

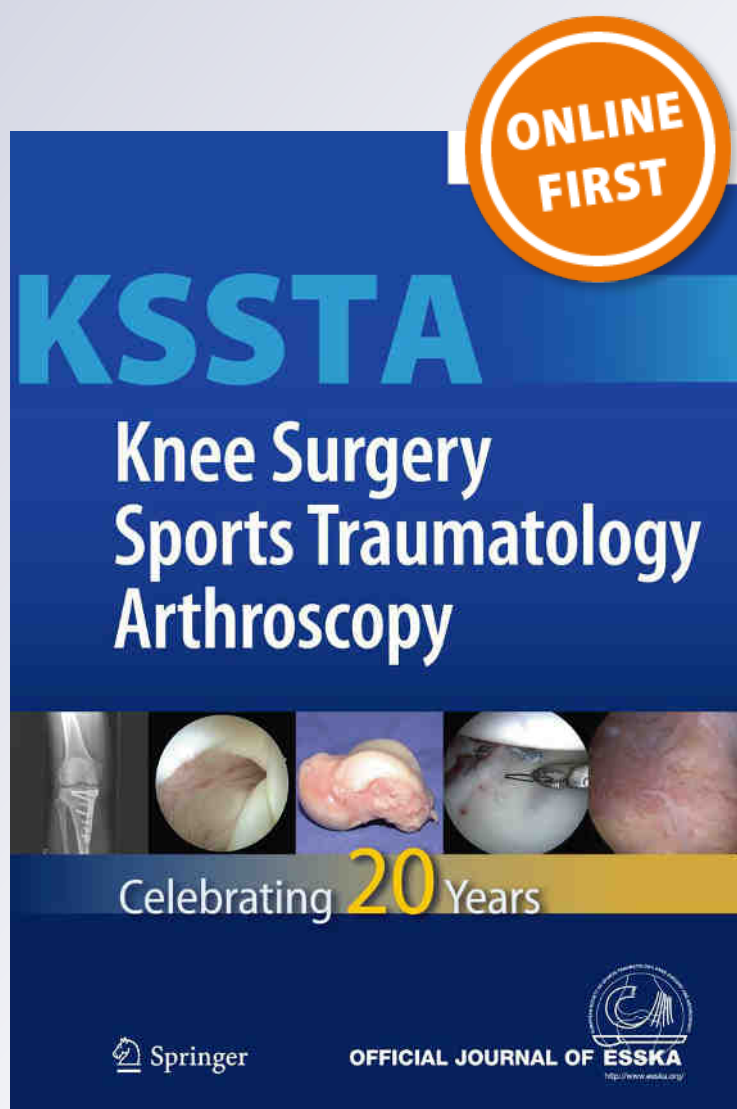
# *Return to work and clinical outcome after open wedge HTO*

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## Return to work and clinical outcome after open wedge HTO

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### Abstract

**Purpose** The purpose of this study was to examine the incapacity of work related to work load according to the classification that has been introduced by the REFA Association and the clinical outcome after open wedge HTO with autologous bone graft from the iliac crest.

**Methods** A total of 32 patients who were employed and able to work at the time of the surgery as well as treated with an open wedge HTO with the LC-DCP and autologous bone wedges from the iliac crest could be included in the radiological and clinical examination (77 months, SD  $\pm$  19). Postoperative duration of the incapacity of work and subjective ratings were based on the information provided by the patients themselves. The German classification that has been established by the REFA Association was used to classify the work load. Several clinical scores were used for clinical assessment.

**Results** The duration of incapacity of work (median, 87 days; range, 14–450) demonstrated a relation to work load according to REFA. The Lysholm score, the HSS score and the score according to Lequesne augmented by  $19.2 \pm 16.8$  ( $p < 0.0001$ ),  $15.6 \pm 13.2$  ( $p < 0.0001$ ) and  $-6.0 \pm 5.1$  ( $p < 0.0001$ ), respectively. The Tegner score gained from median 3 (range, 1–5) to 4 (range, 1–8).

**Conclusion** In this study, a relation was found between work load divided into different categories according to the classification established by the REFA Association and the duration of incapacity of work after open wedge HTO. An improvement of all clinical scores was observed. Typical neurological complications after autologous bone transplantation from the iliac crest were observed in 19 % of our patient population.

**Level of evidence** IV.

**Keywords** Open wedge HTO · Autologous bone graft · REFA classification · Work load · Complication · Incapacity of work

### Introduction

High tibial osteotomy (HTO) is a well-established and commonly used treatment for younger and active older patients with medial compartment osteoarthritis of the knee and varus malalignment. Most of these patients were employed at the time of surgery and had a period of incapacity of work because of the HTO. The aim of the HTO is to shift the load to the lateral compartment in order to reduce pain and delay the application of a total knee replacement (TKR). The open wedge HTO technique via medial approach was first described by Hernigou et al. [11] in 1987. Midterm outcomes after open wedge HTO with autologous bone graft to stabilise the osteotomy gap have only been rarely reported so far [11].

In contrast to clinical outcome studies, up to now, only one report of work incapacity after open wedge HTO has been found [12]. To the knowledge of the authors, just one German classification of work load is available—the classification established by the REFA Association. The REFA

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**Table 1** Classification according to the REFA Association

Grade	Work intensity	Example
0	Work without special physical strain	Work without load like, for example, desk work
1	Work with small physical strain	Handling light work pieces; also lengthy standing or walking around
2	Work with moderate physical strain	Handling of 1–3 kg control device; carrying loads of 10–15 kg; climbing stairs or ladders without load
3	Work with hard physical strain	Carrying loads of 20–30 kg, shovelling, digging, chipping, climbing stairs or ladders with moderate load, moderate work in tense work posture
4	Work with most heavily physical strain	Carrying loads of more than 50 kg, climbing with heavy load, hard work in tense work posture

Association is considered to be Germany's leading organisation in work design, industrial organisation and company development. The REFA classification of work load is simple and easy to use.

The purpose of this study is to examine the relation between the incapacity of work related to work load according to the classification established by the REFA Association and the clinical outcome after open wedge HTO with autologous bone graft from the iliac crest. The hypothesis was that the incapacity of work after open wedge HTO with autologous bone graft is related to work load.

## Materials and methods

The present study was performed with the approval of the local ethics committee. Inclusion criteria were (1) employment and ability to work at the time of surgery, (2) symptomatic medial osteoarthritis or cartilage lesion, (3) varus malalignment and (4) the application of the Limited Contact Dynamic Compression Plate 4.5 (LC-DCP) (Synthes, Umkirch, Switzerland) as well as an autologous bone graft from the iliac crest. A cartilage lesion of maximum ICRS I (International Cartilage Repair Society) in the lateral joint compartment was accepted. The size of the osteotomy gap was not limited in this population. Exclusion criteria were (1) clinically relevant disorders of the bone metabolism (i.e. osteoporosis), (2) active infection, (3) a range of motion of 100° or less of flexion and more than 20° of contraction, (4) total knee arthroplasty in the follow-up, (5) no consent to the radiological and clinical examination and (6) retirement or unemployment of the patients before the surgery.

Out of a consecutive series of HTOs performed at our institution between July 2001 and August 2009, 32 patients could be selected that met the inclusion criteria. The mean time between the surgery and the follow-up of the study group was 77 months (SD ± 19). The clinical examination was recorded at the time of the follow-up. Postoperative

incapacity of work and ratings were based on the information provided by the patients. The in-patient duration, that is, the hospital stay, was obtained from the patient charts. The Hospital for Special Surgery (HSS) score [13, 23], the Lysholm score [29], the score according to Lequesne and Tegner score [29] were used for clinical assessment. The HSS score (62 % subjective, 38 % objective) includes 6 subscales with 7 items. The maximum number of points amounts to 100. The Lysholm score (95 % subjective, 5 % objective) was assessed by the patients as a self-administered questionnaire. It consists of eight items, among which pain and instability account for 30 points out of the total score of 100 points. The score according to Lequesne consists of 6 items. In all four scores, an inferior result indicates a good clinical situation of the patient. The Tegner score consists of following items: recreation, competitive sports and work. All scores were assessed by one examiner. The German classification system according to the REFA Association from occupational medicine and social medicine (Table 1) was used to classify the work load. Complications were subdivided into osteotomy-related, that is, infection and implant failure, and bone graft-related, that is, hyperaesthesia, dysesthesia and infection at the iliac crest.

Preoperative and postoperative radiographs included full-weight-bearing long-standing anteroposterior radiographs of the whole lower extremity as well as anteroposterior and lateral view of the knee. The preoperative planning was done graphically according to a modified technique invented by Dugdale et al. [9]. The radiographic examination included the mechanical tibiofemoral angle (mTFA, varus deviation was indicated by negative and valgus deviation by positive values). 0°–2° mTFA in cases of isolated cartilage defects and 2°–4° overcorrection in cases of osteoarthritis were aimed to achieve. The X-ray prints were either scaled with a reference line or ball scanned (DiagnosticPro Advantage VIDAR, Herndon, USA) and measured with the mediCAD version 2.2 planning software (Hectec GmbH, Niederviehbach, Germany).

## Surgical technique

The surgeries were performed under spinal or general anaesthesia. Single-shot antibiotics and prophylactic low-dose heparin were administered. Open wedge HTO was performed with uniplanar intraligamentary osteotomy and autologous bone wedges from the ipsilateral iliac crest. Extending from the medial aspect, two K-wires were positioned under fluoroscopic control parallel to the tibial slope above the pes anserinus with the tibiofibular joint as the aiming point. The osteotomy was performed with chisels leaving a 1-cm bone bridge within the lateral corticalis. The osteotomy was opened slowly up to the measured gap size according to the preoperative planning. After the bone wedge harvesting, bone wax and Spongostan (Ethicon, Germany) were inserted to the bone surfaces and remaining bone gap to prevent bleeding and haematoma. After that, the bone wedge was inserted in the opened tibial gap. For the osteotomy fixation, an LC-DCP was placed anteromedially under the pes anserinus and the periost. Two or three spongiosa screws for the proximal fixation and a combination of three cortical screws for the distal part were used. The tissue layers were closed at the iliac crest and the tibia, and a drain was placed at both locations. 20 kg partial weight bearing at the affected leg was allowed postoperatively for 6 weeks. No brace or cast was used. Active physiotherapy started after the removal of the drains. After radiological examination, the patients started with full weight bearing 6–8 weeks postoperatively.

## Statistical analysis

JMP 8.0.1 (SAS Institute Inc.) was used for the statistical analysis. The results of the HSS score, the score according to Lequesne and the Lysholm were compared (preoperative vs. postoperative) with the paired Student's *t* test. Radiographic analysis was compared with the paired Student's *t* test, as well. Results of the REFA classification (0–4) and the incapacity of work were compared through multivariate analysis (ANOVA). The results of clinical scores were also evaluated by compared multivariate analyses (ANOVA). The level of significance was defined  $\alpha = 0.05$ .

## Results

The study group comprised of 32 patients. There were 22 men and 10 women with a mean age of 47 years ( $SD \pm 9$ ). The mean BMI was  $28.6 \text{ kg/m}^2$  ( $SD \pm 4.7$ ) and 78 % of the patients had already been operated at the affected knee: In 59 % of the patients, an arthroscopy with partial

meniscal resection, in 6 % of the cases, an ACL reconstruction and in 22 % of the patients, an osteosynthesis of a tibia plateau fracture had been performed. The mean duration of surgery was 127 min ( $SD \pm 28$ ), including harvesting bone from the iliac crest. The mean wedge size was 8.2 mm ( $SD \pm 4.9$ ), and the median in-patient stay was 14 days (range: 8–36 days).

## Radiographic results

The mean preoperative mTFA was  $-6.7^\circ$  ( $SD \pm 4.5^\circ$ ). The preoperative plan was to achieve a postoperative mechanical axis with a mTFA of  $3.1^\circ$  ( $SD \pm 1.9^\circ$ ). At the time of the follow-up (77 months,  $SD \pm 19$ ), the mTFA was  $-0.7^\circ$  ( $SD \pm 3.8^\circ$ ). The mean correction angle was  $5.7^\circ$  ( $SD \pm 3.6^\circ$ ) ( $p < 0.0001$ ). The mean difference between mTFA postoperatively and the planned mTFA was  $3.3^\circ$  ( $SD \pm 4.0^\circ$ ) ( $p < 0.0017$ ). The weight-bearing line crossed the tangent of the tibial plateau at a mean value of 47 % ( $SD \pm 17$  %) postoperatively (medial border is 0 %, lateral border is 100 %).

## Clinical assessment

Concerning the subjective and objective knee function, significant improvements were observed in all scores: The Lysholm score gained 19.2 points ( $SD \pm 16.8$ ) ( $p < 0.0001$ ) (Table 2), HSS score gained 15.6 points ( $SD \pm 13.2$ ) ( $p < 0.0001$ ) (Table 3), score according to Lequesne gained  $-6.0$  points ( $SD \pm 5.1$ ) ( $p < 0.0001$ ) (Table 4) and the Tegner score gained from median 3 (range, 1–5) to 4 (range, 1–8).

## REFA classification and incapacity of work

The classification according to the REFA Association subdivides work load into several categories. The median duration of incapacity of work was 87 days (range, 14–450). After the open wedge HTO, 3 (9.4 %) patients changed their employment to an occupation with less work load. Duration of incapacity of work demonstrated a relation to work intensity according to REFA classification (Table 5, Fig. 1). The results of the REFA grades 3 and 4 are not representative because of the small number of patients in these groups. Furthermore, in the REFA 3 group, two of the patients changed their employment (Table 6).

## Complications

Postoperative infection at the osteotomy location occurred in 1 patient (3 %). No other osteotomy-related complications were found. Regarding bone graft-related complications,

**Table 2** Lysholm score

	Mean preoperative ± SD	Mean postoperative ± SD	Mean difference ± SD	<i>p</i> value
Pain	12.2 ± 8.6	20.6 ± 7.3	8.4 ± 7.8	<0.0001
Instability	26.6 ± 7.1	28.6 ± 2.6	2.0 ± 5.7	<0.0255
Swelling	5.2 ± 3.4	7.8 ± 3.0	2.6 ± 3.1	<0.0001
Stair climbing	6.0 ± 2.8	8.5 ± 2.2	2.5 ± 2.8	<0.0001
Squatting	2.3 ± 1.4	3.4 ± 1.4	1.2 ± 1.4	<0.0001
Limp	2.5 ± 1.8	4.0 ± 1.5	1.4 ± 2.1	<0.0006
Walking aid	4.7 ± 1.12	4.8 ± 0.9	0.2 ± 0.7	n.s.
Atrophy of the thigh	3.4 ± 1.6	4.1 ± 1.2	0.7 ± 1.2	<0.0061
Total score	62.5 ± 17.5	81.7 ± 12.7	19.2 ± 16.8	<0.0001

**Table 3** HSS (hospital for special surgery) score

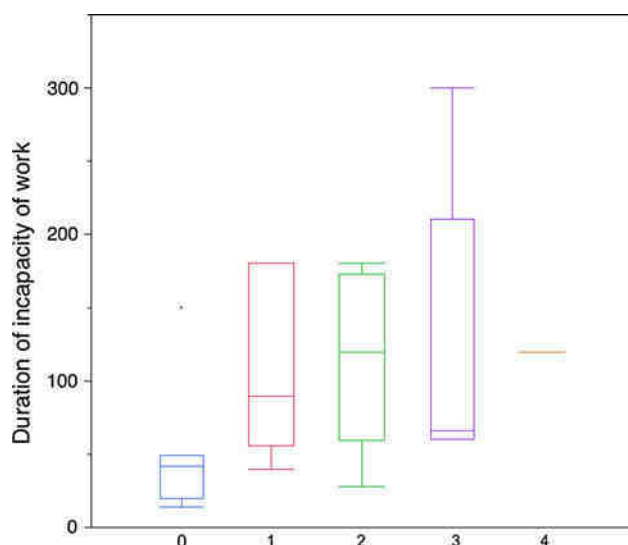
	Mean preoperative ± SD	Mean postoperative ± SD	Mean difference ± SD	<i>p</i> value
Pain	16.7 ± 7.8	25.6 ± 6.4	8.6 ± 8.4	<0.0001
Walking	8.4 ± 2.7	11.0 ± 1.2	2.6 ± 2.7	<0.0001
Climbing stairs	4.6 ± 1.0	5.0 ± 0.0	0.4 ± 1.0	<0.0435
Transfer activity	4.3 ± 1.35	5.0 ± 0.45	0.7 ± 1.3	<0.0061
Range of motion	15.8 ± 2.2	16.3 ± 2.0	0.4 ± 1.2	<0.0368
Muscle strength	9.0 ± 1.0	9.75 ± 0.7	0.75 ± 1.0	<0.0002
Flexion deformity	7.1 ± 3.7	7.6 ± 3.7	0.5 ± 2.0	n.s.
Instability	9.2 ± 1.6	9.4 ± 1.4	0.2 ± 0.6	n.s.
Cane or crutch	-0.13 ± 0.5	0.0 ± 0.0	0.13 ± 0.5	n.s.
Extension lag	-0.8 ± 1.3	-0.5 ± 0.9	0.3 ± 1.3	n.s.
Varus or valgus	-1.3 ± 0.9	-0.3 ± 0.6	1.0 ± 0.6	<0.0001
Total score	72.4 ± 12.4	88.0 ± 9.7	15.6 ± 13.2	<0.0001

**Table 4** Score according to Lequesne

	Mean preoperative ± SD	Mean postoperative ± SD	Mean difference ± SD	<i>p</i> value
Pain or discomfort	3.8 ± 2.0	1.6 ± 1.4	-2.2 ± 2.0	<0.0001
Maximum distance walked	3.0 ± 2.0	1.1 ± 0.7	-1.9 ± 1.9	<0.0001
Climbing stairs up	0.7 ± 0.5	0.3 ± 0.4	-0.4 ± 0.5	<0.0001
Climbing stairs down	0.8 ± 0.6	0.3 ± 0.4	-0.4 ± 0.5	<0.0001
Squatting	1.2 ± 0.6	0.6 ± 0.6	-0.6 ± 0.6	<0.0001
Walk on uneven ground	0.7 ± 0.6	0.3 ± 0.5	-0.4 ± 0.5	<0.0001
Total score	10.3 ± 5.4	4.3 ± 3.3	-6.0 ± 5.1	<0.0001

**Table 5** Duration of incapacity of work related to work load preoperative (REFA) in days

REFA	<i>N</i>	Minimum	10 %	25 %	Median	75 %	90 %	Maximum
0	7	14	14	20	42	49	150	150
1	11	40	43.2	56	90	180	180	180
2	8	28	28	59.5	120	172.5	450	450
3	5	60	60	60	66	210	300	300
4	1	120	120	120	120	120	120	120



**Fig. 1** Duration of incapacity of work according to work intensity (REFA classification)

**Table 6** Occupation classified according to REFA Association

REFA	Preoperative	Postoperative
0	7	8
1	11	11
2	8	9
3	5	3
4	1	1

6 patients (19 %) still suffered from hyperaesthesia or dysaesthesia at the iliac crest at the time of follow-up. No other bone graft-related complications were observed.

## Discussion

The most important finding in this study was that with help of the German work load classification established by the REFA Association, a relation was found between work load and the incapacity of work after open wedge HTO with iliac graft interposition.

The median duration of incapacity of work found in the present study (87 days; range, 14–450) is comparable to that of other studies. Overall, 9.4 % of the patients could not work at the same level of work load after the surgery. Hoell et al. [12] reported a mean duration of incapacity of work of 13.9 weeks after open wedge HTO and 13.6 weeks after closed wedge HTO. This difference may have been caused by the long partial-weight-bearing periods of 12.9 and 12.6 weeks after open wedge and closed wedge HTO, respectively. To the knowledge of the authors, no reports

about incapacity of work related to a classification system of work load such as it was introduced by the REFA Association have been published so far. The demonstrated relationship between work load and the duration of incapacity of work is certainly not surprising. However, with this classification, it is possible to give an individual prediction of the postoperative duration of incapacity of work to the patients. Nowadays, it is quite important to reduce the duration of incapacity of work after surgery.

Time to full weight bearing may be associated with duration of incapacity of work. In the present study, a 20 kg partial weight bearing protocol of 6 weeks was used before the start of full weight bearing, due to the osteosynthesis with no angle stable plates. The relatively long hospital stay of our patients (2 weeks) has no influence on the rehabilitation protocol but is caused by the type of hospital that allows completion of additional rehabilitation time. New concepts of early full weight bearing after open wedge HTO have been described [17]. Regarding the rehabilitation protocol with early full weight bearing, patients after open wedge HTO with the TomoFix plate (angle stable plate) have been analysed with radiostereometry. Clinically insignificant migrations of bone fragments of less than 1 mm or 1° between the proximal and distal part of the osteotomy were measured after full weight bearing started 2 weeks postoperative [7]. Takeuchi et al. [28] using the same implant for fixation described good clinical results after bilateral osteotomy with early full weight bearing after 1 week. The authors assume a significant shorter duration of incapacity of work with the new rehabilitation concept of early full weight bearing as well. This hypothesis is supported by the difference between the results of Hoell et al. [12] and the clinical results found in the present study.

In the present study, the Lysholm score increased from 60.5 (range, 27–95) to 85.5 (range, 51–100). Sterett et al. [27] observed a Lysholm score of 73 points, while Zhang et al. [30] observed a score of 77.5 points 5 years after HTO, although Zhang et al. [30] described an inferior Lysholm score preoperative (42.5) than in the present study (62.5). Marti et al. [19] observed 81 points 42 months postoperatively and Miller et al. [20] observed 75.4 points 24 months after using the Puddu plate for open wedge HTO without bone graft. Niemeyer et al. [22] observed an improvement of the Lysholm score from 54.3 points (SD ± 20.8) to 79.1 points (SD ± 16.6) 36 months after open wedge HTO without bone graft using the TomoFix plate for fixation. Kolb et al. [16] used the TomoFix plate without bone graft and observed a Lysholm score of 83 points after 12 months. The HSS score improved to 88.0 points (SD ± 9.7) at the time of follow-up. Kolb et al. [16] observed a HSS score of 85.6 points 12 months after open wedge HTO with the TomoFix plate. Brouwer et al. [8]

reported a HSS score of 80.9 points 12 months after open wedge HTO with the Puddu plate and bone graft from the ipsilateral iliac crest. Akizuki et al. [3] observed a HSS score of 84 points 5 years after closed wedge HTO.

The median Tegner score improved to 4 points (range, 1–8). The results of other studies demonstrated a Tegner score between 3.8 and 4.3 points [12, 27].

Leg alignment correction with HTO may be aimed at restoring leg alignment to normal, which may even be a varus leg alignment similar to the contralateral leg or overcorrection into valgus unloading an osteoarthritic compartment. At the time of the follow-up, the mTFA was  $-0.7^\circ$  (SD  $\pm 3.8^\circ$ ) and the weight-bearing line crossed the tibial plateau at a mean value of 47 % (SD  $\pm 17$  %) among the patients of the present study. The mean correction angle was  $5.7^\circ$  (SD  $\pm 3.6^\circ$ ) ( $p < 0.0001$ ). The mean difference between mTFA postoperatively and the planned mTFA was  $3.3^\circ$  (SD  $\pm 4.0^\circ$ ) ( $p < 0.0001$ ), which indicated an undercorrection. Although the undercorrections may have negatively influenced the clinical outcome of our patients, the Lysholm score and the HSS score improved to 81.7 (SD  $\pm 12.7$ ) and 88.0 (SD  $\pm 9.7$ ) points, respectively. Magyar et al. [18] achieved a postoperative mTFA of  $2^\circ$  and observed a Lysholm score of 86 points as well as a HSS score of 89 points. Furthermore, it should be noted, however, that the recommended alignment varies among the authors and that the different values cover a wide range. The aTFA recommended by Aglietti et al. [1] was  $8^\circ$ – $14^\circ$  valgus postoperative which corresponds to an mTFA of  $1^\circ$ – $7^\circ$  postoperative. Briem et al. [6] suggest a correction to an mTFA of  $5^\circ$  for patients treated for medial osteoarthritis. In general, as well as in the present study, superior results are found with an mTFA  $>0^\circ$  postoperatively.

The overall rate of bone graft-related complications was 19 %. These patients still had hyperaesthesia or dysaesthesia in the iliac crest graft harvest area at the time of the follow-up. Ahlmann et al. [2] reported a comparable overall iliac crest-related complication rate (23 %) after harvesting bone. Infection as an osteotomy-related complication was found in 1 (3 %) patient in this study. Infection rate after open wedge HTO and closed wedge HTO are reported in 2.3–33.6 % of the patients [4, 5, 8, 10, 12, 14]. The huge difference between the infection rates in the different studies is caused by different definitions of the term “infection” in these studies (superficial, deep infection, etc.). No implant-related complications, like screw failure or implant failure, were reported among our patients. These problems were reported in open wedge HTO with small spacer plates without bone graft [21, 24, 25]. Nowadays, iliac crest-related complications after open wedge HTO with autologous iliac bone graft can be prevented by using more stable implants. These

implants stabilise the osteotomy without using bone grafts [15, 16, 26].

The clinical outcome results of the present study are comparable to those reported in other studies of open wedge HTO with autologous iliac graft interposition and studies without bone grafting.

The retrospective study design, the variation in the length of the follow-up and the absence of a control group treated without autologous bone graft and using angular stable plates are limitations of the present study.

At the time of follow-up (77 months, SD  $\pm 19$ ), every clinical score (HSS, Lysholm, Tegner, Lequesne) that has been used in this study had increased significantly. Open wedge HTO is a frequently used treatment for younger and active older patients with medial compartment osteoarthritis of the knee and varus malalignment. Most of these patients will be employed at the time of surgery and will have a period of incapacity of work because of the HTO. This study describes the REFA classification that subdivides work intensity into different groups and the duration of the incapacity of work of the different patients after open wedge HTO. With this classification, the surgeon can provide an individual orientation of the postoperative duration of incapacity of work for these patients, which is becoming increasingly important in present-day society.

## Conclusion

In this study, a relation was found between work load divided into different categories according to the classification established by the REFA Association and the duration of incapacity of work after open wedge HTO. A postoperative improvement of all clinical scores was found. Typical neurological complications after autologous bone transplantation from the iliac crest were found in 19 % of our patient population.

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