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## High tibial osteotomy alone or combined with ligament reconstruction in anterior cruciate ligament-deficient knees

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**Abstract** High tibial osteotomy (HTO) is widely accepted as a treatment option in patients with medial unicompartimental osteoarthritis (OA) and varus morphotype of the knee. We increasingly see younger patients with a chronic anterior instability, an additional varus morphotype and beginning medial OA. Treatment options for these patients are not clear up to now. In this clinical study we compare for the first time three different treatment rationales and introduce a concept of symptom-oriented surgery in young patients with medial OA and chronic

anterior instability. *Materials/methods:* Between 1984 and 1994 30 patients were treated with a medial unicompartimental OA and chronic anterior instability of the knee. Patients were grouped into three different groups according to treatment. 1) only HTO was performed. 2) HTO and simultaneously an ACL-reconstruction and 3) HTO and 6–12 months later an ACL-reconstruction was performed. 27/30 patients were available for follow-up. All patients had an arthroscopy before surgery. Evaluation was done according to the IKDC-protocol and X-ray documentation. *Results:* Pain was a major problem in all patients. None of them was completely pain-free. 8/27 patients had pain even with light activities. This included 1/11 patients of group 1, 3/8 of group 2 and 4/8 of group 3. 9/27 patients had stable knee joints with a Lachman-test of 3–5 mm. No patient had a Lachman test < 3 mm. 3/11 patients of group 1, 3/8 of group 2 and 2/8 of group 3 had a Lachman test of 5–10 mm. A positive pivot-shift could be found in 9/27 patients. 2/11 of group 1, 4/8 in group 2 and 3/8 in group 3. The overall IKDC-score improved in 23/27 patients, one patient remained unchanged, two deteriorated. Radiologically a slight progression of OA could be seen in all patients. Radiological signs of OA and pain did not show any correlation. There was, however, a significant rate of postoperative complica-

tions involving 4/11 patients of group 1 and 3/8 of group 3. There were 6 major complications in 5/8 patients in group 2. Nevertheless overall patient satisfaction was high. 25/27 patients would undergo the procedure again. *Conclusion:* HTO is a good treatment option for younger patients with medial OA and chronic anterior instability of the knee. These patients pose a high challenge to diagnostic and operative skills of the surgeon. Main symptoms of these patients have to be analysed clearly in terms of instability and pain. In patients aged 40 and older an HTO alone is an excellent treatment option with reproducibly good results. In younger patients we advise an HTO first. If instability persists, an ACL-reconstruction can be done 6–12 months later. One has to be aware that a simultaneous combined procedure has a significant complication rate. Hence if a simultaneous combined treatment is planned the surroundings including surgical technique, rehabilitation and patient compliance have to be ideal. These young patients need an activity counselling in order to realise that their knee joint has suffered significantly from the injury and ongoing high physical demands on their knee joint.

**Key words** Knee · Knee ligament surgery · Osteoarthritis · Anterior cruciate ligament · Anterior instability · High tibial osteotomy

## Introduction

High tibial osteotomy is widely accepted as a treatment option in patients with a unicompartmental osteoarthritis and varus angulated knees. The current literature includes several studies discussing the short- and long-term results after high tibial osteotomy (HTO). Most of them deal with patients over 50 years of age [1, 2, 4–9, 17, 19, 21, 24], while only a few studies are addressed to the young adult patient with osteoarthritis [11, 15, 16, 18, 20, 25–28]. In recent years we increasingly treat young adults aged between 20 and 40 who present with a varus aligned knee and unicompartmental medial osteoarthritis combined with a marked anterior instability due to anterior cruciate ligament (ACL) insufficiency. These patients usually are very active and pose high demands on their knee joint. Most of these patients had undergone one or more previous operative procedures, e.g. partial/total meniscectomy or an ACL reconstruction during their sportive career.

HTO in young adults has been reported to be effective for the treatment of medial osteoarthritis [18, 27]. However, treatment options for patients with unicompartmental osteoarthritis and combined ACL insufficiency are not clearly defined. For example, it is not clear whether the osteoarthritis or instability has to be treated first. HTO alone has been reported to be efficient in certain patients [27]. A combined HTO and ACL reconstruction has been proposed by several authors [3, 11, 15, 16, 18, 23, 26, 27]. It has even been proposed to treat anterior instability in those patients solely with an ACL replacement [29]. Although adequate treatment of medial osteoarthritis and anterior instability is discussed controversially, there is no agreed treatment rationale available at the present time.

In this study we report our patients treated for medial osteoarthritis and anterior instability during 1984 and 1994. We describe three different treatment rationales for three different groups of patients presenting with unicompartmental osteoarthritis and ACL insufficiency. The aim of this study was to introduce a concept of age- and symptom-related treatment for symptomatic patients with ACL insufficiency and beginning medial osteoarthritis of the knee.

## Materials and methods

From 1984 to 1994 163 patients underwent a high tibial valgus osteotomy (HTO). Of these, 117 suffered from medial wear osteoarthritis, 30 anterior instability and medial osteoarthritis, and 16 posterolateral instability and osteoarthritis.

In our study, we assessed a group of 30 patients who underwent HTO for chronic anterior instability, varus alignment and osteoarthritis. The patients were divided into three different groups: (1) all patients who underwent HTO alone (HTOalone); (2) all patients who had had HTO and an ACL reconstruction 6–12 months later (Two-stage); (3) patients who had had HTO and ACL reconstruction done simultaneously (ACL-sim). The indication for HTO or a combined procedure was taken from the patient's level of pain, degree of instability, age, type of previous operative proce-

dures and amount of activity. Generally, a high patient activity and high degree of instability-related symptoms (i.e. giving way) and younger age (< 40 years) were predominant factors for a decision towards a combined treatment. The decision of whether to perform a simultaneous or two-staged procedure depended on the severity of the instability-related symptoms and patients' level of activity.

The initial study population consisted of 30 patients. Three were lost to follow-up, one died, and the other two could not be traced. Two patients were lost in the "HTOalone" group, one was lost in the "ACL-sim" group. At follow-up we saw 11 patients who had undergone HTO alone, 8 with HTO and ACL reconstruction performed simultaneously, and 8 with HTO and ACL reconstruction performed in two stages. There were 12 women and 15 men with a mean age of 37 years when HTO was performed. The mean age differed significantly between the HTO group and the two other combined treatment groups. The HTOalone group had a mean age of 44 years (range 36–55 years). Patients in the Two-stage group had a mean age of 35 years (range 24–56 years), and patients in the ACL-sim group had a mean age of 32 years (range 20–38 years). Overall, the average time since injury was 8.3 years. The HTOalone group naturally had a longer average time since injury (11.3 years). In the Two-stage group patients had been injured on average 8.1 years before the procedure, while for the ACL-sim group 5.6 years had passed between the accident and operation. The average follow-up time was 5.8 years, ranging from 18 months to 10 years. There were no differences between groups concerning follow-up time, gender or injury mechanism.

### Preoperative evaluation

All patients were examined in our outpatient clinic preoperatively. All patients had pain, swelling and giving-way episodes. The Lachman test, pivot-shift test and lateral joint-space opening were documented in all patients. Preoperatively, full standing radiographs, anteroposterior (AP) and lateral single-leg stand, a tunnel view in PA direction in 40° of knee flexion, stress radiographs documenting a varus/valgus stress as well as an anterior drawer in 30° of knee flexion were done for each patient. All patients had an arthroscopically documented rupture or absence of the ACL.

Patients were usually referred to our facility after having undergone various operative procedures. Most of them had had a medial total or partial meniscectomy, and 16/30 had had one or more ACL reconstructions. The overall number of operative procedures before HTO was 2.1 (range 0–7; Table 1).

All patients were examined by arthroscopy before the osteotomy was performed. The arthroscopic findings were listed according to the compartment (medial, lateral, patellofemoral) and the cartilage changes. Cartilage damage was grouped into fissuring and fragmentation or visible subchondral bone. The size of the damaged area was roughly estimated. In our patient population, all patients had medial cartilage changes, 14 fissuring and 13 visible subchondral bone. Some 25 of 27 patients had undergone a previous meniscectomy. The lateral compartment was damaged in 11

**Table 1** Study group parameters

Group parameter	HTO	HTO + ACL two-staged	HTO + ACL simultaneous
Number of patients	11	8	8
Mean age (years)	44	35	32
Gender: male/female	6/5	4/4	5/3
Time elapsed since injury (months)	136	98	67
Previous operations since injury	25 (mean 2.3)	17 (mean 2.1)	14 (mean 1.8)

**Table 2** Preoperative arthroscopic findings

Group	Medial compartment		Lateral compartment		Meniscectomy
	Fissuring	Subchondral bone	Fissuring	Subchondral bone	
HTO ( <i>n</i> = 11)	1	10	3	None	10
HTO + ACL ( <i>n</i> = 8) two-staged	6	2	3	None	7
HTO + ACL ( <i>n</i> = 8) simultaneous	8	0	5	None	8

patients showing fissuring. The lateral meniscus showed a minor tear in 4 patients. In 1 patient this was refixed with two sutures; in the other three patients it was a minor medial substance tear which was not treated. Finally, the patellofemoral compartment showed fissuring and fragmentation in 13 patients, and subchondral bone was exposed in 4 patients. The degree of cartilage damage was highest in the HTOalone group; in the Two-stage group patients mostly had severe fissuring and fragmentation and rarely visible subchondral bone. In the ACL-sim group mainly cartilage fissuring and fragmentation in the medial compartment were seen (Table 2).

#### Postoperative evaluation

The postoperative evaluation of patients consisted of a thorough clinical examination and an interview according to the IKDC scoring system. The preoperative IKDC assessment could be taken from the patients' medical history. Additionally, patients were asked whether they would undergo the procedure again.

The radiological documentation included single-leg stand radiographs in AP and lateral view, a PA tunnel view in 40° knee flexion and a patella-défilé series. Preoperative full-length standing radiographs, single-leg stand AP+ lateral views, PA tunnel views and a patella-défilé were available in 24 patients, whereas there were follow-up radiographs for all patients, not including the full-length standing radiographs. The medial joint space was evaluated according to the IKDC score. Radiologically, our main interest was focused on progression of the medial osteoarthritis and whether there was productive medial osteoarthritis with or without the formation of osteophytes. We did not evaluate the loss of correction or the weight-bearing axis.

#### Operative procedure

In all patients HTO was performed. Generally, two different techniques were used: an opening-wedge osteotomy using a staple fixation or an external fixateur (*n* = 10) or a closing-wedge osteotomy using an angulated buttress plate (*n* = 17). The ACL reconstruction was done arthroscopically using a bone-patella tendon-bone autograft. All patients were fitted with a tourniquet. In those in whom HTO and ACL reconstruction were done simultaneously, the osteotomy was performed first.

Postoperative rehabilitation included partial weight-bearing on two crutches and a range of motion exercises (0°–90°) for 4–6 weeks.

## Results

The results of this study were evaluated according to the IKDC score. We noted a postoperative improvement of activity level. The preoperative activity level in all patients was 2.8, and postoperative activity level 2.3. If the patients were asked to compare the function of the in-

jured to the uninjured knee, 10 of 11 in the HTOalone group described the injured knee as normal or nearly normal. One patient rated his injured knee as abnormal. In the ACL-sim and Two-stage groups only 4 of 8 patients rated their knee function as normal or nearly normal, in the ACL-sim group one patient described the knee function as severely abnormal. The remaining 7 patients with a combined procedure rated their knee as abnormal.

#### Pain

Pain is a major criteria for these patients. No-one was completely free of knee pain. Eight of 27 patients suffered knee pain at rest or with light/sedentary activities. This included 1 of 11 from the HTO group, 3 of 8 from the ACL-sim group and 4 of 8 from the Two-stage group. Nineteen patients felt knee pain only with moderate to strenuous activity (heavy work, higher level sports).

#### Stability

Objective information on knee function as obtained from the IKDC score included Lachman test, pivot-shift test and one-legged hop. In the Lachman test 19 of 27 knees had a firm endpoint and a side-to-side translational difference of 3–5 mm. There was no knee joint with a Lachman test < 3 mm. Eight knees showed a side-to-side difference of 5–10 mm in the Lachman test, with 2 knees lacking a firm endpoint. A Lachman test between 3 and 5 mm was found in 8 of 11 patients with HTOalone, 5 of 8 patients in the ACL-sim group and 6 of 8 patients in the Two-stage group. The knees with a side-to-side difference > 5 mm most likely have to be regarded as potential failures of the ACL graft. Those lacking a firm endpoint certainly have a ruptured or non-functional ACL graft. Three of 11 in the HTOalone group had a Lachman test > 5 mm, 2 of 8 in the Two-stage group and 3 of 8 in the ACL-sim group. Interestingly, the two patients with non-functional ACL grafts belonged to the ACL-sim group and returned to their previous high-level sports postoperatively. A positive pivot-shift test could be found in 9 of 27 patients: 2 of 11 in the HTOalone group, 4 of 8 in the Two-stage group and 3 of 8 in the ACL-sim group (including the two graft failures). 9 of 27 patients experienced giving-way episodes with

light or moderate activities. Two of 11 in the HTOalone group, 4 of 8 in the Two-stage group and 3 of 8 in the ACL-sim group. The functional ability of the knee joint was tested using the one-legged hop: 20 of 27 patients achieved more than 75% of the non-injured leg, and 8 over 90%. Ten of 11 patients in the HTOalone group achieved over 75%, 5 of 8 in the Two-stage group and the same (5 of 8) in the ACL-sim group. Only one patient in the ACL-sim group achieved less than 50% of the non-injured leg.

#### IKDC score

The overall IKDC rating improved in 23 of 27 patients. Preoperatively, all 27 patients scored values of abnormal or severely abnormal knee joints. Postoperatively in the HTO group, all patients rated nearly normal or abnormal, with 4 patients having improved two categories. In the two groups with ACL reconstructions, 6 of 8 rated nearly normal or abnormal, with 2 patients having improved two categories. Two patients did not show any improvement in their severely abnormal knees.

#### Radiological findings

The radiological follow-up was primarily done in order to evaluate the progression of osteoarthritis. The IKDC radiological scoring was analyzed according to the criteria of Lequesne [22]. Hence, single-leg stand radiographs were evaluated using the radiological index. Preoperative radiographs of 24 of 27 patients were available. Twelve showed narrowing of the medial joint space of < 50% (r. index group 1), while eight patients had a joint space narrowing of 50%–90% (r. index group 2). Four patients ranked in group 3 with an obliteration of the medial joint space. Postoperatively, there was a slight progression in all groups. Four patients remained in group 1, ten patients were ranked in group 2, nine patients ranked in group 3, while two patients had a slight attrition of bone (1–3 mm) and therefore ranked in group 4. Significant differences between groups could not be found. As reported in other studies, the radiological signs of osteoarthritis and pain could not be correlated [13, 26].

#### Overall patient satisfaction

During the clinical examination patients were asked whether they would undergo the procedure again. We think that this is an important question to reveal overall patient satisfaction. Twenty-five of 27 patients answered affirmatively. Most of the patients stressed, however, that they would prefer an exact and realistic activity counselling prior to surgery in order to be able to adjust to feasible goals after the procedure. Only two patients were dissatisfied with the operation. One was a 35-year-old

farmer who had been a ski-racer and had gained considerable weight since the operation. She weighed 105 kg at the time of the clinical examination and mainly complained about pain even at rest. The second patient was a 32-year-old labourer who did not succeed in returning to competitive alpine skiing after the procedure.

#### Complications

Complications in HTO are described by several authors [8, 9, 27]. Complications in ACL replacement using the patellar-bone tendon-bone graft are due mainly to technical problems leading to a wrong placement of the graft. In our patient population the overall number of postoperative complications was high. Ten patients suffered major complications postoperatively. This included four extension deficits over 10°. In two cases there was a marked valgus overcorrection (15°), making a re-osteotomy necessary in order to restore 8° valgus knee alignment. One patient suffered an intra-articular fracture. One patient developed a deep venous thrombosis, and one patient had a peroneal nerve injury leading to a 'steppers-foot', which was reversible after 1 year. Long-term complications included one patient with severe pain over the buttress plate. She became painfree after hardware removal. One patient developed a granuloma at the tibial site which needed operative removal. In two patients the ACL graft ruptured following a second trauma during sports activity. Looking at the different groups, there were 4 of 11 patients with complications in the HTOalone group. In the Two-stage group 3 of 8 patients had complications including the patient with the granuloma. In the ACL-sim group there were 6 complications in 5 of 8 patients, 4 of 8 having immediate complications and an additional 2 with a graft rupture. One patient suffered an extension deficit and a deep venous thrombosis.

#### Discussion

The patient with osteoarthritis and severe anterior instability is usually under 50 years of age. Whereas treatment of osteoarthritis in elderly people is a well discussed topic, treatment rationales for younger patients do not exist. HTO as a means to treat medial osteoarthritis in an older patient population averaging 60 years of age or more has been well published as short- and long-term results by several authors [1, 2, 4–9, 17, 19, 21, 24]. Some studies reported on HTO in patients averaging 50 years of age and younger [11, 15, 16, 18, 20, 25, 27, 28]. Only a few authors have specifically investigated HTO as a treatment option for young, athletically active patients with medial osteoarthrosis and anterior instability [11, 15, 16, 23, 26, 27]. All of them report good or very good results when performing a combined procedure of an osteotomy and ACL reconstruction done simultaneously. Patient sat-

isfaction was generally high, but only a few patients returned to their former level of activity. There is only one study evaluating different treatment rationales [27] reviewing 30 patients. In this study they evaluated two different groups. In the first group an HTO and a combined lateral-extraarticular procedure were performed. The second group had an HTO and a simultaneous allograft ACL reconstruction. In the overall rating the 'HTO + ACL reconstruction' group scored significantly better. Subjective assessment showed high patient satisfaction and good stability in the Lachman test. They concluded that HTO and combined ACL replacement should be primarily considered if instability is a main symptom. If giving-way is not a major complaint HTO alone could suffice [27].

### Groups of patients

Our study is the first to compare three distinct treatment rationales. The results of this study show that our patient population does experience significant limitations because as much as 59% ( $n = 16$ ) of the patients reduced their level of activity to merely sedentary or light daily activity. A further 19% ( $n = 5$ ) reduced their activity to light sportive activities such as jogging or bicycling. Preoperative subjective evaluation showed that all patients were dissatisfied with the performance of the injured knee joint. Most of them had been active at a highly competitive level before their injury. At the time of operation all patients had stopped competition sports; most of them did not even perform sports at a recreational level.

Our patient population could be divided into three different groups (Table 3). Treatment of these groups was distinctly different depending on age, symptoms of instability and pain.

One group consisted of patients typically aged between 38 and 48 years, whose major complaint was pain mainly during light daily activity. Instability in terms of giving-way episodes did occur but was not a major complaint. Arthroscopically, most of these patients showed a cartilage lesion down to subchondral bone in the medial compartment. In these patients HTO was performed.

During follow-up 10 of 11 patients felt significant pain relief, and some even returned to recreational sports. The symptoms of instability did not show further progression. The objective testing after 5.8 years revealed an improve-

ment in stability, with only 3 of 11 patients having a Lachman test  $> 5$  mm side-to-side difference. Only 2 of 11 patients reported an occasional giving-way episode.

In the second group patients typically were aged between 25 and 40 years. Those patients had significant symptoms of instability and additionally complained about pain during light daily activities. In most of them severe fissuring and fracturing of the cartilage were seen in the medial compartment. Patients in this group were first scheduled for HTO, and if osteotomy alone did not suffice to restore knee function, the ACL replacement was performed 9–12 months later.

Three of eight patients felt a significant pain relief allowing for light to moderate activities without knee pain. Five patients had ongoing pain but were able to perform pain-free during activities of normal daily life. There were no symptoms of instability in six patients, while in 2 patients there was an occasional episode of giving-way. The objective stability testing showed good result in six patients.

The third group mainly included patients aged  $< 20$ –35 years. Their major complaints were severe symptoms of instability and pain during moderate activities. These patients mostly performed sports at a competitive level and wanted to return to competitive sports. Arthroscopic findings showed mainly fissuring and fragmentation of the medial compartment. All of these patients had undergone partial medial meniscectomy earlier, and all but one had already had a failed ACL reconstruction. In these patients HTO and ACL replacement were performed simultaneously.

Significant pain relief was obtained in 50% of the patients. The remaining half of this group still felt pain during moderate activity. Instability symptoms could be reduced in 5 of 8 patients. Three patients still had occasional giving-way episodes. Objective stability was restored in five patients. Two patients managed to return to their pre-injury sports but performed on a lower level. These two patients both experienced a second trauma to their knee joint and presented with a ruptured ACL graft at the clinical examination. They reported giving-way episodes only with moderate sporting activity.

### High tibial osteotomy

We introduced three different treatment rationales for three distinct groups of patients with medial wear os-

**Table 3** Clinical subdivisions of patients with varus alignment, beginning medial wear osteoarthritis and ACL insufficiency of the knee

Group	Age <sup>a</sup> (years)	Pain	Instability	Arthroscopic findings	Treatment
1	40 and older	+++	+	Subchondral bone	HTO
2	25–40	+ – (++)	(+) – ++	Severe fissuring and fragmentation	HTO first, ACL-graft 9–12 months later if instability persists
3	< 20–35	+	+++	Fissuring	HTO and ACL graft simultaneous procedure

<sup>a</sup>Age of patients might differ; in our patient population this was the typical range

teoarthritis and an ACL insufficiency of the knee. The overall results suggest that the group of patients with a HTO alone had the best results after follow-up. In these patients HTO significantly reduced pain. Even instability was reduced in several patients. This is an effect which has been described by Holden and Noyes. They found that the valgisation of the knee axis led to a higher AP stability. Dejour added another explanation saying that in an osteoarthritic knee there is a certain alteration of knee kinematics due to the formation of osteophytes [12]. Although these patients had an anterior instability, this did not present a major problem. The main focus for treatment therefore was just knee pain. For these patients an average of 11 years had passed since their injury. This time span was significantly longer than in the other two groups who were not as quickly symptomatic as patients in the group with additional ACL reconstruction. Possibly, these patients did adjust their activities to their knee joints, whereas patients in the other two groups did not.

#### Osteotomy and ACL replacement

In the two patient groups with additional ACL replacement the second important factor which had to be treated simultaneously was a significant instability. Compared with the literature the overall results in patients with a combined treatment seem to be similar. Almost 50% felt pain during moderate sporting activities and only 2 of 16 returned to their previous sport. These young individuals suffered major damage to their knee joints. Most of them were painfree during active daily life and were generally satisfied with the status quo of their knee joint achieved after the operation. This is an encouraging result. Interestingly, in our patient population, we noticed that almost all of the ACL-replaced knee joints presented with a Lachman test of 4–5 mm. Our ACL replacements therefore seemed to become loose to a certain degree. Perhaps this constitutes a need for a lax ACL graft in an arthritic environment. A stiff graft might 'trap the arthritic knee joint and lead to an increase in cartilage wear' [14]. We can only explain this phenomenon on a rather speculative basis, assuming that the altered kinematics due to the formation of osteophytes [12] and furthermore the 'hostile' cytokinetic environment of an arthritic knee lead to an increase in graft laxity [14]. One has to be aware of the fact that surgery in these patients cannot provide a 'restoration ad integrum'. It is important that patients be aware of this in order to prevent disappointment. The goal of surgery is pain-free daily use of the knee [14].

We did not see any significant differences between the two groups with ACL replacement. Results regarding satisfaction as well as stability and function of the knee were almost identical. We conclude that patients with a two-stage procedure do not lose time in rehabilitation of their knee joint compared with a simultaneous procedure. One of the disadvantages of a two-staged procedure is the sec-

ond round of hospitalisation of patients for the ACL replacement. We tried to schedule the ACL replacement at the same time as hardware removal of the osteotomy. Thus, hospitalisation of patients could be kept reasonably short, and a third admission was not necessary.

In the available literature it is generally the simultaneous osteotomy and ACL reconstruction that have been studied in order to evaluate the risk and possible damage due to this procedure. It was thought that the greater amount of surgery could hinder early rehabilitation and therefore be harmful to the ACL graft. Many studies could, however, clearly show that results after this procedure are satisfactory, and that the patients cope well [11, 16, 23, 27]. Boss et al. even favoured the simultaneous approach since in his study group there were no complications and very good overall results [3]. The simultaneous approach carries, however, several risks which have been described by various authors [12, 18, 27]. Even HTO alone has a considerable risk of complications [8, 9].

We believe that simultaneous osteotomy and ACL replacement can be a valuable procedure if patient selection is done thoroughly. A high degree of surgical skill and experience as well as patient cooperation and motivation for the rehabilitation programme are necessary. However, there is a higher risk of postoperative complications, which has to be taken into account. The two-stage procedure is equally effective in the long run. In addition, there is the advantage that a patient can adjust to the changed weight-bearing axis. In some patients this leads to a significant reduction of instability and thus renders ACL replacement unnecessary. Currently, it is not known whether an intra-articular procedure has a significant arthrogenic effect on the knee joint. Furthermore, we do not know whether an ACL replacement in a knee joint which lacks a medial meniscus can prevent an early progression of osteoarthritis [10]. We therefore believe that it is important to do as much surgery on a knee as necessary but as little as possible. Thus, the identification of patients not requiring additional ACL replacement should be done carefully.

There are limitations to this study. We did not carry out statistical analysis of our data since a valid and sound statistical analysis in a retrospective study with three inhomogenous groups (11/8/8) of a total of 27 patients is not feasible. We therefore listed our results as numbers from a total. Objective testing was performed according to the experience (Lachman manual estimation of displacement) of the senior author. An instrumented testing device such as the KT-1000 was not used. All patients were seen and evaluated by the senior author. We did not examine the weight-bearing axis of the involved knees. We therefore cannot comment of the extent of loss of correction and the influence of the osteotomy alone. Our main focus was to evaluate the outcome of three different treatment rationales for three different groups of patients.

Generally, in patients with medial osteoarthritis, a varus morphotype and ACL deficiency pose a great chal-

lenge to diagnostic evaluation and operative treatment. Different treatment options have to be evaluated carefully. These treatment options strongly depend on the patient's symptoms and expectations as well as on the surgeon's operative skills. In particular, patients aged 40 years and older and not primarily presenting with a high degree of instability have to be selected since they can be optimally treated with HTO alone. An additional ACL replacement is not necessary and does not improve function.

Especially if a simultaneous procedure has been taken into account, the surrounding facilities have to be ideal. Possible complications have to be balanced against the

benefit of a simultaneous procedure. The operative technique as well as postoperative rehabilitation protocol present a challenge to patient and surgeon.

The osteoarthritic patient with a combined ACL deficiency has to be aware that the knee joint has suffered from both the injury and the ongoing high activity demands. In our series most of the patients did not return to their pre-injury sports level. We believe that the aim of operative treatment in those knees should be a pain-free knee joint during light or moderate activities of daily living. Thus, activity counselling must play an important role in patient guidance and preoperative planning.

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