Thieme

Influence of Weight Bearing on Postoperative Complications after Surgical Treatment of the Lower Extremity

Einfluss der frühen postoperativen Belastung auf die Entstehung von Komplikationen

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ABSTRACT

Purpose In order to prevent implant failure and secondary fracture dislocation, it is often recommended that patients perform partial weight-bearing after surgery of the lower extremity. Previous examinations showed that patients are often not able to follow these instructions. In this study, patients who had undergone surgery of the lower extremity were studied in order to analyze whether incorrect loading influenced the number and severity of complications.

Methods Fifty-one patients were equipped with electronic shoe insoles, which measure loading and other parameters. The measurement period was 24 to 102 hours. Median duration of follow-up was 490 days. The primary outcome parameter was postoperative complications leading to revision surgery. Statistical analysis was performed using the chi-square and Fisher exact tests with significance set at a $p < 0.05$.

Results Seven out of fifty-one patients had postoperative complications. Four wound complications, one implant failure, chronic instability after fracture of the tibia, and one implant loosening of a hip prosthesis were recorded. In total, 26 of 39 patients were not able to follow the postoperative instructions. Five of the twenty-six patients with difficulties in partial weight-bearing suffered a postoperative complication. In comparison, only 2 of the other 25 patients were affected. There was no statistically significant correlation between high weight-bearing and occurrence of complications ($p = 0.29$).

Conclusion Most of the patients were unable to follow the surgeon's instructions for partial weight-bearing. Excessive loading did not seem to influence the number and severity of postoperative complications, especially regarding implant failure. Therefore, we should continue with measurements and reevaluate the "partial weight-bearing doctrine".

ZUSAMMENFASSUNG

Fragestellung Um ein postoperatives Implantatversagen oder eine sekundäre Dislokation von Frakturen zu vermeiden, werden Patienten häufig angewiesen die betroffen Extremität nach operativer Versorgung nur limitiert zu belasten. Untersuchungen haben gezeigt, dass diese Vorgaben nur bedingt von den Patienten umgesetzt werden können. In dieser Studie soll gezeigt werden ob durch ein solchen Verhalten das Auftreten von Komplikationen begünstigt wird.

Material und Methoden 51 Patienten wurden mit elektronischen Schuheinlagen, welche in der Lage sind Belastungen und weitere Parameter zu messen, ausgerüstet. Die Messdauer betrug 24 bis 102 Stunden. Das Follow up betrug durchschnittlich 490 Tage. Zielparameter waren postoperative Komplikationen, welche in der Patientenakte dokumentiert wurden. Statistische Analyse wurden mit Chi Quadrat Test und dem exakten Test nach Fischer durchgeführt, wobei p-Wert von unter 0,5 als signifikant gewertet wurde.

Ergebnisse Bei 7 der 51 Patienten zeigten sich Komplikationen. 4 Wundkomplikationen, ein Implantatversagen, eine chronische Instabilität nach einer Tibiakopffraktur und eine Nachsinterung eines Hüftschafts konnten beobachtet werden. 26 von 51 Patienten waren nicht in der Lage die Empfehlungen einzuhalten. Bei 5 dieser 26 Patienten zeigten sich Komplikationen, wohingegen nur bei 2 der übrigen 23 Patienten Komplikationen beobachtet wurden. Es zeigte sich kein statistisch signifikanter Zusammenhang zwischen einer hohen postoperativen Belastung und dem Auftreten von Komplikationen (p-Wert 0,29).

Schlussfolgerung Die meisten Patienten befolgen nicht die Belastungsempfehlung des Operateurs. Eine übermäßige Belastung scheint jedoch nicht das Auftreten und die Schwere von Komplikationen zu beeinflussen- vor allem in Hinblick auf Implantatversagen. Daher sollten die Messungen fortgeführt und die Sinnhaftigkeit einer limitierten Belastung reevaluiert werden.

Introduction

Surgeons often recommend partial or no weight-bearing after surgery to avoid complications such as implant failure, secondary fracture dislocation, or problems with tissue and bone healing [1, 2]. Different studies have demonstrated that patients are often not able to realize the surgeons' recommendation. Braun et al. observed incompliance of 53 % of patients with femur, tibia shaft, and ankle fractures, whereas Chiodo et al. reported that 27.5 % of the probands did not follow instructions [3, 4]. Especially patient age and high body weight were predictors for incompliance [5].

Different training methods are known to improve compliance. Bathroom scales are often used by physiotherapists to visualize loading, but recent investigations confirmed that biofeedback methods, e.g., real-time haptic (vibratory) biofeedback, are more successful [6, 7, 8].

Correlation of early excessive weight-bearing and occurrence of complications in trauma patients has not been well examined yet. Biomechanical studies have shown that immediate weight-bearing accelerates bone healing [1]. Clinical investigations support this statement for ankle fractures or intramedullary nailing after femoral fractures [9]. In addition, early full weight-bearing did not increase the number of complications after uncemented total hip arthroplasty [10]. In orthopedic trauma surgery, especially after intra-articular fractures, the majority of surgeons recommend partial weight-bearing for 6 to even 12 weeks to avoid secondary fracture displacement [9].

The aim of this study was to investigate the influence of early excessive weight-bearing on the number and severity of complications, making surgery necessary. Smart shoe insoles manufactured by Moticon were chosen to examine weight-bearing behavior.

Material and Methods

Sixty-one patients with an injury and subsequent surgery of the lower extremity were included in this prospective study. Inclusion was not linked to a specific fracture, therefore different injuries, e.g., pertrochanteric fractures, femoral neck fractures, tibia head and ankle fractures as well as patients with a meniscal repair, were included. Different weight-bearing recommendations (full weight-bearing, partial weight-bearing [20 kg], non-weight-bearing) were given. Different aftercare protocols were recommended to support wound and bone healing as well as osseointegration of implants.

Excluded were patients with dementia or an injury of the opposite side.

Each patient was equipped with special electronic shoe soles (Moticon OpenGo System) the first day after surgery. First- and second-generation electronic shoe soles were used for this study. Electronic shoe soles were removed 1 to 4 days after surgery and read immediately.

In 51 cases, follow-up was complete and insole data was sufficient for statistical analysis.

Insoles included 13 sensors, which measured plantar pressure, balance, movement, and gait (▶ **Fig. 1**a).

Data can be downloaded wireless or with a USB cable. Subsequent analysis was performed with software that generates patient-specific reports (▶ **Fig. 1**d,e).

The insoles also had a smart record function, which saves battery and memory capacity. A sampling rate of 10 Hz was used in the study. Equipped with the electronic shoe insole the first day after surgery, measurements took 24 to 101 hours depending on the residence time. Patients were seen in our outpatient clinic after 3, 6, and 12 months for reevaluation of complications. Furthermore, electronic patient records were scanned for additional complications (e.g., wound infections, fracture displacement, implant loosening). Complications leading to subsequent surgery were detected. Occurrence of complications was compared to initial weight-bearing.

Incompliance was defined as exceeding the limitation of 20 kg on average during the period of measurement, when partial weight-bearing was required.

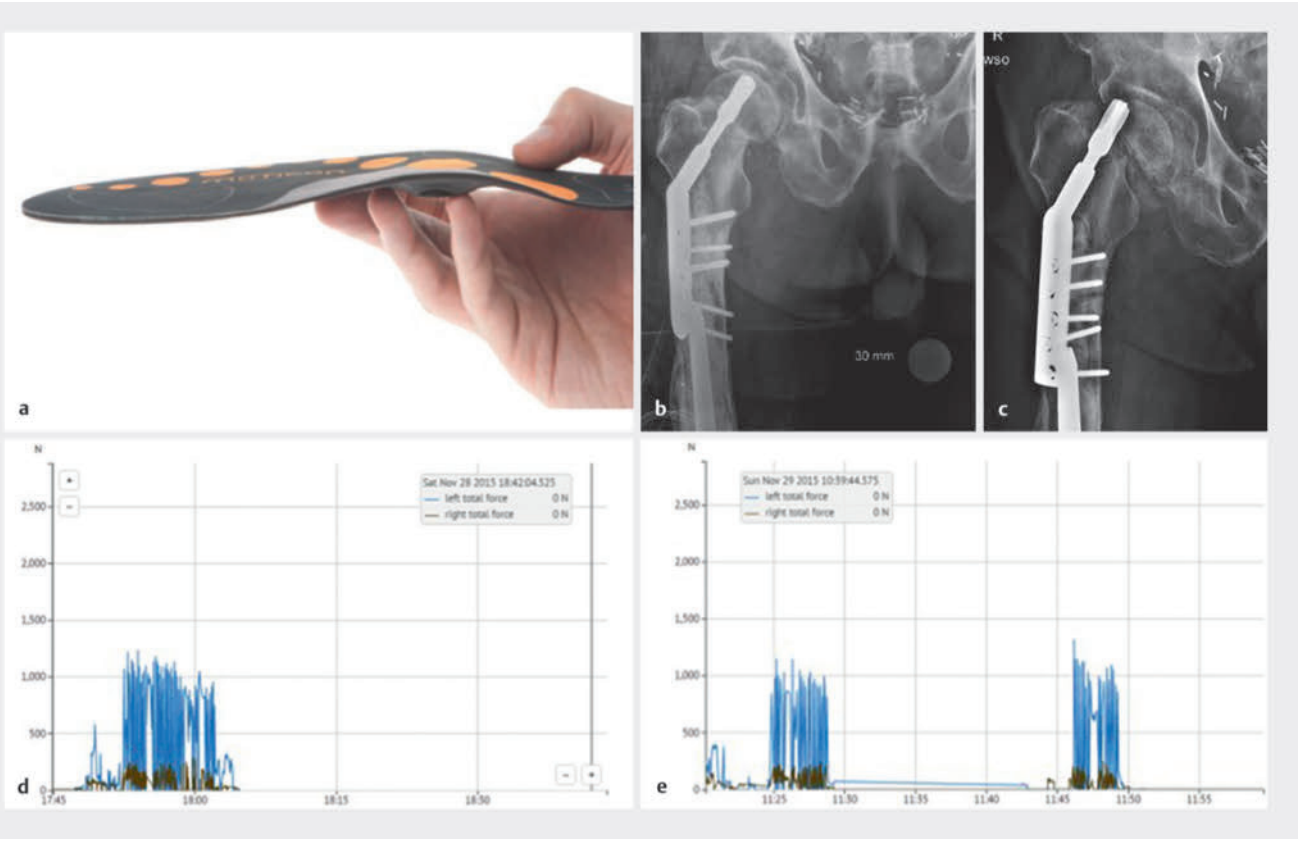
Statistical analysis was performed after talking to our department for statistics using chi-square, t-test, and Fisher's exact test with significance set at a p value < 0.05.

Results

The mean age of the collective was 56.3 years (range 19–92 years, SD 19.9).

Partial weight-bearing of 20 kilograms was recommended in 39 patients. Eleven patients were allowed to perform full weight-bearing and one patient had to perform non-weight-bearing (▶ **Table 1**).

Average load of the whole collective was 32.6 kilograms (4.8–109.2 kg, SD 20.9). Fifteen patients with restricted weight-bearing were able to follow the instructions. Consequently, 25 patients could not meet partial weight-bearing instructions (compliance



▶ **Fig. 1** Case study with gait report.

rate 37.5 %). Average load of the patients who were supposed to perform partial weight-bearing was 27.3 kg (4.8–66.8 kg, SD 14.3). No statistically significant correlation between postoperative behavior instructions and real loading could be observed (p value 0.39).

Elderly patients (> 65 years of age) were less able to meet instructions compared to younger patients (36 kg [9.4–109.2 kg, SD 23.8]) vs. 30.2 kg (8.6–66.8 kg, SD 18.2, p value 0.27) even though their body weight was lower (73.8 vs. 77.1 kg). Active patients overloaded their injured extremity more than non-active patients (37.8 kg [10.7–83.8 kg, SD 18.8] vs. 28.7 kg [4.8–109.2 kg, SD 21.5], p value 0.79). Female patients overloaded the operated extremity more in comparison to male patients (37.4 kg [8.6–109.2 kg, SD 25] vs. 28.4 kg [4.8–66.3 kg, SD 15.2], p value 0.32). Patients with a higher body mass index (BMI, over 25) followed the instructions less than lightweight patients (36.9 kg [4.8–66.8 kg, SD 18.1] vs. 25.1 kg [8.6–109.2 kg, SD10.2], p value 0.58, ▶ **Fig. 2**).

Seven out of fifty-one patients had postoperative complications (13.7 %). In four cases, wound complications were observed. One implant failure (76-year-old male), one chronic instability after a tibial head fracture (34-year-old male), and one subsidence of the shaft after implantation of a hip prosthesis (80-year-old female) were seen. In total, 26 of the 39 patients were not able to follow postoperative instructions (67 %). Five of these patients had a complication, whereas two of the other “compliant” twenty-five study participants were affected. There was no statistically significant correlation between high weight-bearing and occurrence of complications (p value 0.29). On the other hand, no early weight-bearing related-benefits like decreased number of pneumonia or thromboembolic events were observed.

The patient with subsidence of a hip prosthesis was advised to execute partial weight-bearing for at least 2 weeks after surgery and had an average loading of 22.8 kilogram.

Average weight-bearing of the patient with implant failure of a DHS, 6 weeks after surgery, was 15.4 kilogram, which implies that he followed the 20-kilogram weight-bearing instructions (▶ **Fig. 2**). One patient had a subjective instability after plate fixation of a tibial head fracture. In this case, we measured an average loading of 8.6 kg. The average weight-bearing of the four patients with wound infections was 36.5 kg, so higher than the weight-bearing recommendation.

▶**Table 1** Number, treatment, and aftercare of patients (fwb: full weight-bearing, pwb: 20 kg partial weight-bearing, nwb: non-weight-bearing).

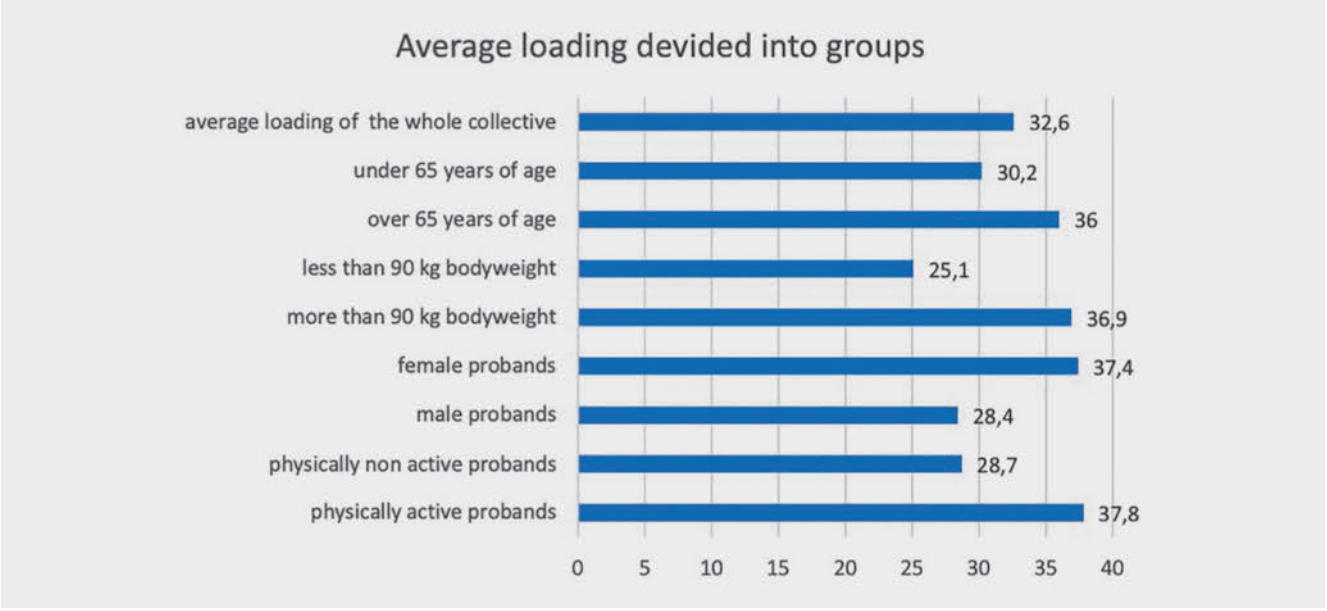
Kind of injury	Kind of treatment	Number of patients	Instruction	Mean age	Gender
Pertrochanteric femur fracture	CRIF (Proximal femur nail anti-rotation)	2	fwb	84	50% female 50% male
Subtrochanteric femur fracture	ORIF (Proximal femur nail anti-rotation with cerclage)	3	pwb (2 weeks)	76	33% female 67% male
Coxarthrosis with destruction of the acetabulum	Total hip arthroplasty	4	pwb (2 weeks)	68	50% female 50% male
Coxarthrosis	Total hip arthroplasty	5	fwb	61	80% female 20% male
Tibial head fracture	ORIF (Plate)	1	pwb (6 weeks)	78	female
Gonarthrosis	Total knee arthroplasty	3	pwb (2 weeks)	67	male
Medial femoral neck fracture	Hemiarthroplasty	3	pwb (2 weeks)	79	67% female 33% male
Medial femoral neck fracture	Hemiarthroplasty (cemented)	2	fwb	77	50% female 50% male
Weber B fracture	ORIF (Plate)	1	pwb (6 weeks)	23	female
Meniscal tear	Meniscal repair	2	pwb (6 weeks)	42	male
Meniscal tear	Partial meniscus resection	4	pwb (2 weeks)	38	25% female 75% male
Patella fracture	Removal tension belt	1	fwb	69	female
Patella fracture	Tension belt	3	pwb (2 weeks)	36	33% female 67% male
MPFL rupture	Mpfl plastic	2	pwb (6 weeks)	23	female
Skin defect after sarkom resection	Flap plastic	2	pwb (6 weeks)	48	50% female 50% male
Medial femoral neck fracture	ORIF (DHS Blade)	1	pwb (6 weeks)	68	female
Consolidated lower leg fracture	Implant removal tibia and fibula	6	pwb (2 weeks)	64	67% female 33% male
Periprosthetic femoral fracture	Revision arthroplasty	1	pwb (6 weeks)	77	male
Distal femur fracture	ORIF (Plate)	1	nwb (6 weeks)	43	male
Sacral fracture	CRIF (Iliosacral screw)	2	fwb	56	50% male 50% female

Discussion

Partial weight-bearing has always been a major point of discussion after surgery of the lower extremity by orthopedic trauma surgeons. Since new devices are available for the measurement of loading and the possibility of even giving biofeedback, monitoring of mobilization after trauma is much easier [8]. This study demonstrates that many patients experience difficulty with postoperative weight-bearing instructions. A big limitation of this study is the short period of measurement (24 to 101 hours after surgery). However, even in the first hours after surgery, patients could not meet weight-bearing restrictions. Other investigations showed an increase in noncompliance over time [3, 4].

Furthermore, the study demonstrated that in the investigated cohort, early excessive loading did not seem to influence the number and severity of postoperative complications, especially in regard to implant failures.

One patient with shaft subsidence of a hip prosthesis performed an average loading of 22.8 kg, so there was overloading of only 3 kilograms. Tian et al. included in his meta-analysis six randomized controlled and three non-randomized controlled trials comparing patients with partial to full weight-bearing after uncemented total hip arthroplasty. The group with full weight-bearing showed greater femoral subsidence after 3 months, but no significant difference of femoral subsidence after 2 and 4 years. Furthermore, no difference of the Harris hip score in both groups could be detected [10]. They concluded that no reason for partial weight-bearing in uncemented total hip arthroplasty could be identified. Baer et al. examined the influence of mobilization and early weight-bearing on in-hospital outcome in geriatric patients with hip fractures. They showed that mobilization with full weight-



▶ **Fig. 2** Average loading in kilograms divided into different groups.

bearing within 24 hours is associated with significantly lower in-hospital mortality and a lower number of complications. There was no correlation regarding length of stay, ability to walk, pain, and mobility of the hip [11]. In this study, the subsidence of the shaft was therefore most likely induced by the implantation of an inadequate shaft size, but not by early or excessive weight-bearing. Nevertheless, only one patient after hip arthroplasty was included. Consequently, no statement can be made regarding shaft subsidence and early full weight-bearing.

In this study, no early weight-bearing-related benefits such as decreased number of pneumonia or thromboembolic events were observed. The number of different injuries, which may be less predestined for the occurrence of thromboembolic events and pneumonia, as well as the low patient age of the collective (56 years of age) could be responsible for this.

In 51 patients, only 1 implant failure in a patient with a femoral neck fracture and DHS implantation only 5 days after surgery could be seen. This was a revision intervention after an implant failure of three cannulated screws in a 76-year-old patient as a salvage procedure. The average loading of this patient was 15.4 kg even though excessive weight-bearing was expected. This leads to the assumption that the exact reduction and correct implant placement and not partial weight-bearing is relevant to prevent the loss of reduction and an implant failure. To our knowledge, no studies are known proving this hypothesis.

Four of the other five observed complications were wound complications like wound infections or hematoseromas. In this group, the average loading was 36.5 kg, without a significant correlation between excessive loading and occurrence of wound complications (p value 0.23).

One patient mentioned chronic instability after a tibial head fracture. An average loading of 8.6 kg was measured. In this young patient, an associated injury of the ACL was subsequently detected. Therefore, excessive weight-bearing was not responsible for the limitation.

In total, 26 of 51 included patients could not follow partial weight-bearing instructions. The majority of complications could be seen in these patients (n = 5). No significant correlation between excessive weight-bearing and number of complications could be demonstrated (p value 0.29).

Smeeing et al. included 115 patients ranging from 18–65 years of age after surgery of ankle fractures comparing three groups (unprotected weight-bearing, protected weight-bearing, unprotected non-weight-bearing) in regards to complications and function with a follow-up of 1 year. The unprotected weight-bearing cohort showed a significantly earlier return to work and earlier return to sport without an increased number of complications. Compared to this study, our injury pattern was different, and the collective was rather young (39 to 56 years of age). It can be assumed that bone quality was higher, and the risk of secondary dislocation of the fracture and implant loosening was reduced compared to the oftentimes geriatric patients [12]. In addition, Lorente et al. investigated elderly patients with conservatively treated ankle fracture with regards to complications, function, and quality of life measured by the SF-12. Thirty-seven patients were instructed to perform partial weight-bearing and thirty-three patients were allowed to perform full weight-bearing. The full weight-bearing group showed a significantly higher quality of life and better function without the prevalence of more complications [13].

Williamson et al. displayed in a study of 90 patients, divided into 60 patients performing partial weight and 30 patients performing full weight-bearing after internal fixation of a proximal tibia fracture with a plate, that early full weight-bearing was not as-

sociated with a higher number of complications [14]. This study is limited by the design of a retrospective, only radiographic investigation. Another limitation of these studies [12, 13, 14] is that electronic wearables for measurement of objective weight-bearing were not used.

However, the current trend of aftercare protocols after fracture fixation of the lower extremity shifts to the conclusion that excessive weight-bearing does not seem to influence the number of complications, especially regarding secondary fracture dislocation and implant failures.

Further limitations of this study are the small number of cases and the short follow-up period (12 months). Ten patients dropped out due to malfunction of the insoles (16.4%).

Especially the inhomogeneity of the collective, reaching form injuries of the meniscus to hip arthroplasty, complicates the interpretation of the results. Another limitation is the short measurement time after surgery (24–101 hours), which reduces the meaningfulness of the results as well.

In this study, the first and second generation of the "Moticon Go system" was used. In the meantime, only the third generation is available, having other specifications compared to the first and second generation of the system.

Conflict of Interest

The authors declare that they have no conflict of interest.

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