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Factors that influence high tibial osteotomy results in patients with medial gonarthritis: a score to predict the results

G. Spahn Dr. med.†*, S. Kirschbaum Dr. med.† and E. Kahl Dr. med.‡
† *Clinic of Traumatology and Orthopaedic Surgery, Eisenach, Germany*
‡ *Department of Traumatology, Hufelan Hospital, Bad Langensalza, Germany*

Summary

Objective: High tibial osteotomy (HTO) for the treatment of unicompartmental knee osteoarthritis in the presence of axial malalignment is recognized as an effective treatment for young and active patients. The aim of this study was to identify HTO prognostic factors.

Methods: A total of 94 patients who had undergone HTO with additive arthroscopy were scored using the "knee injury and osteoarthritis outcome score" (KOOS). A KOOS of less than 114 points was judged as a poor outcome.

Results: A total of 84 patients were available for follow-up after a time-interval of 45.9 ± 7.6 (range 34–60) months. The KOOS increased from 46.1 ± 11.1 to 120.3 ± 40.8. The preoperative varus angle in all patients was 7.5° ± 1.9 (range 5–14°). In follow-up the patients had a mean valgus angle of 3.7° ± 2.5. Twenty-three patients (27.4%) had suffered a loss of correction (0.8°, range 0–2°). A loss of correction correlated with a minor result in tendency. A total of 25 patients (29.8%) had a poor KOOS. Factors associated with a poor HTO outcome were a patient history of more than 24 months, a preoperative KOOS > 50 points, obesity, and smoking. However, the results were also influenced by radiological findings, such as medial tibial exophyte, a medial joint space width of less than 5 mm, and intraarticular damage, such as a degree IV cartilage defect of the tibia. Gender was also a minor prognostic factor. Patient's age and the event of prior surgery did not influence the outcome.

Conclusion: This study identified relevant factors that significantly influenced HTO results. It was possible to create a "predictive score" for HTO patients. Patients with more than 4 of the poor prognostic factors should chose primary arthroplasty.

Key words: Osteotomy, Knee, Osteoarthritis, KOOS, Score.

Introduction

Gonarthritis associated with substantial pain and functional limitations is a common problem in middle-aged and older patients. More than 13% of Americans aged 55–64 years and 17% of Americans aged 65–74 years suffer from limitations related to gonarthritis[1,2]. High tibial osteotomy (HTO) has been established as a component in the treatment of various osteoarthritis patients younger than 55 years since Coventry[3]. Essentially, HTO relocates the weight-bearing line from the medial, the degenerated joint space, to the lateral knee compartment, the nonaffected joint space. Similar operative options are possible for the HTO, the classical lateral closed-wedge HTO with or without fibular osteotomy[3] or hemicallotasis[4]. In recent years the medial opening-wedge HTO with special implants for internal fixation has become very popular[5–7]. The advantages of this method are that it is a relatively simple operation; there is minimal damage to the tibial bone and no fibular osteotomy, which means no great danger to the peroneal nerve.

The medial HTO still has some pitfalls[8]. Numerous studies have evaluated the median- and long-term results following HTO. It is indisputable that HTO produces good and excellent results in the majority of patients who are suffering from a medial unicompartmental gonarthritis[9]. However, in 10–50% of the cases a poor result is the outcome[10–17]. Previous studies have shown that the success of HTO depends on the angle of correction, the operative technique, or the rate of complications[8,17]. However, very little is known about what individual factors, such as sex, age, and obesity, influence the outcome of HTO. Additionally, it is unclear if preoperative clinical findings, such as radiological changes or intraarticular arthroscopic findings, and arthroscopic surgery influence the results of HTO significantly. Therefore, clear prognostic factors for patient evaluation prior to HTO are required. The aim of this retrospective study was to identify significant factors that influence the outcome of HTO at midterm follow-up.

Methods

PATIENTS

A total of 94 patients (53 males, 41 females; age 48.5 ± 7.2 [range 31–67] years) suffering from degree II osteoarthritis of the medial knee compartment, according to Kellgren and Lawrence[19], who had undergone HTO were selected for this study. Patients' osteoarthritis history averaged 26.9 ± 17.9 [range 6–84] months. The right knee was involved in 55 patients and the left knee was involved in the remaining 39 patients. Patients were excluded

*Address correspondence and reprint requests to: Dr Gunter Spahn, Clinic of Traumatology and Orthopaedic Surgery, Eisenach, Sophienstraße 16, D-99817 Eisenach, Germany. Tel: 49-3691-73500; Fax: 49-3691-735011; E-mail: spahn@pk-eisenach.de, spahn.esa@t-online.de
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in cases of radiological osteoarthritis of the femoropatellar joint or the lateral knee compartment. Patients with chondral defects of the femoropatellar joint and the lateral compartment (degree III or IV according to the IRCS score[20]) were also excluded from the study.

Arthroscopy was always performed during the HTO. Arthroscopy always included medial meniscectomy and lavage. The chondral defects in 52 patients were debrided with a shaver. The remaining patients had microfracturing performed according to Steadman *et al.*[21]. An opening-wedge technique was performed using an internal fixation (Puddu-plate, Arhrex®, or c-plate Königsee-Implantate®). The osteotomy space was filled with autologous cancellous bone from the ipsilateral pelvic crest for corrections of 12 or more degrees. Bone grafts were used in eight cases. The angle of HTO (9.5° ± 2.3, range 5–15°) was determined prior to the operation by using standard standing radiographs as described by Dugdale *et al.*[18]. The osteotomy was aimed to provide a correction of the valgus with the weight-bearing line within a 75% intersection of the lateral tibia. Seven patients had received prior arthroscopy an average of 30.5 [range 10–84] months before HTO, and a partial medial meniscectomy and a chondral debridement were performed in each case.

CLINICAL AND RADIOLOGICAL EVALUATION

All patients were scored by the German version of the "knee injury and osteoarthritis outcome score" (KOOS) before the operation and at the time of follow-up[22]. This self-reported questionnaire includes 42 questions. The patient's judgment range is from 0 (very poor) to 4 (very good) points. The items are clustered into four categories, which include symptoms (five questions), stiffness (two questions), pain (nine questions), activity of daily life (17 questions), sports activity and recreation (five questions), and quality of life (four questions). The score has a maximum of 168 points. In other arthritis scores the judgment from excellent to poor is divided as follows: excellent (85–100%), good (70–84%), fair or moderate (60–69%) and poor (<60%). Accordingly, a KOOS of 114 or less was defined as a poor result[23].

Body weight and height were determined to calculate the body-mass-index (BMI = weight (kg)/height^2 (m^2)). The definition of obesity was adjusted for sex and age according to Cronk and Roche[24]. Smoking was defined as a daily consumption of three or more cigarettes[25]. Weight-bearing radiographs were taken for all patients before surgery to evaluate the varus angle and the angle of correction according to Dugdale *et al.*[18]. Control standing radiographs were taken 6 weeks postoperatively and at the time of follow-up. The patients stood with equal weight on both legs and with their knees semiflexed. The varus or valgus angle and the width of the medial joint space were then measured[26].

STATISTICS

The Kolmogorov–Smirnov test was used to assess the normality of distributions. Analysis of variance (ANOVA) along with the Newman–Keuls test was used for multiple comparisons. Odds ratios (OR) were calculated using multiple logistic regression adjusted for the possibility of a poor result prediction. OR are given with 5–95% confidence interval. The Pearson correlation coefficients were used to examine the relationships between the KOOS and prognostic factors. A *P*-value <0.05 was considered significant.

Results

FOLLOW-UP AND COMPLICATIONS

The follow-up of 84 patients (89.4%) was performed at 45.9 ± 7.6 (range 34–60) months. Three patients had undergone arthroplasty between the HTO and follow-up. The preoperative findings for these patients did not differ from the others. The rate of complications was 6.4% ($n = 6$). Three patients (3.2%) suffered from deep vein thrombosis within 4 weeks of the operation. The thrombosis required treatment with low molecular weight heparin and compressive therapy. These complications did not influence the final result. However, two patients suffered from a severe soft tissue and bone infection 2 and 4 months following the operation. The infection was associated with the implantation of synthetic bone substitutes. These two patients were excluded. One patient had a second operation due to an overcorrection at another clinic. This patient did not come in for a follow-up. Four patients were lost to follow-up because of long traveling distance or change of address. The preoperative findings of the drop out patients did not differ from the patients included in the study.

CLINICAL EVALUATION

The preoperative KOOS averaged 46.1 ± 11.1 points. The KOOS level was increased substantially overall at the time of follow-up (120.3 ± 40.8). Twenty-five patients (29.8%) had a poor result with a KOOS less than 114 points. Female patients had a tendency toward an inferior result (Table I); frequency of poor results in females was 36.1% and in males was 25.0%. There was no correlation between patient's age and the preoperative or

Table I
KOOS adjusted for possible prognostic factors of poor results

		Preoperative	Follow-up
Sex	Male	46.8 ± 12.6	124.5 ± 36.4
	Female	45.2 ± 10.3	114.7 ± 46.2
Age	≤50 years	47.6 ± 11.9	122.1 ± 34.6
	>50 years	44.0 ± 11.1	117.7 ± 48.7
Prior surgery	No	46.3 ± 11.7	118.6 ± 42.0
	Yes	43.0 ± 10.3	138.6 ± 18.1
History*	≤24 month	49.2 ± 10.6	141.2 ± 14.7
	>24 month	40.7 ± 11.5	84.6 ± 46.5
Preoperative KOOS**	≤50 points	58.8 ± 4.3	138.5 ± 15.9
	>50 points	37.8 ± 6.0	108.5 ± 47.4
Obesity*	No	47.2 ± 12.2	127.5 ± 32.7
	Yes	44.0 ± 10.2	106.0 ± 51.3
Smoking*	No	46.8 ± 11.9	128.8 ± 37.2
	Yes	44.3 ± 10.9	97.8 ± 42.5
Width of the medial joint space**	≤5 mm	51.0 ± 10.6	130.7 ± 33.0
	>5 mm	35.8 ± 4.7	98.3 ± 47.4
Medial tibial exophyte**	No	48.3 ± 11.4	133.2 ± 30.5
	Yes	40.2 ± 10.4	86.0 ± 45.6
Complete (degree IV) tibial chondral defect*	No	46.8 ± 11.5	125.4 ± 37.4
	Yes	43.3 ± 12.0	98.7 ± 48.8
Microfracturing*	Yes	44.6 ± 12.2	132.5 ± 25.6
	No	47.3 ± 11.0	110.2 ± 48.1
	Yes	43.3 ± 12.0	98.7 ± 48.8

*$P < 0.05$ for postoperative KOOS.
**$P < 0.05$ for preoperative and postoperative KOOS.

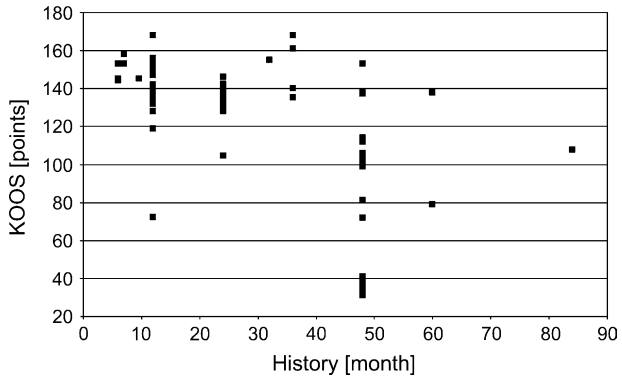

Fig. 1. Correlation between history length and follow-up KOOS. The history length correlated significantly with the preoperative KOOS ($R = 0.28$, $P < 0.011$) and the follow-up KOOS ($R = 0.724$, $P < 0.00$).

postoperative KOOS. The results for patients 50 years or more in age did not differ from younger patients (Table I). A prior surgery event did not influence the outcome (Table I). However, the history length correlated significantly with the preoperative KOOS ($R = 0.28$, $P < 0.011$) and the follow-up KOOS ($R = 0.724$, $P < 0.00$) as shown in Fig. 1. Patients with a history of osteoarthritis greater than 24 months exhibited a decrease in their postoperative KOOS (Table I). Patients with a poor result had a significantly longer history (51.8 $\pm$ 9.6 months) than patients with an acceptable result (16.4 $\pm$ 11.4 months).

As shown in Fig. 2, there was also a significant correlation between poor preoperative KOOS and the KOOS at the time of follow-up ($R = 0.469$, $P < 0.00$). Patients with a poor result had a significantly lower preoperative KOOS than the other patients (Table I). The mean BMI was 27.1 $\pm$ 3.6 kg/m^2. A total of 32.9% ($n = 28$) of the patients were obese according to the classification of Cronk and Roche[24]. Obese patients had a significantly inferior result compared to patients of normal weight. However, no differences were found in the preoperative KOOS between obese and nonobese patients (Table I). All patients were questioned about smoking habits. According to the definition of the WHO, 27.1% of the patients (29.2% males and 25.0% females) were daily smokers. Nonsmokers had a significantly superior KOOS (Table I). Patients with a complete

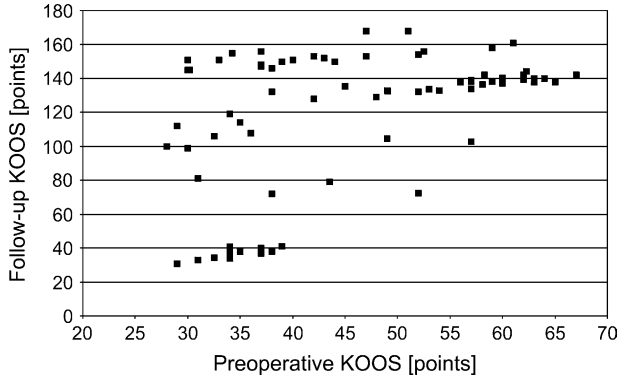

Fig. 2. Correlation between preoperative and follow-up KOOS. There was a significant correlation between poor preoperative KOOS and the KOOS at the time of follow-up ($R = 0.469$, $P < 0.00$).

(degree IV) cartilage defect of the tibia also had a significantly inferior result (Table I). Patients who had undergone microfracturing instead of simple chondral debridement had a superior result (Table I).

The factors associated with a poor result after HTO were individual patient characteristics of a history greater than 24 months, a preoperative KOOS of less than 50 points, obesity, and smoking. The HTO results significantly correlated with the grade of intraarticular lesions. Patients with chondral defects of the femoropatellar joint and the lateral compartment (degree III or IV according to the ICRS (International Cartilage Repair Society) score[20]) were also excluded from the study.

RADIOLOGICAL EVALUATION

The degree of osteoarthritis was determined from the varus and valgus angles, the angle of correction for HTO, and the width of the medial joint space from standing radiographs. All patients were suffering from degree II osteoarthritis[19]. The subchondral bone of the femoral and tibial joint surface had substantial sclerosis and irregularities, a reduced joint space diameter, and partial initial tibial osteophytes. An initial tibial osteophyte (Fig. 3) was found in 23 patients (24.5%). Patients with an osteophyte had a significantly minor result after HTO (Table I). The preoperative varus angle in all patients was 7.5° $\pm$ 1.9 (range 5–14°). A mean valgus angle of 3.9° $\pm$ 1.7 (range 3–10°) was found in control standing radiographs 6 weeks after HTO. A standing radiograph was taken during the follow-up for 84 patients. The valgus angle did not differ from the

Fig. 3. Standing radiograph (detail) from a 41-year-old woman with degree II osteoarthritis. The arrow indicates the initial tibial osteophyte. These exophytes were significantly associated with minor results.

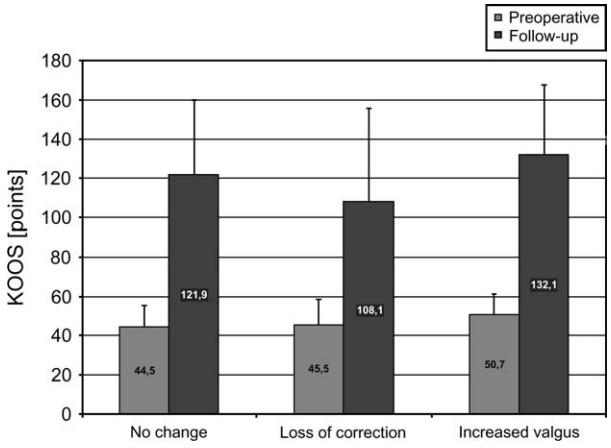

Fig. 4. Correlation of KOOS with overcorrection and loss of correction.

postoperative control in 43 patients (51.2%). Twenty-three patients (27.4%) had suffered a loss of correction. The varus angle in these patients was 0.8° ± 0.8 (range 0–2°). The remaining 18 patients exhibited (21.4%) an increase in the valgus angle, 5.7° ± 2.1 (range 4–10°). Patients who exhibited a loss of correction had an inferior outcome, while patients with a progressive valgus had a superior outcome (Fig. 4).

Patients with a superior result had a significantly higher preoperative medial joint space (5.4 ± 1.2 mm) compared to patients with a poor result (4.3 ± 0.9 mm). The correlation between the joint space width and KOOS is shown in Fig. 4. Patients with a medial joint space less than 5 mm had a significantly lower preoperative and follow-up KOOS (Table I). Patients who demonstrated an initial tibial exophyte (Fig. 5) had a significantly inferior preoperative and postoperative KOOS.

SCORE AS A PREDICTOR OF OUTCOME

The results of the multiple logistic regression adjusted for predicting factors of poor results are shown in Table II. A history length greater than 2 years, a preoperative KOOS

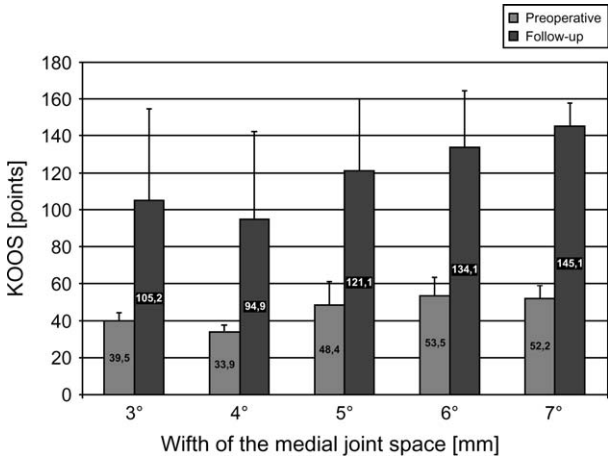

Fig. 5. Correlation of KOOS with the width of the medial joint space. Patients with a medial joint space less than 5 mm had a significantly lower preoperative and follow-up KOOS.

Table II
Factors associated with a poor outcome after HTO

	OR	Confidence interval (5–95%)
History > 24 months	73.3	14.4–37.2
Preoperative KOOS > 50 points	12.7	2.7–58.9
Obesity	3.2	1.2–8.5
Smoking	5.3	1.8–14.9
Medial tibial exophyte	18.7	5.7–61.7
Width of the medial joint space less 5 mm	5.8	2.1–16.3
Degree IV cartilage defect of the tibia	3.0	1.9–9.2

less than 50 points, obesity, and smoking were found to be predictive of poor post-HTO results. The radiological pathologies of medial tibia exophytes, a joint space width less 5 mm, and tibial defects of degree IV were also significant factors for predicting a poor outcome after HTO. The female gender and the inability to microfracture also tended to be associated with poor results. These results were the basis for creating the "predictive score" as shown in Table III and Fig. 6. Significant factors were given 2 points and factors that tended to be associated with poor results after HTO were given 1 point. A predictive HTO score of more than 9 points was a significant predictor of poor results.

Discussion

Complaints concerning intensity of pain, quality of life, effects on the patient's physical activity, and results after operative treatment of patient's suffering from gonarthritis depend on multiple factors. The severity of the disease correlates with the degree of joint damage, which often correlates with high radiological degrees of osteoarthritis or arthroscopic stages of joint damage[27]. However, "nonarticular factors" can also exacerbate osteoarthritic complaints. Possible cofactors for the extent of arthritis complaints can be gender, race, level of physical activity in a person's profession, recreation or sports, patient's individual pain perception, consumption of legalized drugs, such as cigarettes or alcoholic beverages, and obesity[27–29].

HTO for the treatment of unicompartmental knee osteoarthritis in the presence of axial malalignment is an effective measure in young and active patients with acceptable middle- or long-term results. However, there are reports, which range from 10 to 50% of patients, regarding poor outcomes[10–17]. A poor outcome after HTO can be a result of various factors. The operative technique influences the rehabilitation time and the complication rate. The prevention

Table III
Score for predicting a poor result after HTO

Factor	Points
Female sex	1
History > 24 months	2
Preoperative KOOS > 50 points	2
Obesity	2
Smoking	2
Medial tibial exophyte	2
Width of the medial joint space less 5 mm	2
Degree IV cartilage defect of the tibia	2
Impossibility of microfracturing due to severe sclerosis	1

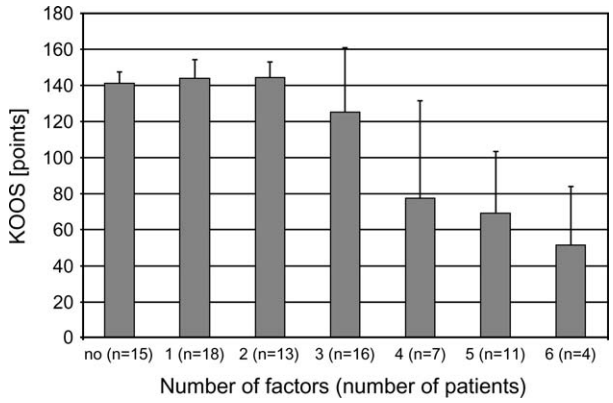

Fig. 6. Predictive HTO Score. The scoring was performed according to the schema given in Table III. A score greater than 8 points was a significant predictor of a poor result. This would indicate primary arthroplasty for these patients.

of complications is surely an indicator of a good result after HTO[8].

Additionally, correction to a relevant valgus angle is required for a good long-term result[9]. However, the general progression of the gonarthritis may or may not be expected to affect the long-term results after HTO.

A total of 23 patients suffered from a loss of correction (0.8°, range 0–2°). However, patients with a loss of correction had a minor result compared to patients without loss. In general, patients who had a mild valgus progression had the best outcome.

Factors for predicting the loss of correction could be evaluated. A significant valgus overcorrection depends on an exact preoperative planning[3,12,18] as well as on a stable internal fixation after the osteotomy[8].

Our results suggest that poor selection of patients is likely the predominant reason for a poor result after HTO. Schuller *et al.*[30] found that 27 out of 30 patients suffering from a rheumatoid arthritis exhibited a poor result after HTO. HTO for rheumatoid arthritis patients is no longer performed.

In our study we found no significant difference with respect to gender or patient's age in the frequency of poor results after HTO. It is generally accepted that patients older than 55 years should be treated by arthroplasty. However, we did not observe a general contraindication for HTO in older active patients.

We did find a direct correlation between a long-term history (more than 2 years) and a poor result after HTO. This result was not easily explainable. However, it might be expected that chronic pain and functional limitations would produce muscular atrophy, loss of proprioception, and decreased physical activity[31]. Muscular dysfunction in gonarthritis includes impaired proprioception, especially in the more extended knee joint positions, impaired ability to accurately and steadily control submaximal force, and impaired eccentric strength.

Overweight, especially obese, individuals have a higher risk of gonarthritis. Patients with a BMI greater than 30 kg/m^2 have over a fourfold higher prevalence of gonarthritis than normal weight persons[32]. Excess weight produces a chronic overload in the joint that is followed by progressive degeneration, and continued overloading of a degenerated joint can exacerbate osteoarthritic complaints. Excess weight overloads chondral surfaces, increases plantar pressure, and overloads the muscular system leading to gait disorders. All these factors are found in gonarthritis patients[33]. Our results indicated that being overweight was a significant factor for predicting a poor outcome after HTO.

Smoking was another extraarticular factor that influenced the complaints of patients suffering from gonarthritis. It is well known that smokers more frequently suffer from gonarthritis. It has been shown that smoking can promote locomotor discomforts[34]. However, there is no clear biologic explanation for the relationship between gonarthritis and smoking. Theories have suggested that smoking may affect the cartilage directly or it may indirectly act by making the subchondral bone more deformable by impact loads[28]. Dahl and Toksvig-Larsen[35] reported a higher complication rate and a higher rate of delayed union after HTO (hemicallotasis) in smokers. In our patients, smokers did not have a higher percentage of complications. However, a delayed union after HTO in smokers must be regarded as another factor leading to persistent complaints after HTO.

The correlation between tibial osteophytes with signs of cartilage damage and clinical signs has been demonstrated[36]. The presence of exophytes often is a better indicator of the severity of gonarthritis than joint space narrowing. Our results suggest that these radiological signs (tibial exophytes and medial joint space width less than 5 mm) or severe chondral damage of the medial tibial surface predict a poor result after HTO.

It is reasonable to expect that additional arthroscopic surgery could influence the outcome of HTO. All patients in our study had undergone simultaneous arthroscopy, which is recommendable. Arthroscopy makes it possible to evaluate the chondral surfaces, especially the quality of the tibial area. Meniscal tears often are involved in the degenerative process and require meniscectomy[37]. However, microfracturing or chondroplasty should be performed. Microfracturing is an established method for treatment of deep chondral defects[21]. The concept of a microfracture is to stimulate the underlying bone marrow and rely on normal vascular responses to injury to heal the chondral defect. Microfracturing produces superior results over simple debridement[38]. We aimed to include only those patients in our study who had microfracturing of the deep chondral defects. However, microfracturing is only possible for near normal subchondral bone. Severe sclerosis makes this method infeasible.

This study aimed to provide information regarding clear indicators for post-HTO results. It would be useful to know the factors that predict a poor result after HTO. These investigations are necessary because HTO is an expensive operation with potential risks and failure can decrease the potential for successful arthroplasty results[8,39]. This is the first report that explicitly evaluates the prognostic factors for the results after HTO. Age or prior surgery did not influence the result after HTO. Women tended to have a slightly higher rate for poor results. The correction of a significant valgus alignment was absolutely required. However, there were several evaluated factors that significantly correlate with a poor result after HTO. These factors were a history of more than 24 months, a very poor clinical status (KOOS $<$ 50 points) before operation, obesity, and smoking. A tibial exophyte, a reduction of the medial joint space less than 5 mm, and arthroscopic findings, such as deep chondral defects of the tibia and the inability to perform a microfracture, were also factors that predicted a poor outcome. It was possible to create a score for the prediction of the outcome after HTO from our results. This score may be a useful instructional guide for patient selection in future.

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