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ORTHOPAEDIC OUTCOME ASSESSMENT

# Long-term outcome after high tibial osteotomy

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**Abstract**
*Introduction* The frequency of tibial osteotomy in the treatment of osteoarthritis of the knee has decreased due to the demanding surgical procedure and the rising number of total knee replacements (TKR). Only few data exist concerning survival rates after high tibial osteotomy (HTO) with a follow-up exceeding 10 years. We want to present long-term results with a follow-up of more than 18 years after operation.
*Materials and Methods* Survival rates and the influence of age, gender and the mechanical axis were investigated in 134 lateral closing-wedge osteotomies in 111 patients.
*Results* The survival rate was 94% after 5 years, 79.9% after10 years, 65.5% after 15 years, and 54.1% after 18 years. Age had a significant influence on the survival and gender and the mechanical axis had no significant influence.
*Conclusion* We conclude, that with a 54.1% survival after 18 years HTO is a useful facility to protract the implantation of a total knee prosthesis.

**Keywords** High tibial osteotomy · Survival · Long term

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## Introduction

High tibial osteotomy (HTO) is one of the surgical options for the treatment of the medial unicompartimental osteoarthritis of the knee or varus malalignment of the knee [6–9, 14].

The frequency of tibial osteotomy in the treatment of osteoarthritis of the knee has decreased due to the demanding surgical procedure and the rising number of TKR [23]. However, TKR in young patients has limitations due to possible wear, loosening and revision procedures. Additionally young and active patients may benefit from the increased range of motion provided by HTO compared to TKA [18]. HTO is recommended for active male patients under 60 years with an active, sportive life style suffering from early medial gonarthrosis [12, 14]. The recommended degree of femorotibial alignment after osteotomy ranges from 5° to 14° of valgus [6, 14]. Several risk factors for early deterioration have been discussed, including age, body mass index, insufficient valgus correction and the presence of a lateral tibial thrust [15–17, 20].

The purpose of this retrospective study was to assess the survival rates after HTO including influencing factors, like age, gender and the mechanical axis. Furthermore complications associated with the procedure were recorded.

## Materials and methods

### Patients

A total of 134 high tibial osteotomies , which were performed between 1981 and 1997 (74 right knees and 60 left knees), in 111 patients were assessed retrospectively. The group of patients comprised 53 women and 58 men, 23 patients were operated bilaterally. Patients operated due to

primary arthrosis and secondary gonarthrosis were 76.1 and 23.9%.

The average age at surgery was 54.46 years (range 19–74 years, median 56 years). A previous medial meniscectomy had been performed in 18 patients, an arthroscopy in 22.

Mean follow-up time was 12.4 years (1–25 years). Ten patients were lost to follow-up because they could not be reached.

## Methods

### Operative procedures

In all knees, a lateral closing-wedge osteotomy was done through a lateral approach, as descibed by Coventry [7, 8]. The osteotomy passes through the tibia proximal to the tibial tubercle. The size of the wedge to be removed can be accurately measured by transposing the measurements of the preoperative weight bearing radiographs and by accurately measuring the base of the wedge. Union can be expected within 5–6 weeks [8]. Fixation was done with a staple. Postoperatively patients had to wear a knee brace and to use two crutches for 6 weeks.

### Clinical assessment

Patients were invited for follow-up controls 6 weeks, 6 months and 12 months postoperatively. Examination included the evaluation of pain, using a visual analogue scale ranging from 0 to 10 points, measurement of the range of flexion using a goniometer and stability testing of the cruciate and collateral ligaments. Instability ranged from slight (+, 0–5 mm), to moderate (++, 5–10 mm) and severe (+++, >10 mm). X-rays (weightbearing anteroposterior, lateral and full leg alignment films) were taken and the mechanical axis was measured before and 1 year after HTO, a straight line was drawn in the line of the femoral shaft from center of hip to intersect a corresponding line drawn through the tibial shaft to the center of the ankle [2, 3]. To investigate a possible correlation between the mechanical axis and survival rate, three groups of axis were established: 1°–5°, 6°–10° and 11°–15° of varus preoperatively, and 0°–5°of varus, 1°–5°of valgus and 5°–10°of valgus postoperatively.

### Statistical analyses

Patient characteristics were summarized with frequencies and percentages or with mean, SDs, minimum and maximum values. The time between HTO and TKR was defined as "survival". Survival rates were calculated using the Kaplan–Meier method. Comparisons of survival rates of men and women, age groups or mechanical axis at 1 year postoperatively were achieved by either the Log-Rank test or the generalized Wilcoxon test. Additionally Cox proportional hazard models were used to compute hazard ratios and 95% CIs for certain characteristics. Spearmans correlation coefficient was calculated to test for significance between femorotibial angle and pain before and 1 year after surgery. The *P*- values are two-sided and a type-1 error level of 5% was used.

Calculations were performed using SPSS (version 11.5) software and S-PLUS (version 6.1).

## Results

Preoperatively, all patients had moderate to severe pain (VAS 7.9, range 0–10). A slight (+) mediolateral instability of the knee joint was shown by 27.6%. Range of flexion was 118°on average (range 80°–150°). The preoperative femorotibial angle was 6°–10° varus in 56.9% of the patients, 11°–15° varus in 21.5% and 1°–5° in 17.8%. One year after surgery the femorotibial angle was 1°–5° of valgus in 59.7%, and 0°–5° of varus and, respectively, 5°–10° of valgus in 20.1% of the patients.

One year after surgery, the average VAS decreased to 2.9 points (range 0–9.7).

Operated knees that had to be converted to TKA were 53 (39.6%) (Table 1). The 5-year survival rate was 94%, the 10-year survival rate 79.9%, the 15-year survival rate 65.5%, and after 18 years the overall survival was 54.1% (Fig. 1).

The patients` age at operation influenced the survival time significantly ($P = 0.004$). The older the patient was at HTO, the shorter was the survival time, regarding both individual cases and three age groups (<50 years, 50–65 years, >65 years). A Hazard ratio of 1.050 (95% CI 1.016–1.086) indicates that the probability of conversion to TKA increases approximately 5% every year with the patient`s age at HTO. Comparing the survival between

**Table 1** Frequency of conversion to TKA

| | Frequency | Frequency (%) |
|---|---|---|
| Years after HTO | | |
| 1–5 years | 7 | 5.2 |
| 6–10 years | 19 | 14.2 |
| 11–15 years | 20 | 14.9 |
| 16–18 years | 7 | 5.2 |
| Total TKA | 53 | 39.6 |
| No TKA | 81 | 60.4 |
| Total | 134 | 100.0 |

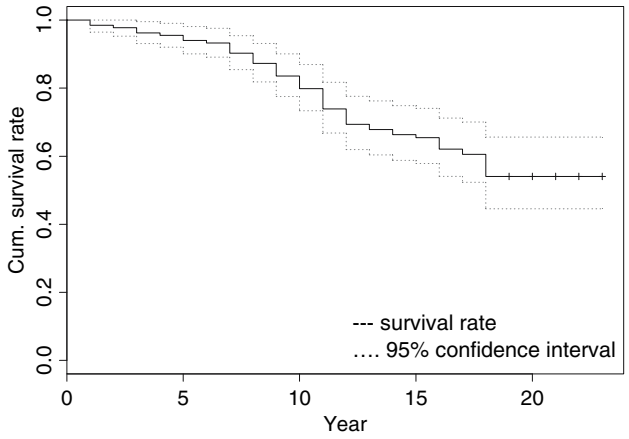


**Fig. 1** Survivorship analysis of all study patients using the Kaplan–Meier method. The revision to total knee replacement was used as the endpoint. The 5-year survival rate was 94%, the 10-year survival rate 79.9%, the 15-year survival rate 65.5%, and after 18 years the overall survival was 54.1%

patients younger than 50 years and patients older than 65 years, there is a significant difference between the groups ($P = 0.013$). The comparison between survival rates of men and women revealed no significant difference ($P = 0.1216$). But the Hazard ratio of 1.485 (95% CI 0.865–2.549) seems to reveal a trend of an earlier need for TKA in women (Fig. 2). The mechanical axis before operation and 1 year postoperatively had no influence on the survival rates ($P = 0.864$ and $P = 0.614$). Regarding the preoperative axis, the average survival time was 17 years (95% CI 14–20 years) in the group 1°–5° of varus ($n = 27$), 18 years (95% CI 16–20 years) in the group 6°–10° of varus ($n = 55$) and 17 years (95% CI 15–19 years) in the group 11°–16° of varus ($n = 52$).

Regarding the axis 1 year postoperatively, the average survival time was 17 years (95% CI 14–19 years) in the group

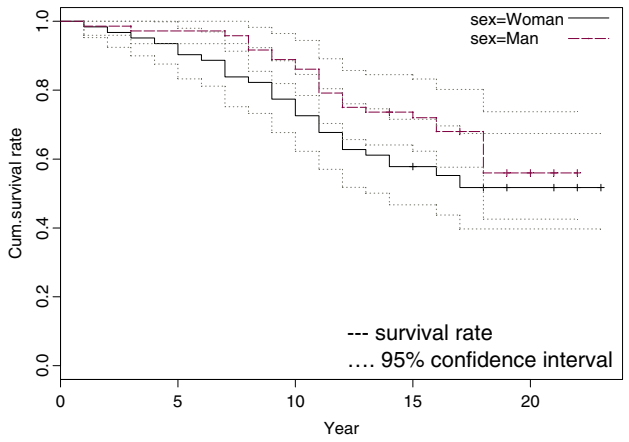


**Fig. 2** Survivorship analysis comparing the genders using the Kaplan–Meier method. Comparison between survival rates of men and women revealed no significant difference ($P = 0.1216$)

0°–5° of varus ($n = 27$), 18 years (95% CI 16–19 years) in the group 1°–5° of valgus ($n = 80$) and 18 years (95% CI 15–21 years) in the group 5°–10° of valgus ($n = 27$).

The correlation between the mechanical axis and pain was not significant before ($P = 0.651$) and after HTO ($P = 0.810$).

Thirty-eight cases of peri- and postoperative complications were observed.

There were ten cases of thrombosis, seven cases of peroneal palsy, and two cases of superficial wound infection. Four patients revealed a delayed reunion of the osteotomized tibia and 15 patients of the fibula.

## Discussion

During the last three decades, an international trend is reported in the literature showing that the number TKR has increased while the frequency of high tibial osteotomy has considerably decreased [22]. As recent studies emphasize the importance of HTO in combination with new chondral resurfacing techniques [22] and the maintenance of an active life style [20, 22], we assessed the long-term results after HTO and different factors influencing the survival rate, to evaluate the possible reestablishment of this former widespread surgical procedure. Indications and contraindications have been discussed extensively in the literature [22]. HTO is recommended for isolated medial compartment gonarthrosis in varus alignment, in the absence of lateral meniscus loss, symptomatic patellofemoral joint disease, and inflammatory arthritis [22]. Different techniques have been described to correct valgus malalignment: lateral closing wedge osteotomy, medial opening wedge osteotomy and dome osteotomy [22]. We performed lateral closing wedge osteotomy in all cases, which implies among others the risk of peroneal palsy, which we saw in seven cases. In contrast to the opening wedge osteotomy there is no need for auto- or allograft bone, and it permits earlier weight bearing.

The low follow-up rate in the current study is comparable to other studies. However, due to long postoperative course some patients moved to other countries and could not be traced. Lower follow-up rates are frequently reported in studies with long follow-up periods [12, 16].

The overall survival rates in the current study were equal or higher compared to the literature [5, 10, 18, 19] (Tables 1, 2). There was an approximately 5% higher survival rate after 5 and 10 years compared to previous studies [19]. Even 18 years after surgery, more than 50% of the knee joints were not converted to TKR. After 15 years, 74 patients were investigated for follow-up, after 18 years 25 patients. All other patients had undergone total knee replacement or were lost for follow-up.

**Table 2** Comparison of survival rates

| Study | 5-year survival (%) | 10-year survival (%) | 15-year survival (%) | 18-year survival (%) | 20-year survival (%) |
|---|---|---|---|---|---|
| Coventry et al. [10] | 87 | 66 | – | – | – |
| Naudie et al. [16] | – | 51 | – | – | 30 |
| Billings et al. [5] | 85 | 53 | – | – | – |
| Sprenger et al. [18] | 86 | 74 | 56 | – | – |
| Tang et al. [19] | 89.5 | 74.7 | 66.9 | – | – |
| Current study | 94 | 79.9 | 65.5 | 54.1 | – |

Trieb [20] found that age influences the survival rate significantly in a former study: the 10-year survival rate was 90% in patients younger than 65 years at surgery and only 70% in older patients. The current study supports the finding that age influences the survival rate. The hazard of failure increased by 5% per year of age, confirming the fact that higher age at surgery is a risk factor of failure in HTO. Nevertheless, as costs for the health care system caused by total joint arthroplasty have been raised extensively over the last years, indications should be considered thoroughly. HTO could be a cost effective alternative in even some older patients, to whom inclusion criteria apply [11].

We did not find a statistically significant difference between both the genders, with a survival rate of over 70% at 10 years in females also. Sprenger et al showed that a survial for more than 10 years can be expected, if the obtained femoro-tibial angle ranges from 8° to 16° of valgus [10]. Aglietti et al stated, that best results would be achieved at a consolidation between 8° and 14° of valgus, whereas he reported on short survival times in knees with "insufficient" correction (<7°valgus) and "excessive" correction (>15° valgus) [1]. Most of the follow-up studies describe similar results [6, 10, 14, 15, 17, 18]. Some authors recommended valgus correction of ≥8° [1, 6–8, 10, 13]. In our series, the mechanical axis showed an average valgus angle of 3.4° (0°–11°), 1 year postoperatively. This means only a slight overcorrection of the axis compared to the common recommendations in the literature [1, 6, 10, 13, 21].

The achievement of a larger valgus angle tended to result in a better outcome, but we found no statistically significant difference concerning long-term outcome between the three groups of mechanical axis. Therefore HTO resulting in only a slight valgus angle appeared to be an effective treatment. This is particularly important in patients, who refuse HTO leading to an excessive valgus angle for cosmetical reasons. Further prospective studies should be undertaken to evaluate the outcome of HTO leading to valgus angles between 3° and 5°, to confirm these results. The rate of complications has been reported to be as high as 40–80% in some studies [5, 15]. In the current study, in 28.4% of 111 patients complications occurred, which is low compared to the complication rate reported in TKR [4].

We conclude that HTO is still a useful facility to treat medial osteoarthritis and to protract the implantation of a TKR at an acceptable rate of complications when compared to TKA. There is a good chance of positive and long-lasting results with HTO, even more than 18 years after surgery. The impact of only slight valgus correction should be evaluated in prospective studies.

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