences graft survival, and if the status of the graft and the extent of cartilage regeneration influence clinical outcome. Further, the influence of the graft function on cartilage regeneration was evaluated.

The study protocol of this retrospective case series was approved by the competent research ethics board. Preliminary clinical results of nearly half of the cases of this study have previously been reported as a prospective series, but no evaluation of the tibial slope and its influence in this context has been performed [22].

2.2. Surgical technique

All patients were treated with standardized surgical procedures, which have not substantially changed during the 10-year period of this study. In all cases, surgery was performed with single-shot antibiotic prophylaxis (30–60 min prior to surgery) and with an inflated pneumatic tourniquet (350 mm Hg). Arthroscopy was performed using two standardized anterior portals. A chondral resurfacing procedure of areas with full-thickness cartilage defects and exposed subchondral bone was performed in the medial compartment in all cases (Figure 3). First, a debridement of unstable cartilage was performed with a curette. Then