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Health-related quality of life after open-wedge high tibial osteotomy

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Abstract
Purpose (1) To monitor longitudinal changes in health-related quality of life (HRQOL), pain, knee function, and return to work (RtW) following high tibial osteotomy (HTO) for medial compartment osteoarthritis (OA), and (2) to investigate the influences of psychopathological comorbidities on preoperative impairment and post-operative course.
Methods Sixty-four patients were prospectively followed for 24 months after HTO to determine HRQOL, pain, functional outcome, and RtW. Psychopathological comorbidities (e.g. depression) were determined preoperatively. Patients with no psychological distress (ND) were compared to patients with psychological distress (PD) in order to investigate the influence of psychopathological comorbidities on outcome.
Results There was a significant increase in HRQOL and decrease in pain from 6 month follow-up on. Functional outcomes increased significantly from 12 month follow-up on. In general, there was a steady state of outcomes from 6- to 12-month follow-up on. At final follow-up, 90 % returned to their previous occupation without limitations. Mental component summary (MCS) and functional outcome showed a positive correlation with RtW, while depression had a negative one. A significantly inferior outcome of group PD versus ND was observed at baseline and early follow-up. RtW was significantly prolonged in group PD (8.9 ± 7.6 vs. 3.9 ± 3 months; $p < 0.001$). At final follow-up, both groups presented with comparable outcomes.
Conclusion HTO for medial compartment OA significantly improves HRQOL, pain, and knee function. Time to RtW is high and critically depends on PD. Further, extend of preoperative impairments, an initially inferior course, and inferior MCS outcome was influenced by PD. However, otherwise no significant differences were observed between groups PD and ND at final follow-up.
Level of evidence Prospective case series, II.

Keywords Knee · Osteoarthritis · High tibial osteotomy · Quality of life · Return to work

Tim Saier and Philipp Minzlaff have contributed equally to this work.

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Introduction

Osteoarthritis (OA) of the knee is one of the most common joint disorders, representing a major public health problem

that significantly impairs quality of life (QOL) [12, 18, 19]. In case of medial compartment OA due to varus malalignment, medial open-wedge high tibial osteotomy (MOW HTO) is a well-established and successful procedure to relieve pain and to improve knee function [6, 7, 29]. Given the high demands of patients on the integrity of their knee joint concerning occupational and recreational aspects of daily living [3, 33, 35], standardised functional knee scores and/or radiographic follow-up examinations alone are not suitable to characterise QOL following MOW HTO [14]. Since QOL after MOW HTO is dependent on knee functioning in daily living, rather than expanding lifespan, the term health-related quality of life (HRQOL) has to be emphasised when evaluating the outcome of MOW HTO. Bullinger et al. [5] define HRQOL as 'the impact of perceived health on an individual's ability to live a fulfilling life'. Therefore, HRQOL is a multifactorial construct, which measures physical, social, emotional, and psychological components in consideration of individual goals, values, and priorities in life [10, 16, 30]. It fundamentally refers to the influence of a patient's health status on their noticed well-being and life quality [14].

Concomitant psychological distress which can lead to prolonged hospitalisation, inferior outcomes, and impaired occupational productivity [4, 25, 31, 32, 34, 36, 37] has to be taken into account when measuring and interpreting HRQOL. Besides, OA of the knee is associated with disadvantageous implications on the psychological well-being [30, 40], and up to 27 % of individuals seeking for medical advice for physical distress suffer from psychological disorders [8, 23]. However, to the best of the author's knowledge, no study has investigated the effect of psychopathological comorbidities on the clinical course after MOW HTO so far.

The first purpose of this prospective case series was to monitor longitudinal changes in HRQOL, pain, knee function, and return to work following MOW HTO for medial compartment OA. The second purpose was to investigate the incidence of preoperative psychopathological comorbidities and to analyse their influence on preoperative impairments and the longitudinal course after MOW HTO.

The first hypothesis of the present study was that MOW HTO for medial compartment OA of the knee significantly improves HRQOL and functional outcome. The second hypothesis was that the presence of psychopathological comorbidities is associated with higher preoperative impairments, a prolonged clinical course, and a longer return-to-work period.

Materials and methods

Between November 2010 and January 2012, 135 consecutive patients were treated with MOW HTO for medial compartment OA at one author's institution (ABI).

Inclusion and exclusion criteria for this prospective study are shown in Fig. 1.

Data acquisition was conducted by two independent investigators and took place the day before surgery (baseline) and at 6, 12 weeks, 6, 12, 18, and 24 months after surgery.

Seventy-five patients fulfilled the in- and exclusion criteria. Six patients were lost during the follow-up period, and another five patients were excluded because of post-operative complications. In detail, four patients withdraw participation because of no longer time to complete further questionnaires, one patient had died independently of the procedure, one patient was converted to a total knee arthroplasty between the 18- and 24 month follow-up at another institution, two patients were re-operated because of local infections, and three patients were revised for non-unions. Accordingly, the final study group consisted of 64 patients (85 % follow-up rate) (Fig. 1). Of these, 46 patients (73.5 %) were male and 18 (26.5 %) were female. The mean age at surgery was 45.5 years (range 20–63), the mean body mass index (BMI) before surgery was 26.6 kg/m^2 (range 19–35), and the mean preoperative varus malalignment was 4.3° (range 3.7°–7.5°).

Surgical technique

Prior to surgery, digital planning of the osteotomy was performed using a landmark-based planning software (mediCAD, Hectec GmbH, Germany). The amount of correction was adapted to the criteria published by Feucht et al. [13].

All surgeries were performed by two specialised orthopaedic surgeons (SH, ABI), or under their direct supervision. Before MOW HTO, diagnostic knee arthroscopy was performed to proof medial compartment OA and to confirm the indication for MOW HTO with respect to an intact cartilage status in the lateral compartment. MOW HTO was performed in a biplanar technique as described by Hinterwimmer et al. [20, 21]. Fixation of the osteotomy was performed with an internal fixation locking plate (Tomofix®, DePuySynthes, Switzerland; or Peek-Power-Plate®-II. generation-, Arthrex Inc., USA).

Post-operative rehabilitation consisted of immediate free range of motion with partial weight-bearing (20 kg) for 2 weeks. From the third post-operative week on, weight-bearing was increased by 20 kg/week until full weight-bearing was achieved. Return to sport (e.g. jogging, cycling, and swimming) was allowed at 3 months after surgery. Contact sports were not advised until complete osseous consolidation was proofed by radiographic control. The plate fixator was removed in case of local discomfort after the osteotomy had healed (93 % removal rate).

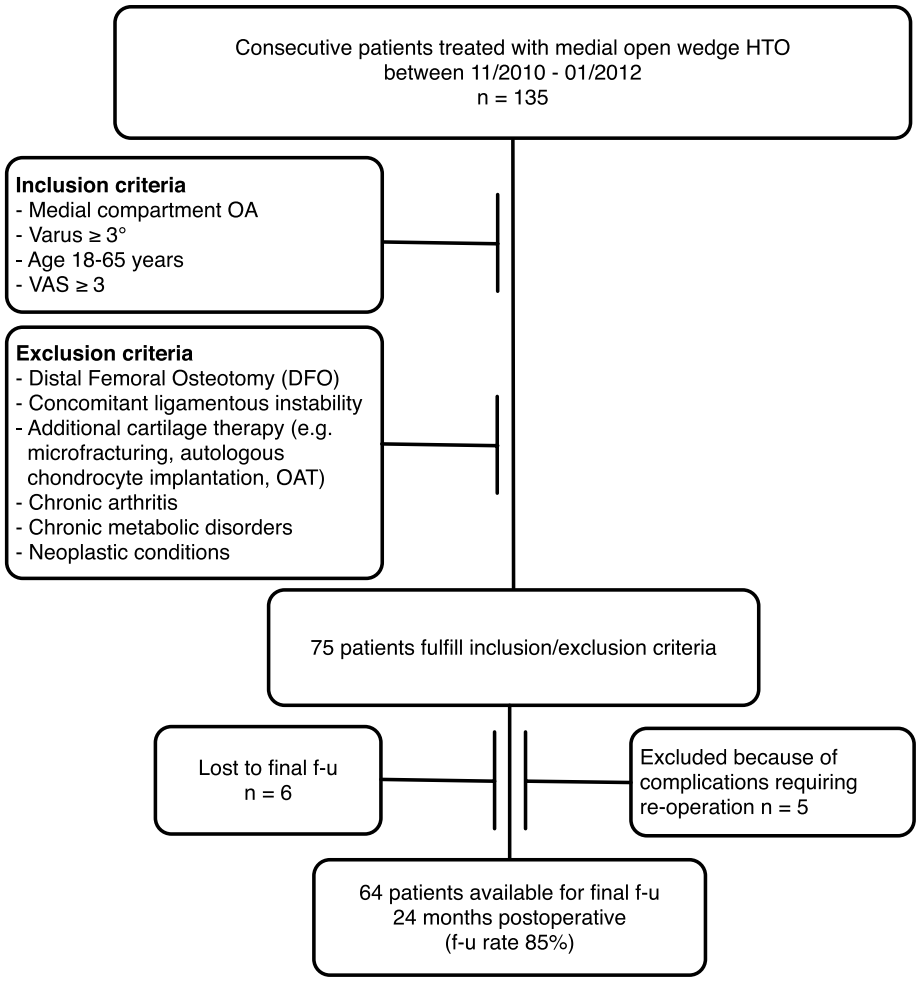

Fig. 1 Characterisation of patients included in this study. Flow chart with inclusion/exclusion criteria, description of final follow-up rate (%) due to patients excluded because of complications and/or lost to follow-up (f-u)

Functional outcome and return to work

To evaluate the longitudinal functional outcome, the Lysholm score and Western Ontario McMaster Universities Osteoarthritis Index (WOMAC) were used [2, 26]. Pain with weight-bearing was recorded using the visual analogue scale (VAS) [17]. Time (months) lost to return to work due to surgery, as well as reasons for ongoing inability to work (pain, limited range of motion, impaired mobility, other reasons), was assessed.

Health-related quality of life and psychological assessment

The Short-Form 36 (SF-36 V2) Health Survey and the Prime MD Patient Health Questionnaire (PHQ) were used to determine health-related quality of life and health status [38, 44]. The SF-36 included the following eight items: physical functioning (PF), role limitations due to physical health (RP), bodily pain (BP), general health (GH), vitality (V), social functioning (SF), role limitations due to emotional problems (RE), and mental health (MH). Furthermore, subscales for mental and physiological well-being (PCS: physical component summary, MCS: mental component summary) were calculated. PHQ was used to calculate PHQ subscales (depression, somatisation, stress) and to detect psychopathological comorbidities. Based on the baseline PHQ findings, the initial cohort was divided into two groups (18/46): patients who were identified to have at least one psychopathological comorbidity (somatoforme disorders, major/other depression, panic/anxiety syndrome, alcohol abuse) were assigned to the psychologically distressed (PD) group ($n = 18$; 28 %, see Table 1), whereas all others were enlisted in the non-psychologically distressed (ND) group ($n = 46$; 72 %). There was no significant difference between groups in terms of gender, age, BMI, and preoperative varus malalignment (n.s.).

The study was approved by the institutional review board (registration number 415/15), and all patients gave their written informed consent to participate in this investigation.

Table 1 Number and prevalence of syndrome-based diagnosis of subpopulation with psychological distress (group PD) based on Physical Health Questionnaire (PHQ) scoring (multiple comorbidities possible)

Psychopathological comorbidity	Number (prevalence)
Somatoforme syndrome	7 (10.3 %)
Other depression	5 (7.4 %)
Alcohol abuse	4 (5.9 %)
Major depression	3 (4.4 %)
Panic syndrome	2 (2.9 %)
Anxiety disorder	2 (2.9 %)

Statistical analysis

Data analysis was performed using SPSS® 22.0 (IBM SPSS Statistics, New York, USA). For longitudinal data analyses, repeated measures generalised linear models with one within-subject factor (with/without psychological distress) and Greenhouse–Geisser correction were applied. Descriptive data were either presented as mean ± standard deviation or in percentages. A $p < 0.05$ was considered to be indicative of statistical significance. For post hoc power analyses, η^2_{partial} is depicted. To test for correlations between changes from baseline until 12 month and changes from 12 month until 24 month, either Pearson's correlation coefficient or Spearman's rank correlation (in case the p value for the Kolmogorov–Smirnov test to evaluate normal distribution was >0.05) was conducted.

Results

Longitudinal changes in health-related quality of life

The detailed data of the SF-36 physical component summary (PCS), mental component summary (MCS), and PHQ are provided in Table 2.

PCS and MCS changed significantly over time ($p < 0.001$). Both remained constant from the 6-month follow-up on. With the exception of general health, all SF-36 items improved significantly between baseline and 24 months post-operatively ($p < 0.001$). All remained constant from 12 to 24 months post-operatively (for details, see supplement).

Stress and depression subscales of PHQ improved significantly until final follow-up ($p < 0.001$).

Longitudinal changes in pain and functional outcome

Changes over time of VAS, Lysholm score, and WOMAC are described in detail in Table 2. All scores improved significantly after the operation (each $p < 0.001$). The maximum pain relief was achieved at 6 months post-operatively and remained constant to 24 months post-operatively. Lysholm and WOMAC scoring remained constant from 12 to 24 months post-operatively.

Return to work

Before surgery, 79 % of the patients were working on a regular base, 10 % were not able to work due to knee symptoms/impairment, and 10 % were not working for other reasons. At final follow-up, 90 % returned to their previous occupation without any limitations. 3 % experienced impairment, and 7 % did not return to work due to knee symptoms/impairment. The mean total inability to work after surgery was 5.2 ± 5.1 months (range 1.5–24). At the 12-week follow-up, the two most common reasons for inability to work were pain (44 %) and restricted range of motion (42 %). Impaired mobility was named in 12 % and other reasons in 2 %.

Correlation of health-related quality of life with functional outcome and return to work

Correlations of PCS, MCS, PHQ subscales, functional outcome, and return to work within the first 12 months (delta I) and 12–24 months after surgery (delta II) are described in Table 3.

Correlation coefficients for delta I and delta II were 0.28–0.68 and 0.28–0.7, respectively.

For details on SF-36 items correlation, see supplement.

Influence of psychological distress on pain, functional outcome, health-related quality of life, and return to work

With baseline PHQ findings, patients were assigned into two groups (18/46) whether PHQ indicated psychological distress (PD, see Table 1) or no psychological distress (group ND). Table 2 summarises the influences of psychopathological distress on HRQOL, pain, functional outcome, and return to work in detail.

Health-related quality of life

Baseline PCS and MCS scoring for group PD was inferior compared to group ND. There was only a significant difference between groups for MCS outcome ($p = 0.038$). Details of SF-36 items outcome are provided within the supplement.

Depression, somatisation, and stress subscales of PHQ improved significantly over time ($p < 0.001$, $p = 0.05$, respectively $p < 0.001$) and were significantly inferior in group PD versus ND ($p = 0.012$, $p = 0.01$, respectively $p = 0.005$).

Table 2 Twenty-four month longitudinal outcomes of HRQOL (SF-36) and health status (PHQ), pain, and functional clinical status (Lysholm, WOMAC) following MOW HTO [data presented for all individuals (All) and for patients with and non-psychological distress (PD vs. ND)]

	Lysholm			Pain (VAS) with weight-bearing			WOMAC		
	All Mean ± SD	ND Mean ± SD	PD Mean ± SD	All Mean ± SD	ND Mean ± SD	PD Mean ± SD	All Mean ± SD	ND Mean ± SD	PD Mean ± SD
Preop.	51.3 ± 19.9	54.3 ± 20.4	43.3 ± 16.7	5.0 ± 2.6	4.7 ± 2.6	5.6 ± 2.7	22.5 ± 13.3	20.6 ± 12.6	27.9 ± 14.1
6 w	42.7 ± 20.5	46.7 ± 19.4	32.0 ± 19.9	2.8 ± 2.0	2.3 ± 1.8	4.2 ± 2.1	28.8 ± 15	26 ± 13.3	37.1 ± 17.1
12 w	49.2 ± 22.5	52.9 ± 23.2	39.5 ± 18.0	3.2 ± 1.8	2.9 ± 1.7	4.0 ± 1.8	19.4 ± 12.7	16.5 ± 12	27.9 ± 11.2
6 m	67.8 ± 18.4	70.2 ± 18.3	61.7 ± 17.9	2.5 ± 1.8	2.1 ± 1.5	3.7 ± 2.1	11.1 ± 10.0	9.8 ± 9.2	15.2 ± 11.4
12 m	76.5 ± 18.0	79.5 ± 17.6	68.5 ± 17.1	2.0 ± 2.1	1.8 ± 2.0	2.5 ± 2.2	7.1 ± 8.6	5.9 ± 8.1	10.5 ± 9.6
18 m	75.4 ± 18.0	76.8 ± 17.2	71.7 ± 12.0	2.0 ± 2.1	1.8 ± 2.1	2.7 ± 1.9	8.0 ± 9.0	7.1 ± 9.1	10.5 ± 8.2
24 m	75.6 ± 17.1	75.2 ± 18.6	75.4 ± 13.2	2.4 ± 2.2	2.6 ± 2.2	2.1 ± 2.1	8.1 ± 9.0	8.0 ± 10.0	10.5 ± 8.2
	p value	$\eta^2_{partial}$	p value	$\eta^2_{partial}$	p value	$\eta^2_{partial}$	p value	$\eta^2_{partial}$	p value	$\eta^2_{partial}$	p value	$\eta^2_{partial}$
Within	<0.001	0.5			<0.001	0.2			<0.001	0.5		
Between			0.023	0.083			0.006	0.129			0.008	0.118
IA			n.s.				n.s.				n.s.	

	PCS (SF-36)			MCS (SF-36)		
	All Mean ± SD	ND Mean ± SD	PD Mean ± SD	All Mean ± SD	ND Mean ± SD	PD Mean ± SD
Preop.	37.9 ± 10.8	39.1 ± 10.2	34.4 ± 1.0	52.1 ± 11.7	54.3 ± 10.6	46.5 ± 12.7
6 w	28.5 ± 11.3	28.6 ± 12.2	28.3 ± 8.7	54.4 ± 12.8	56.7 ± 10.9	48.6 ± 15.5
12 w	38.3 ± 7.7	39.2 ± 8.0	35.6 ± 6.2	56.6 ± 7.5	57.4 ± 6.8	54.6 ± 8.7
6 m	45.0 ± 7.0	45.7 ± 6.7	43.0 ± 7.7	55.9 ± 8.3	57.3 ± 7.7	52.3 ± 9.1
12 m	49.1 ± 9.1	49.8 ± 9.5	47.4 ± 7.9	54.4 ± 9.0	55.3 ± 8.8	52.0 ± 9.3
18 m	47.6 ± 12.1	47.7 ± 13.0	47.5 ± 9.7	54.8 ± 9.4	56.0 ± 9.4	51.8 ± 9.0
24 m	46.5 ± 13.6	46.5 ± 13.9	46.7 ± 13.3	55.1 ± 8.0	55.5 ± 7.9	54.0 ± 8.4
	p value	$\eta^2_{partial}$	p value	$\eta^2_{partial}$	p value	$\eta^2_{partial}$	p value	$\eta^2_{partial}$
Within	<0.001	0.4			0.008	0.1		
Between			n.s.				0.038	0.077
IA			n.s.				n.s.	

	Depression (PHQ)			Somatisation (PHQ)			Stress (PHQ)		
	All Mean ± SD	ND Mean ± SD	PD Mean ± SD	All Mean ± SD	ND Mean ± SD	PD Mean ± SD	All Mean ± SD	ND Mean ± SD	PD Mean ± SD
Preop.	4.3 ± 3.7	3.3 ± 2.7	6.9 ± 4.8	5.8 ± 3.4	4.7 ± 2.5	8.6 ± 3.6	3.9 ± 3.2	3.2 ± 2.7	6.4 ± 3.5
6 w	3.6 ± 3.3	3.0 ± 0.9	5.3 ± 3.6	6.9 ± 10.2	6 ± 11.5	8.9 ± 5.8	3.0 ± 2.7	2.6 ± 2.4	4.5 ± 3.2
12 w	2.9 ± 2.6	2.4 ± 2.2	4.2 ± 3.1	4.4 ± 3.3	3.5 ± 2.3	6.7 ± 4.9	2.4 ± 2.0	2.0 ± 1.9	3.6 ± 1.8
6 m	2.9 ± 3.1	2.5 ± 2.8	4.0 ± 3.6	4.5 ± 3.8	3.7 ± 2.9	6.5 ± 4.9	2.7 ± 2.4	2.2 ± 2.3	4.1 ± 2.2
12 m	2.4 ± 3.0	2.1 ± 2.9	3.2 ± 3.1	4.3 ± 3.9	3.6 ± 2.7	6.1 ± 5.6	2.5 ± 2.9	2.3 ± 2.7	3.4 ± 3.3
18 m	2.7 ± 3.4	2.4 ± 3.2	3.5 ± 3.7	4.9 ± 4.4	4.3 ± 3.8	6.5 ± 5.5	2.7 ± 2.6	2.1 ± 2.5	4.4 ± 2.2
24 m	2.8 ± 3.3	2.4 ± 3.4	3.7 ± 3.1	5.1 ± 4.5	4.3 ± 3.9	5.1 ± 5.4	2.9 ± 2.9	2.7 ± 2.9	3.7 ± 2.8
	p value	$\eta^2_{partial}$	p value	$\eta^2_{partial}$	p value	$\eta^2_{partial}$	p value	$\eta^2_{partial}$	p value	$\eta^2_{partial}$	p value	$\eta^2_{partial}$
Within	<0.001	0.1			0.05	0.1			<0.001	0.1		
Between			0.012	0.104			0.01	0.113			0.005	0.133
IA			n.s.				n.s.				n.s.	

Table 3 Correlation of HRQOL (SF-36) and health status (PHQ), pain, and functional clinical (Lysholm, WOMAC) outcome 0–12 months (delta I) and 12–24 months (delta II) following MOW HTO

12–24 m DELTA (II) 0–12 m DELTA (I)	Lysholm	Pain with weight-bearing	WOMAC	PCS (SF-36)	MCS (SF-36)	Depres. (PHQ)	Somat. (PHQ)	Stress (PHQ)	RtW
Lysholm		−0.6 (<0.001)	0.7 (<0.001)	0.6 (<0.001)	n.s.	n.s.	−0.3 (0.021)	n.s.	0.3 (0.029)
Pain with weight-bearing	−0.5 (<0.001)		0.6 (<0.001)	−0.4 (0.001)	n.s.	n.s.	n.s.	n.s.	n.s.
WOMAC	−0.7 (<0.001)	0.6 (<0.001)		0.6 (<0.001)	n.s.	n.s.	-0.3 (0.028)	n.s.	n.s.
PCS (SF-36)	0.6 (<0.001)	−0.5 (<0.001)	−0.5 (<0.001)		−0.3 (0.013)	n.s.	n.s.	n.s.	n.s.
MCS (SF-36)	n.s.	n.s.	n.s.	−0.3 (0.037)		−0.6 (<0.001)	n.s.	−0.3 (0.026)	0.4 (0.004)
Depres. (PHQ)	n.s.	n.s.	n.s.	n.s.	−0.5 (<0.001)		0.6 (<0.001)	0.6 (<0.001)	n.s.
Somat. (PHQ)	n.s.	n.s.	n.s.	n.s.	−0.4 (0.001)	0.5 (<0.001)		0.5 (<0.001)	n.s.
Stress (PHQ)	n.s.	n.s.	n.s.	n.s.	−0.4 (0.001)	0.5 (<0.001)	0.5 (<0.001)		n.s.
RtW	n.s.	n.s.	n.s.	n.s.	n.s.	−0.3 (0.009)	n.s.	n.s.	

RtW return to work, SF-36: *PCS* physical component summary, *MCS* mental component summary, PHQ: *Depres.* depression, *Somat.* somatisation

Pain

Significantly higher levels of pain (VAS) were observed preoperatively in group PD ($p = 0.006$). VAS improved significantly for both groups until final follow-up ($p < 0.001$). At final follow-up, both groups achieved about equal levels of pain.

Functional outcome

With an inferior baseline Lysholm and WOMAC scores, the longitudinal functional outcome in group PD was significantly different compared to group ND ($p = 0.023$, $p = 0.008$, respectively). At final follow-up, differences between groups were nullified (n.s.).

Return to work

Group PD lost significantly more time to return to work compared to ND (mean 8.9 months, SD 7.59 vs. mean 3.9 months, SD 3; $p < 0.001$).

Discussion

The most important finding of this study was a significant improvement in health status and HRQOL 24 months after MOW HTO. Patients with psychopathological comorbidities had greater functional impairments and lower HRQOL preoperatively, but no significant difference compared to individuals without psychological distress was observed at final follow-up. Depression, somatisation, and stress subscales of PHQ significantly improved post-operatively, with greater improvements in patients with psychopathological comorbidities. However, the return-to-work period was significantly longer in patients with psychological distress.

Satisfying short- and midterm functional outcomes for MOW HTO has been described before, as well as equivalent outcomes between the two plates used within this study [2, 6, 7, 15]. Functional results of the presented study are comparable to the present literature and represent significant clinical improvement [1, 6, 24, 27, 29, 35, 39].

It has been shown that OA of the knee affects physical activity, mood, and HRQOL [11]. McNamara and colleagues showed that young and active patients with medial compartment OA of the knee and varus malalignment preoperatively suffered from similar impairment in HRQOL than older patients with OA undergoing total knee replacement [27]. Since HTO is performed in younger and active patients, inclusion of HRQOL to standard outcome measures seems to be even more important.

The SF-36 is a widely accepted tool to measure HRQOL. Furthermore, it has been demonstrated that the SF-36 is a responsive general measure of global HRQOL in patients

with knee OA [42, 43]. In the current study, SF-36 component summaries for physical and mental health and all SF-36 subscales, with the exception of general health perception, showed significant improvement following MOW HTO. On the other hand, the PHQ stress subscale declined significantly over time. The authors hypothesise that medial compartment OA of the knee especially affects physical function that results in impaired role function. MOW HTO appears to reduce role limitations due to physical and emotional impairments and supports individuals to regain physical and social functioning, which in consequence results in a higher level of HRQOL.

The results demonstrate that MOW HTO substantially improved general health status and HRQOL of individuals suffering from medial compartment OA of the knee. It is important to note that the maximum improvements for HRQOL, knee function, and pain were achieved as early as 6–12 months post-operatively and remained constant thereafter. This may indicate that 1 year after surgery patients already reached the final short-term outcome of the procedure. If further improvements can be expected after more than 24 months remains unknown.

Besides the recent study by McNamara et al. [28] using SF-12 as a secondary outcome measure to investigate on outcome of HTO with non-locking plates, the authors of this study are not aware of the literature investigating on HRQOL after comparable MOW HTO surgery using locking plates. In accordance with the findings by McNamara et al. [28], the presented study found a clinically significant increase in HRQOL following valgus-producing HTO.

Concerning return to work after HTO, Schröter et al. [35] reported a median duration of incapacity to work of 2.9 months. Hoell et al. [22] reported a mean duration of incapacity to work of 3.5 months. However, both studies were retrospective in nature with the risk of a recall bias. Using a prospective study design, we observed a mean incapacity to work of 5.2 months. In our opinion, the mentioned retrospective studies may have underestimated the return-to-work period. In the presented study, only 3 % returned to work with impairment, compared to 9 % in the study by Schröter et al. [35]. Nevertheless, 7 % of the patients in our study did not return to work permanently due to knee symptoms/impairment.

Correlation analysis within the first year after surgery showed a positive correlation between MCS and pain, and a negative correlation with return to work. It is interesting to mention that 44 % of patients reported pain to be the cause for ongoing inability to work at 12-week follow-up, but pain was not correlated with return to work. In contrast, return to work positively correlated with knee function measured with the Lysholm score. Furthermore, delayed return to work correlated negatively with depression. And, from 1 year after surgery on, pain was negatively correlated with MCS. Overall, the authors conclude that functional outcome, pain, return to work, and depression must be considered important factors for short-term HRQOL following HTO. Further research will be necessary to underline these findings.

PHQ is a reliable measure to diagnose symptom-based psychopathological impairment. These concomitant disorders are a common cause for subjective suffering, somatic symptoms, more frequent medical consultations, diagnostic and therapeutic interventions, prolonged hospitalisation, impaired occupational productivity, and inferior outcomes [4, 25, 31, 32, 34, 36, 37]. Furthermore, there are reports that OA of the knee is associated with disadvantageous implications on psychological well-being [31, 40]. To the knowledge of the authors, this has never been investigated on in patients undergoing HTO. In this study, patients with psychological distress (group PD) showed inferior baseline scores for all analysed parameters. Except for vitality, which only grew up to baseline levels of individuals with non-psychological distress (group ND) and mental health, all other results were comparable with group ND at final follow-up. The biggest increase in HRQOL subscales was observed for physical functioning (+39 %), role limitations due to physical health (+35 %), and bodily pain (+35 %). While both groups achieved the same PCS outcome from 18-month follow-up on, there was a significant difference between the groups for MCS throughout the study. With initially 100 % inferior results, group PD improved in PHQ depression, somatisation, and stress subscales until final follow-up to a mean difference to group ND by 1 point. Since other studies have shown that somatisation and depression can be caused by OA, the authors hypothesise that MOW HTO was effective in treating OA, and thus, these comorbidities were reduced by the intervention. Nevertheless, psychopathological comorbidities seem to influence the longitudinal outcome after MOW HTO negatively. This was especially true for the most important finding that individuals in group PD lost a double fold time to return to work (8.87 months), compared to the mental healthy patients (3.85 months). Overall, this group increased total time for return to work substantially. The authors conclude that psychopathological comorbidities must be considered as a risk factor for prolonged incapacity to work after MOW HTO. Since PHQ is an easy and feasible assessment for psychological distress in daily clinical work, it may serve as a valuable measure to identify patients at risk for a potentially prolonged course after MOW HTO.

With the knowledge that more than 50 % of psychological disorders of patients presenting with physical impairment remain unrecognised and in consequence untreated [9, 41], further research is necessary to investigate whether psychological intervention ahead of surgery would modify baseline results and function as well as HRQOL outcomes after MOW HTO.

Conclusion

In conclusion, MOW HTO for medial compartment OA improves HRQOL, pain, and knee function in a clinical significant way. However, time until return to work is high and depends on the existence of preoperative psychological distress. Significant difference in preoperative mental and functional impairments as well as short-term improvements after MOW HTO exists between patients with and without psychopathological comorbidities. However, except for a significantly longer return-to-work period and inferior MCS scoring in patients with psychopathological comorbidities, no significant differences were observed between the two groups at 24 months after surgery.

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Authors' contributions Tim Saier designed the study, analysed the data, and drafted the abstract, introduction, material and methods, results, and discussion; Philipp Minzlaff designed the study, analysed the data, and drafted the abstract, introduction, results, and discussion; Matthias J. Feucht designed the study and critically reviewed introduction, results, and discussion; Lena Lämmle analysed the statistics and drafted the materials and methods, results, and tables; Maike Burghoff collected and analysed the data, and processed the figures; Christoph Ihle discussed the results; Andreas B Imhoff critically reviewed the study; and Stefan Hinterwimmer designed and critically reviewed the study.

References

1. Angst F, Aeschlimann A, Stucki G (2001) Smallest detectable and minimal clinically important differences of rehabilitation intervention with their implications for required sample sizes using WOMAC and SF-36 quality of life measurement instruments in patients with osteoarthritis of the lower extremities. Arthritis Rheum 45(4):384–391
2. Bode G, von Heyden J, Pestka J, Schmal H, Salzmann G, Südkamp N, Niemeyer P (2015) Prospective 5-year survival rate data following open-wedge valgus high tibial osteotomy. Knee Surg Sports Traumatol Arthrosc 23(7):1949–1955
3. Bonnin MP, Laurent JR, Zadegan F, Badet R, Pooler Archbold HA, Servien E (2013) Can patients really participate in sport after high tibial osteotomy? Knee Surg Sports Traumatol Arthrosc 21(1):64–73
4. Broadhead WE, Blazer DG, George LK, Tse CK (1990) Depression, disability days, and days lost from work in a prospective epidemiologic survey. JAMA 264(19):2524–2528
5. Bullinger M, Anderson R, Cella D, Aaronson N (1993) Developing and evaluating cross-cultural instruments from minimum requirements to optimal models. Qual Life Res 2(6):451–459
6. Cotic M, Vogt S, Feucht MJ, Saier T, Minzlaff P, Hinterwimmer S, Imhoff AB (2014) Prospective evaluation of a new plate fixator for valgus-producing medial open-wedge high tibial osteotomy. Knee Surg Sports Traumatol Arthrosc. doi:10.1007/s00167-014-3287-8
7. Cotic M, Vogt S, Hinterwimmer S, Feucht MJ, Slotta-Huspenina J, Schuster T, Imhoff AB (2015) A matched-pair comparison of two different locking plates for valgus-producing medial open-wedge high tibial osteotomy: peek-carbon composite plate versus titanium plate. Knee Surg Sports Traumatol Arthrosc 23(7):2032–2040
8. Demyttenaere K, Bruffaerts R, Posada-Villa J, Gasquet I, Kovess V, Consortium WHOWMHS et al (2004) Prevalence, severity, and unmet need for treatment of mental disorders in the World Health Organization World Mental Health Surveys. JAMA 291(21):2581–2590
9. Docherty JP (1997) Barriers to the diagnosis of depression in primary care. J Clin Psychiatry 58(Suppl 1):5–10
10. Edlund M, Tancredi LR (1985) Quality of life: an ideological critique. Perspect Biol Med 28(4):591–607
11. Fautrel B, Hilliquin P, Rozenberg S, Allaert FA, Coste P, Leclerc A, Rossignol M (2005) Impact of osteoarthritis: results of a nationwide survey of 10,000 patients consulting for OA. Joint Bone Spine 72(3):235–240
12. Felson DT, Zhang Y (1998) An update on the epidemiology of knee and hip osteoarthritis with a view to prevention. Arthritis Rheum 41(8):1343–1355
13. Feucht MJ, Minzlaff P, Saier T, Cotic M, Sudkamp NP, Niemeyer P, Imhoff AB, Hinterwimmer S (2014) Degree of axis correction in valgus high tibial osteotomy: proposal of an individualised approach. Int Orthop 38(11):2273–2280
14. Filbay SR, Ackerman IN, Russell TG, Macri EM, Crossley KM (2014) Health-related quality of life after anterior cruciate ligament reconstruction: a systematic review. Am J Sports Med 42(5):1247–1255
15. Floerkemeier S, Staubli AE, Schroeter S, Goldhahn S, Lobenhoffer P (2013) Outcome after high tibial open-wedge osteotomy: a retrospective evaluation of 533 patients. Knee Surg Sports Traumatol Arthrosc 21(1):170–180
16. Gill TM, Feinstein AR (1994) A critical appraisal of the quality of quality-of-life measurements. JAMA 272(8):619–626
17. Gould D, Kelly D, Goldstone L, Gammon J (2001) Examining the validity of pressure ulcer risk assessment scales: developing and using illustrated patient simulations to collect the data. J Clin Nurs 10(5):697–706
18. Guillemin F, Rat AC, Mazieres B, Pouchot J, Fautrel B, Euller-Ziegler L, Fardellone P, Morvan J, Roux CH, Verrouil E, Saraux A, Coste J, 3000 Osteoarthritis group (2011) Prevalence of symptomatic hip and knee osteoarthritis: a two-phase population-based survey. Osteoarthr Cartil 19(11):1314–1322
19. Heir S, Nerhus TK, Rotterud JH, Loken S, Ekeland A, Engebretsen L, Aroen A (2010) Focal cartilage defects in the knee impair quality of life as much as severe osteoarthritis: a comparison of knee injury and osteoarthritis outcome score in 4 patient categories scheduled for knee surgery. Am J Sports Med 38(2):231–237
20. Hinterwimmer S, Mehl J (2014) Combination of ACL-replacement and high tibial osteotomy. Oper Orthop Traumatol 26(1):43–55
21. Hinterwimmer S, Beitzel K, Paul J, Kirchhoff C, Sauerschnig M, von Eisenhart-Rothe R, Imhoff AB (2011) Control of posterior tibial slope and patellar height in open-wedge valgus high tibial osteotomy. Am J Sports Med 39(4):851–856
22. Hoell S, Suttmoeller J, Stoll V, Fuchs S, Gosheger G (2005) The high tibial osteotomy, open versus closed wedge, a comparison of methods in 108 patients. Arch Orthop Trauma Surg 125(9):638–643
23. Kessler RC, Chiu WT, Demler O, Merikangas KR, Walters EE (2005) Prevalence, severity, and comorbidity of 12-month DSM-IV disorders in the National Comorbidity Survey Replication. Arch Gen Psychiatry 62(6):617–627

24. Kolb W, Guhlmann H, Windisch C, Koller H, Grutzner P, Kolb K (2010) Opening-wedge high tibial osteotomy with a locked low-profile plate: surgical technique. J Bone Joint Surg Am 92(Suppl 1 Pt 2):197–207
25. Lingard EA, Riddle DL (2007) Impact of psychological distress on pain and function following knee arthroplasty. J Bone Joint Surg Am 89(6):1161–1169
26. Lysholm J, Gillquist J (1982) Evaluation of knee ligament surgery results with special emphasis on use of a scoring scale. Am J Sports Med 10(3):150–154
27. Marti RK, Verhagen RA, Kerkhoffs GM, Moojen TM (2001) Proximal tibial varus osteotomy. Indications, technique, and five to twenty-one-year results. J Bone Joint Surg Am 83-A(2):164–170
28. McNamara IR, Birmingham TB, Marsh JD, Chesworth BM, Bryant DM, Giffin JR (2014) A preference-based single-item measure of quality of life following medial opening wedge high tibial osteotomy: large improvements similar to arthroplasty. Knee 21(2):456–461
29. Niemeyer P, Schmal H, Hauschild O, von Heyden J, Sudkamp NP, Kostler W (2010) Open-wedge osteotomy using an internal plate fixator in patients with medial-compartment gonarthritis and varus malalignment: 3-year results with regard to preoperative arthroscopic and radiographic findings. Arthroscopy 26(12):1607–1616
30. Revicki DA (1989) Health-related quality of life in the evaluation of medical therapy for chronic illness. J Fam Pract 29(4):377–380
31. Rosemann T, Gensichen J, Sauer N, Laux G, Szecsenyi J (2007) The impact of concomitant depression on quality of life and health service utilisation in patients with osteoarthritis. Rheumatol Int 27(9):859–863
32. Rosenberger PH, Jokl P, Ickovics J (2006) Psychosocial factors and surgical outcomes: an evidence-based literature review. J Am Acad Orthop Surg 14(7):397–405
33. Salzmann GM, Ahrens P, Naal FD, El-Azab H, Spang JT, Imhoff AB, Lorenz S (2009) Sporting activity after high tibial osteotomy for the treatment of medial compartment knee osteoarthritis. Am J Sports Med 37(2):312–318
34. Saravay SM, Lavin M (1994) Psychiatric comorbidity and length of stay in the general hospital. A critical review of outcome studies. Psychosomatics 35(3):233–252
35. Schröter S, Müller J, van Heerwaarden R, Lobenhoffer P, Stöckle U, Albrecht D (2013) Return to work and clinical outcome after open wedge HTO. Knee Surg Sports Traumatol Arthrosc 21(1):213–219
36. Sharpe M, Peveler R, Mayou R (1992) The psychological treatment of patients with functional somatic symptoms: a practical guide. J Psychosom Res 36(6):515–529
37. Simon GE, VonKorff M, Piccinelli M, Fullerton C, Ormel J (1999) An international study of the relation between somatic symptoms and depression. N Engl J Med 341(18):1329–1335
38. Spitzer RL, Kroenke K, Williams JB (1999) Validation and utility of a self-report version of PRIME-MD: the PHQ primary care study. Primary Care Evaluation of Mental Disorders. Patient Health Questionnaire. JAMA 282(18):1737–1744
39. Sterett WI, Steadman JR, Huang MJ, Matheny LM, Briggs KK (2010) Chondral resurfacing and high tibial osteotomy in the varus knee: survivorship analysis. Am J Sports Med 38(7):1420–1424
40. Tallon D, Chard J, Dieppe P (2000) Exploring the priorities of patients with osteoarthritis of the knee. Arthritis Care Res 13(5):312–319
41. Thompson C, Kinmonth AL, Stevens L, Peveler RC, Stevens A, Ostler KJ, Pickering RM, Baker NG, Henson A, Preece J, Cooper D, Campbell MJ (2000) Effects of a clinical-practice guideline and practice-based education on detection and outcome of depression in primary care: Hampshire Depression Project randomised controlled trial. Lancet 355(9199):185–191
42. van der Waal JM, Terwee CB, van der Windt DA, Bouter LM, Dekker J (2005) Health-related and overall quality of life of patients with chronic hip and knee complaints in general practice. Qual Life Res 14(3):795–803
43. van der Waal JM, Terwee CB, van der Windt DA, Bouter LM, Dekker J (2005) The impact of non-traumatic hip and knee disorders on health-related quality of life as measured with the SF-36 or SF-12. A systematic review. Qual Life Res 14(4):1141–1155
44. Ware JE Jr, Gandek B (1998) Overview of the SF-36 health survey and the international quality of life assessment (IQOLA) project. J Clin Epidemiol 51(11):903–912