



Excellent long-term results in combined high tibial osteotomy, anterior cruciate ligament reconstruction and chondral resurfacing in patients with severe osteoarthritis and varus alignment

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Abstract

Purpose To determine survivorship and functional results of medial open-wedge high tibial osteotomy (HTO) combined with anterior cruciate ligament reconstruction (ACLR) and a chondral resurfacing (CR) procedure (abrasion/microfracture) in patients with Kellgren-Lawrence grade 3 and 4 osteoarthritis with full thickness-cartilage defects, ACL-insufficiency and varus alignment.

Methods A cohort of 23 patients undergoing a combined procedure of HTO (fixation with angular stable internal fixator, Tomofix[®]), ACLR and CR for the treatment of severe symptomatic medial osteoarthritis, ACL insufficiency and varus alignment ($>4^\circ$) between 2005 and 2009 was prospectively surveyed with a minimum follow-up of 10 years with regard to survival (not requiring arthroplasty), functional outcome (subjective IKDC score), pain level (numeric rating scale), Oxford Knee Score (OKS) and subjective satisfaction. The Wilcoxon signed-rank-test was used for statistical evaluation of non-parametric data in these related samples.

Results Twenty-one cases were included, one case with incomplete follow-up data and another case excluded. The follow-up rate was 91% at 12.0 ± 1.0 years (10.0–13.4). Mean age at time of surgery was 47.3 ± 5.9 years (37.8–57.7). At final follow-up, no arthroplasty was performed in any of the cases (survival: 100%). Subjective IKDC score improved from 47 ± 11 to 75 ± 15 at 1, 72 ± 15 at 3, 73 ± 17 at 6 years and 70 ± 16 at final follow-up ($p < 0.001$), respectively. At final follow-up the OKS was 40 ± 7 (17–48) and pain-level significantly decreased from 7.5 ± 1.0 preoperatively to 2.9 ± 2.3 ($p < 0.001$) at final follow-up. All patients were satisfied with the result and stated that they would retrospectively undergo the procedure again.

Conclusion A combined approach of HTO, ACLR and a CR shows excellent results in a long-term follow-up in selected young patients even in severe osteoarthritis. However, the role and potential benefit of the ACLR and CR compared to HTO alone remains unclear.

Level of evidence Therapeutic case series, Level IV.

Keywords HTO · Osteotomy · Osteoarthritis · Knee · Malalignment · Anterior cruciate ligament · ACL · Chondral resurfacing · Slope · Varus · Joint preservation · Cartilage

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Introduction

Anterior cruciate ligament (ACL) insufficiency often leads to meniscus lesions and progressing cartilage damage, especially in combination with varus deformity and consequently to early osteoarthritis of the medial compartment, particularly in young patients [1, 18, 22, 27, 31]. Treatment of these patients is challenging: Total knee arthroplasty in young patients has shown unacceptable high rates of revision already in the first years after implantation [3]. Unicondylar replacement (UKA) is problematic in unstable knees and with a more posteromedial pattern of osteoarthritis, and there is only very little clinical data for combined UKA and anterior cruciate ligament reconstruction (ACLR) [18, 21, 32, 33].

In contrast, osteotomies have gained increasing interest within the last years, especially in younger patients and early osteoarthritis [4, 11, 20, 23, 25].

For the condition of coincident ACL insufficiency, there is a decent number of studies reporting good functional outcomes after combined high tibial osteotomy (HTO) and ACLR [9, 13, 15, 16, 30]. Furthermore, increasing understanding of the role of the tibial slope in sagittal instabilities has led to new concepts of multidirectional corrections to address both problems [7, 10, 24]. However, to date, no clinical outcome data are available in comparison of slope changing osteotomies without ligament reconstruction to osteotomies with additional ligament reconstructions. Further, no long term data are available for combined procedures with modern techniques, and only little data are available for cases of advanced osteoarthritis.

Therefore, the purpose of this study was to determine long-term survivorship and functional results of a combined joint preserving approach consisting of medial open wedge HTO (fixation with angular stable plate fixator) ACLR and a chondral resurfacing procedure (CR, abrasion/microfracture) in patients with severe medial osteoarthritis, chronic ACL insufficiency and varus alignment.

The hypothesis was that this combined approach leads to significant functional improvements and can postpone arthroplasty in patients for whom this would have been the alternative surgical treatment. Mid-term results of this patient cohort (after a mean of 6 years) have previously been reported [26].

Materials and methods

A total of 23 consecutive cases of HTO combined with ACLR and CR were performed between October 2005 and March 2009, and were all included in this prospective case

study. From the 23 cases one was excluded because of incomplete follow-up data and another one was excluded because of suffering from end stage cancer disease at the time of final follow-up. Therefore, follow-up rate was 91% (21 of 23) after 12.0 ± 1.0 years (10.0–13.4). Patient characteristics are displayed in Table 1.

Inclusion criteria were medial compartment osteoarthritis grade 3 or 4 according to Kellgren and Lawrence (Fig. 1), symptomatic ACL-insufficiency (defined as suffering from subjective instability episodes currently or in the past), full thickness large-area articular cartilage defects in the medial compartment as confirmed during arthroscopy according to the International Cartilage Research Society (ICRS) classification and a varus alignment of more than 4° (angulation between femoral and tibial mechanical axes on a hip-to-ankle standing anterior–posterior radiograph) [6, 14].

Contraindications included a body mass index (BMI) greater than 30, posterior cruciate ligament insufficiency and absence or extensive loss of the lateral meniscus.

Patients were regularly contacted by telephone and postal questionnaire. Survivorship was defined as not requiring arthroplasty during follow-up. All patients completed the self-administered IKDC subjective knee evaluation form preoperatively and at the different points of follow-up. Pain level was measured with the numeric rating scale (NRS) with 0 = no pain and 10 = worst pain imaginable. At last point of follow-up, the Oxford Knee Score was additionally obtained, and patients were asked if they would retrospectively undergo the operation again regarding the long-term outcome (subjective satisfaction).

Surgical technique

At the time of the study, surgery was performed with inflated tourniquet (350 mmHg). ACLR was performed using hamstring tendon autografts (4-strand semitendinosus and gracilis tendon), anteromedial portal drilling technique for

Table 1 Demographics

Age (years)	47.3 \pm 5.9 (37.8–57.7)
Sex	
Male	18 (85.7%)
Female	3 (14.3%)
Side	
Left	11 (52.4%)
Right	10 (47.6%)
BMI	25.5 \pm 1.8 (22.6–30.1)
Smoker	2 (9.5%)

Data presented as mean \pm standard deviation (and range) or number (percentage)

BMI body-mass index

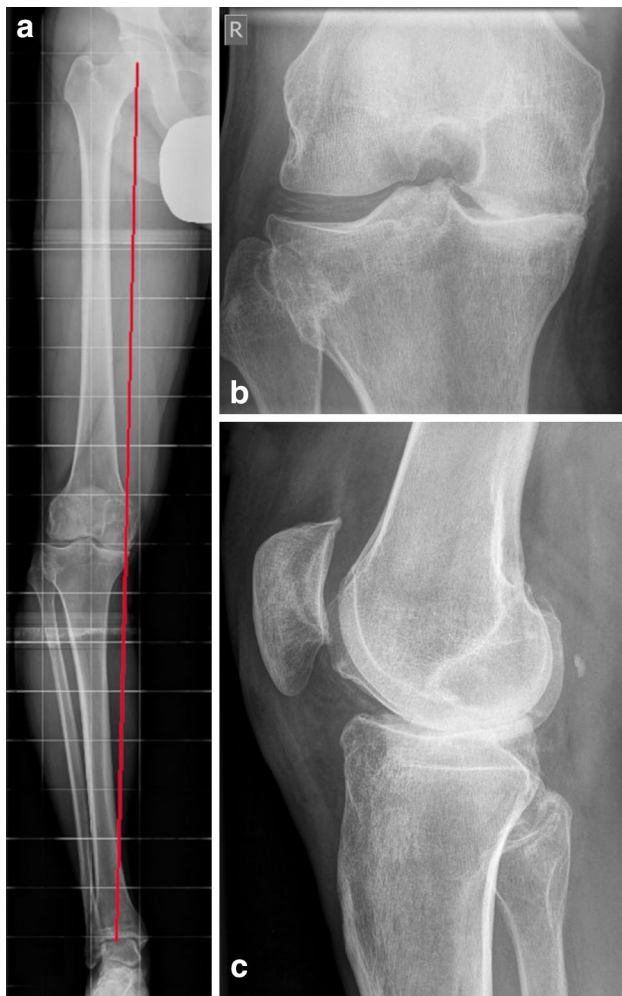


Fig. 1 Preoperative radiologic evaluation of a 48 years old male: massive varus deformity (a), grade IV osteoarthritis in the medial compartment (according to Kellgren and Lawrence, (b), and anterior subluxation of the tibial plateau in chronic anterior cruciate ligament insufficiency

independent femoral tunnel placement and aperture fixation with interference screws. If ipsilateral hamstring tendons were not available, contralateral tendons were used. In revision-ACL, a tibial hybrid fixation was used (interference screw and non-absorbable suture material fixed to the plate). A CR procedure was performed in all cases in the medial compartment. CR consisted of debridement of unstable cartilage, an abrasion with a burr to remove the sclerotic layer and expose the subchondral bone, and an additional microfracture for further bone marrow stimulation [25].

A medial opening-wedge osteotomy in a biplanar fashion was performed [17, 29]. In the years of the study, the mechanical axis was planned to cross the tibial plateau at a point of 62% of its transverse medio-lateral diameter, aiming at a slight valgus alignment [12]. The TomoFix® instrumentation system (Synthes, Oberdorf, Switzerland) was used

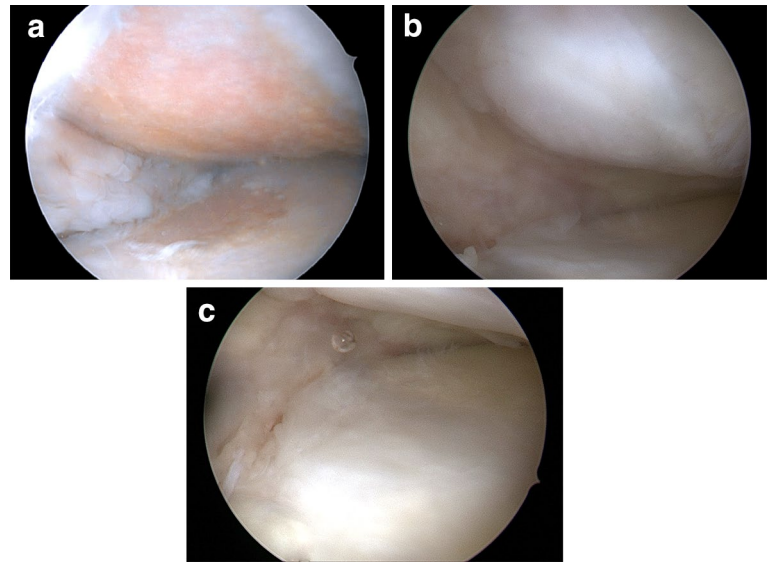


Fig. 2 Same case as Fig. 1. Postoperative radiologic evaluation after combined high tibial osteotomy, anterior cruciate ligament reconstruction and chondral resurfacing with corrected axis (a) and consolidated osteotomy (b, c)

for fixation in all cases (Fig. 2). Osteotomy was performed beneath the entry point of the tibial tunnel and screw placement was performed cautiously and under fluoroscopic control when necessary to avoid damage to the transplant or tibial tunnel.

Weight bearing was limited to 10–20 kg for eight weeks postoperatively, with no brace and no limitation in the range of motion. Continuous passive motion (CPM) was applied for eight weeks (4–5 times per day for 30–45 min). At the time of the study, hardware removal was usually recommended after consolidation of the osteotomy at 1–2 years and was performed in all included cases combined with arthroscopy (Fig. 3).

Fig. 3 Intraoperative evaluation of the medial compartment at the time of surgery, with exposed subchondral bone in large areas. Medial compartment of the same patient at the time of hardware removal after 1 year with complete filling of the former cartilage defects after chondral resurfacing procedure combined with osteotomy and anterior cruciate ligament reconstruction



The study protocol was approved by the competent research ethics board (Landesärztekammer Baden-Württemberg, Germany, F-2014-022).

Statistical analysis

Data were obtained prospectively but analysed retrospectively. Statistical analysis was performed using IBM SPSS Statistics for Windows (version 20, IBM Corp., Armonk, NY, USA). For statistical evaluation of nonparametric data in related samples the Wilcoxon signed-rank test was used. All reported p values are two-tailed, with an alpha level < 0.05 considered as significant. Unless otherwise stated, descriptive results are demonstrated as mean \pm standard deviation (and range).

A post-hoc power analysis was performed with G.Power (Version 3.1., Kiel, Germany) exemplary for the obtained IKDC score preoperatively and at final follow-up. With a given alpha of 0.05 and the calculated effect size a statistical power of 99.9% was found.

Results

In the majority of cases primary ACLR was performed together with osteotomy. Six cases (28.6%) had prior ACL surgery (ACL repair in two cases and ACLR in four cases) and consequently underwent revision-ACLR with osteotomy. All patients had at least undergone one prior operation with either partial or total resection of the medial meniscus. Mechanical tibiofemoral axis was $8.5^\circ \pm 2.5^\circ$ of varus preoperatively, and $1.9^\circ \pm 2.3^\circ$ of valgus postoperatively (at the time of hardware removal), respectively ($p < 0.001$).

No arthroplasty was performed in any case during follow-up (survival 100%). Subjective IKDC score improved from 47 ± 11 to 75 ± 15 at 1, 72 ± 15 at 3, 73 ± 17 at 6 years and 70 ± 16 at final follow-up (Fig. 4), respectively. The difference to the preoperative value was significant at any point of follow-up ($p < 0.001$). There was no difference between the four points of follow-up (n.s.).

At final follow-up the OKS was 40 ± 7 (17–48), and pain-level significantly decreased from 7.5 ± 1.0 preoperatively to 2.9 ± 2.3 ($p < 0.001$). All patients were satisfied with the result and stated that they would retrospectively undergo the procedure again.

There were two complications within follow-up (9.5%): In one case of reoccurring subjective instability revision-ACLR was performed 4 years after the index procedure, and one case with extension deficit was treated with arthrolysis and notchplasty at the time of hardware removal. There was

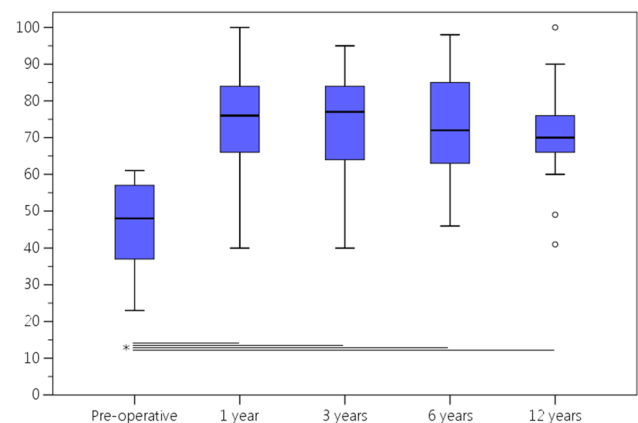


Fig. 4 Subjective IKDC score preoperatively and within follow-up ($*p < 0.001$)

no thrombosis, infection, mal-union or vascular or neural injury.

Discussion

The major finding of this study is that a combined approach of HTO, ACLR and CR is a highly effective procedure in the treatment of severe medial osteoarthritis, chronic ACL-insufficiency and varus alignment in selected young patients, especially in terms of postponing arthroplasty, functional results and subjective satisfaction.

Treatment of young patients with severe osteoarthritis is challenging. Frequently, these early degenerations can be attributed to chronic instability with consequential meniscus loss and cartilage damage [22]. It has been clearly shown, that arthroplasties in these young patients are highly problematic: Unacceptable high revision rates of total knee arthroplasties up to 35% for men in their early 50 s have been reported [3]. Especially in these cases of chronic instability and posteromedial type of osteoarthritis unicondylar arthroplasties are discussed controversially, and there is only limited and heterogenic data on combined UKA combined with ACLR [18, 21, 32, 33].

Therefore, there is a need for alternative treatment strategies focusing on joint preservation and biological reconstruction. In the past, this combined approach has been titled a salvage procedure, and was attributed a high complication rate [15, 16]. However, with modern surgical techniques, increasing knowledge and a decent number of studies showing promising results and considerably less complications the idea of biological joint reconstruction became a standard procedure for selected patients [30].

Available reports in the literature are very heterogenic in terms of used surgical technique of HTO (lateral closed wedge in the majority of cases), used implants (mainly not angular stable) and technique of ACLR (mainly bone-patellar-tendon-bone grafts with non-anatomic femoral positioning [5, 9, 13, 15, 16, 35]). Therefore, comparison is very limited.

Li et al. showed improvements in all subjective evaluations in a review of 11 studies with simultaneous HTO and ACLR and a total of 218 cases [16]. In a longer follow-up of 12 years (comparable to the presented study) but only with cases of early osteoarthritis included, Bonin et al. showed a subjective IKDC score of 78 at final follow-up in a series of 30 knees [5]. Another study reported on an increase in subjective IKDC from 58 to 72 at 6.5 years in a group of 32 cases of combined closing wedge lateral HTO and over-the-top ACLR [35]. Hinterwimmer and Mehl reported on a very high satisfaction rate of 94% and a Lysholm score of 74 in a mid-term follow-up of 64 cases with combined procedures

using different techniques (medial and lateral osteotomies; with and without ACLR) [13].

The majority of included patients in the abovementioned studies suffered from early or moderate osteoarthritis, whereas the presented study is the only long-term investigation focusing on cases with severe osteoarthritis and instability so far. Generally, slightly inferior functional results have been reported in cases of more severe osteoarthritic changes compared to early osteoarthritis in HTO without instability and concomitant ligament reconstruction [11, 20]. To the best of the authors' knowledge this is the first study presenting long term results (> 10 years) of combined procedures using modern techniques (fixation with angular stable plate fixators and anatomic ACLR). In the years of the study the tibial slope was kept neutral. Recent studies have shown that the tibial slope has substantial influence on the integrity of the ACL graft, and that slope corrections either alone or in combination with frontal plain correction might positively influence graft function and survival [8, 24, 28].

However, there is still a paucity of high quality studies on the issue how pathologic anterior translation should ideally be addressed. No studies compared HTO with slope modification to HTO plus ACLR (either with or without slope change). Therefore, there is still controversy in optimal treatment. Mehl et al. reported on 26 cases of isolated HTO compared to 26 cases of HTO plus ACLR after nearly 6 years [19]. Interestingly, there was no difference in the improvement of subjective stability between the groups. However, Lysholm and IKDC score were superior in the group of combined procedure, without a higher rate of postoperative complications. Williams et al. reported on generally satisfying results in a short term follow-up of 26 cases, but they found a higher rate of good and excellent results in a combined approach of osteotomy and ligament reconstruction [34]. With regard to slope modifications in combined approaches, Arun et al. reported on 30 cases with a combined approach: They found significant better functional results when a slope decrease of 5° or more was present postoperatively [2]. Further, it has been recently shown that a slope of 10°–12.5° or more is associated with a high graft failure rate in combined approaches [24]. Finally, it should be kept in mind that failure of the osteotomy usually results in arthroplasty. Apart from other relevant factors, a functional ACL at that time might enable UKA instead of total knee replacement for these cases, which would be preferable.

In conclusion, the authors generally recommend a combined approach of osteotomy plus ligament reconstruction. The tibial slope should carefully be respected, and the postoperative slope should be 10° or less. Caution is advised in cases with marginal extension deficits preoperatively, as cases of extension deficits were seen in this series and combined approaches. For these cases an individual two-staged treatment (first osteotomy and secondary ligament

reconstruction at the time of hardware removal) might be superior.

Within the years of the study all valgus osteotomies were performed on the tibial side, regardless of the present constitutional deformity. Although the case number in this series is too low for a valid analysis of the influence of the pre- and postoperative tibial geometry, even better results might be achieved if the osteotomy would be performed at the site of deformity [23].

Although the present study reports reliable long-term data it finally remains unclear to which extent the ACLR influences the overall clinical results compared to isolated HTO, which is still under debate. With regard to the presented results, the authors strongly recommend this combined approach in selected patients, and it should be seen as a standard treatment option instead of a salvage procedure nowadays. However, future studies should focus on this issue, and also on the posterior tibial slope and tibial geometry to clarify for which patients an additional slope correction would be beneficial and to what extent this should be performed.

With increasing incidence of osteoarthritis, rising numbers of joint replacements and consequent complications, alternatives currently play an important role in daily clinical practice, and will be even more in the future. Therefore, there is a need for these treatment options of joint preservation. This study presents reliable data on a combined approach for these challenging patients with good long-term results and low complication rate, which can clearly be recommended in selected cases.

Limitations

Several limitations of this study must be considered. First, the overall number of cases is low, however, the topic restricts high numbers. There is a selection bias, because patients enrolled in this study elected not to undergo TKA and were referred for joint preservation. Further, follow-up examination was done by telephone interview and postal questionnaire, no clinical examination was performed. No control group without cartilage addressing procedure was available to allow conclusions concerning the role of these procedures. There is an ongoing discussion whether osteotomy should be combined with ACLR or if osteotomy alone would lead to similar results. With low complication rates as described above, this combined procedure is the standard and recommended approach for these cases at the authors' institution. This question has already been discussed in the mid-term follow-up report of this cohort, and cannot be clearly answered as no control group is available [26]. Generally, the aim of this study was to present the long-term results of the technique. Last, evaluation of how long

arthroplasty can be postponed is limited as there is no control group of conservatively treated patients.

Conclusion

A combined approach of HTO, ACLR and a CR shows excellent results in a long-term follow-up in selected young patients even in severe osteoarthritis. However, the role and potential benefit of the ACLR and CR compared to HTO alone remains unclear.

Compliance with ethical standards

Conflict of interest The authors declare they have no conflict of interest.

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Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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