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Predictors of outcome of non-displaced fractures of the base of the fifth metatarsal

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Abstract The purpose of this study was to identify those factors that influence the outcome after conservative treatment of undisplaced fractures of the fifth metatarsal. This was done with univariate analyses and, for the first time, with regression analyses of day-to-day clinical practice. Thirty-eight patients were treated with plaster and periods of no weight bearing (NWB). Their mean age was 48 years. They were evaluated using the Olerud ankle score, with analogue scales for pain and comfort, and with questions about cosmesis and wearing of shoes. Six patients sustained a Jones fracture and 32 a tuberosity avulsion fracture. The mean period of NWB was 17 days and of casting was 38 days. Three Jones fractures and all the avulsion fractures were healed at the end of treatment. After a mean of 490 days, the global ankle score was 82/100. Ten patients reported problems with shoes and nine reported cosmetic problems. The linear analogue scale for pain was 2.11/10 and for comfort 8.42/10. Gender, age, and fracture type did not affect outcome. The most significant predictor of poor functional outcome was longer NWB, which was strongly associated with worse global outcome, discomfort, and reported stiffness. NWB should be kept to a minimum for acute avulsions of the tuberosity of the fifth metatarsal.

Résumé Le but de cette étude était d'identifier les facteurs influençant le devenir des fractures sans déplacement du cinquième métatarsien après traitement conservateur. Ceci a été fait par analyse univariée et analyses de régression sur la pratique clinique quotidienne. 38 patients, d'âge moyen 48 ans, étaient traités par plâtre et décharge. L'évaluation était faite avec le score de cheville d'Olerud, des scores analogiques pour la douleur et le confort et des questions sur le chaussage et l'aspect cosmétique. Six patients avaient une fracture de Jones et 32 une fracture d'avulsion. La durée moyenne de décharge était de 17 jours et celle de plâtre de 38 jours. Trois fractures de Jones et toutes les fractures d'avulsion étaient consolidées à la fin du traitement. Après une moyenne de 490 jours le score global de la cheville était de 82/100. Dix patients rapportaient des problèmes de chaussage et 9 des problèmes cosmétiques. L'appréciation de la douleur était de 2,11/10 et celle du confort de 8,42/10. Le sexe, l'âge, et le type de fracture n'affectaient pas le résultat. Le facteur le plus prédictif d'un mauvais résultat était la longueur du temps de décharge. La décharge doit être prolongée un minimum de temps après une avulsion de la tubérosité du cinquième métatarsien.

Introduction

Acute proximal fifth metatarsal (MT5) fractures are among the most common foot injuries [1, 3, 6, 7]. Little is known about the factors that influence the final clinical outcome. This is surprising when one considers that inadequate treatment of metatarsal fractures can cause painful plantar keratosis and metatarsalgia [12]. Other factors such as age, gender, fracture type, and treatment characteristics may have a substantial impact on the final clinical outcome. A better knowledge of these factors might provide better understanding of the impact of these fractures on the future lifestyles of these patients.

Therefore, the purpose of this study was to identify the factors contributing to clinical outcome among patients who had undergone conservative treatment. For the first time, this was done by multivariate analysis.

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Materials and methods

The study design was observational, retrospective, and reflective of standard day-to-day clinical practice.

Fifty-five consecutive patients were treated for an acute undisplaced fracture of the base of the fifth metatarsal. Skeletally immature patients and those with stress fractures were excluded. Of these patients, 16 could not be contacted, and one was excluded because of secondary fracture displacement. Thus, 38 patients were available for analysis.

A fracture was considered an avulsion when it was located in the tuberosity of the styloid process of the fifth metatarsal without extension into the intermetatarsal artic-

ulation. For a Jones fracture, the fracture had to extend into but not beyond this intermetatarsal articulation [2].

All patients were given a splint made of plaster of Paris in the emergency department and were instructed in non-weight bearing (NWB) on the affected limb for at least 1 week. Afterwards, the patients were treated by a number of different orthopaedic residents and surgeons. The further modalities of treatment were determined by each doctor according to his or her current day-to-day clinical practice. Specifically, the physicians decided for how long a synthetic cast was applied and how long the patient was not allowed to bear weight.

Table 1 Individual patient data: details of patient characteristics and outcome results (*FU* time of follow-up, *NWB* period of non-weight bearing, *LAS* linear analogue scale, *F* female, *M* male, *A* avulsion fracture, *J* Jones fracture, *N* no problems, *M* mild problems, *B* big problems)

Patient	Gender	Age	FU (days)	Fracture	NWB (weeks)	Shoe problems	Cosmetic problems	LAS pain	LAS comfort	Ankle score
1	F	57	131	A	1	N	N	2	10	95
2	F	69	348	A	1	N	N	0	10	100
3	F	78	161	A	1	M	N	0	10	90
4	F	40	850	A	1	N	M	0	10	100
5	M	26	328	A	1	N	N	2	7	75
6	M	35	602	A	1	N	N	3	9	85
7	M	15	207	A	1	N	N	1	10	80
8	M	19	429	A	2	N	N	0	10	100
9	F	44	397	A	2	M	M	8	3	25
10	M	42	185	A	2	N	N	3	10	95
11	F	72	358	A	2	N	N	0	10	100
12	F	53	584	A	3	M	M	2	8	80
13	M	35	353	A	3	N	N	3	8	70
14	F	20	399	A	3	N	M	4	9	80
15	M	56	358	A	3	M	N	4	5	60
16	F	66	521	A	3	N	N	0	10	100
17	M	34	523	A	3	N	M	3	8	85
18	F	36	603	J	3	N	N	0	10	100
19	F	38	422	A	3	N	N	0	10	100
20	F	48	596	A	3	M	N	3	9	90
21	F	51	433	A	3	N	N	4	7	60
22	F	52	525	J	3	M	N	3	6	80
23	F	54	419	A	3	N	N	0	10	90
24	F	61	884	A	2	N	N	0	10	100
25	F	64	582	A	3	N	N	0	10	85
26	F	66	583	A	3	N	N	0	10	100
27	F	71	940	A	3	N	N	2	10	90
28	F	64	112	A	5	M	M	3	5	50
29	M	20	892	A	2	N	N	4	9	85
30	F	25	842	A	3	N	M	0	10	100
31	M	29	898	J	3	N	N	2	8	90
32	F	35	862	A	3	N	M	6	5	60
33	M	37	155	A	4	N	N	0	10	100
34	F	38	120	A	1	M	N	5	6	70
35	F	47	102	J	5	B	N	6	3	20
36	F	77	884	A	3	N	N	0	10	95
37	F	77	860	J	3	N	N	0	10	95
38	F	77	155	J	3	M	M	7	5	60

Relevant data concerning patient characteristics, fracture type, and treatment modalities were collected from the internal data network and the archives.

The patients were interviewed to obtain information about symptoms and activity level by using a score that had originally been developed by Olerud and Molander for evaluating ankle fractures [11]. It was chosen because it was the only reasonably validated score that covers the aspects of outcome that we considered useful: pain, stiffness, swelling, stair climbing, running, jumping, squatting, use of supports, and ability to work and activities of daily living (ADL). Additional questions about residual cosmetic and shoe problems (none, minor, or major problems) and also about intensity of pain and general feeling of comfort [linear analogue scale (LAS)] were added. The pain scale ranged from 0 (no pain) to 10 (the worst pain one could imagine), and the comfort scale also ranged from 0 (the least possible comfort) to 10 (perfect comfort). Information about the mechanism of trauma was also collected.

We analysed the association between the characteristics of the patients, those of the treatment, and the final outcome measures with univariate analysis, without any adjustment for confounding variables, using the Student's *t*-test and the chi-square test or the Fisher's exact test as appropriate. Next, multiple linear and logistic regression were used to identify the variables that made an important contribution to the variability of the outcome scores while adjusting for confounding variables. Data analyses were performed using SPSS version 12.0 (SPSS, Inc., Chicago IL).

Results

Table 1 summarizes the final clinical outcome measures of the included patients.

The mean age at the time of injury was 48 years (range 15–78). Eleven patients were men (mean age 32 years), and 27 were women (mean age 55 years). Six patients had Jones fractures, and 32 had tuberosity avulsion fractures.

Although most patients did recall an inversion trauma, answers about the mechanism of the fracture were so vague and incomplete that this information could not be included in our analyses.

The mean non-weight-bearing period was 2 weeks and 3 days (range 1–5 weeks), while the cast was worn for a mean of 5 weeks and 3 days (range 1–10 weeks). Except for the fact that Jones fractures were kept non-weight-bearing about a week longer than the avulsion fractures, we could not detect uniform criteria on which decisions about the duration of weight bearing, the duration of cast immobilisation, and so on, were based. Study of the medical records revealed that these decisions were based not only on repeat X-rays but also on the level of pain, the patient's preferences, and the clinical experience of the orthopaedic resident/surgeon.

In the avulsion fracture group, the fracture line showed a tendency to disappear radiographically towards the end of

treatment in all cases. For the Jones fractures, this was definitely not the case in three patients. Nevertheless, they received no further treatment because of lack of symptoms. In both groups it was felt that the exact time to union could not reliably be determined retrospectively. This was, however, not the aim of this study.

The mean follow-up time was 490 days, ranging from 102 to 940 days. The mean result of the ankle score at the final follow-up was 82.4 (range 20–100). Of the 38 patients, ten reported problems with wearing shoes. For one of them this problem was important; the others considered it mild. Only eight patients experienced any form of cosmetic problems. The mean linear analogue score for pain was 2.11, and the mean score for general comfort was 8.42.

The univariate analyses showed the following results: The women were 23 years older than the men ($p=0.0001$). For Jones fractures, the NWB period was a week longer ($p=0.02$), and problems with stair climbing and jumping ($p=0.009$ and 0.006 , respectively) were more frequent than after avulsion fractures. Patients older than 45 experienced more problems with jumping and running than younger patients ($p=0.048$ and 0.009 , respectively). After this age there was also a tendency ($p<0.15$) to report more shoe problems and difficulties with stair climbing. In women there was a tendency ($p<0.15$) to report more problems with jumping. A NWB period of more than 4 weeks was associated with more pain, more problems with running, more problems with jumping, and a lower level of work and daily activities ($p=0.038$, 0.014 , 0.030 , and 0.001 , respectively). A longer NWB period was also associated with a tendency ($p<0.15$) to report more shoe problems, more stiffness, more swelling, and more problems with squatting. A follow-up time of more than a year was associated with a tendency ($p<0.15$) to report pain more often.

Given these results, the following variables were considered for the multiple regression analyses: gender, age, fracture type, time of follow-up, and duration of NWB. The studied outcomes were the global outcome scale, shoe and cosmetic problems, and also five subcategories of the ankle scores (stiffness, stair climbing, running, jumping, and work ADL). Linear regression models were fitted for the continuous variables, and logistic regression models were fitted for the categorical variables of outcome.

The results of these regression models are shown in Tables 2 and 3. These analyses point to a significant association ($p=0.019$) between the duration of NWB and the total ankle score, with a decrease of this score of 6.18/100 for every supplementary week of NWB, and to a marginally significant association ($p=0.088$) between the NWB period and the analogue comfort score, with a decrease of the latter of 0.58 for every supplementary week (Table 2). Furthermore, a longer NWB period was significantly associated ($p=0.045$) with a higher incidence of reported stiffness (odds ratio 3.58) and marginally significantly ($p=0.145$) with a decrease of work and ADL level (odds ratio 3.18; Table 3). Neither gender, age, nor fracture type was associated with changes of parameters of

global outcome (Table 2). A Jones fracture, on the other hand, was associated statistically ($p=0.045$ and 0.042 , respectively) and clinically (odd ratios of 40 and 24, respectively) with difficulty in stair climbing and jumping (Table 3). Finally, a longer follow-up time was significantly associated with an increase of total ankle score and marginally significantly (p -values of 0.115 and 0.052, respectively) with a better pain and comfort score. These associations are, however, not clinically significant, with changes of 1/100 for the total ankle score for every 5 weeks of extra follow-up or 1/10 for pain and comfort for every 70 and 50 weeks of extra follow-up, respectively (Table 2). Also, the clinical significance of the association between follow-up time and some subparameters of outcome (Table 3) is limited, with odds ratios around 1.

Discussion

Fifth metatarsal fractures are relatively common. However, scientific evidence about the best conservative treatment for acute tuberosity avulsion fractures is scarce, and the factors affecting the clinical outcome and prognosis of all proximal fifth metatarsal fractures are unknown [1, 5, 17]. Identifying those factors is useful in order to study their exact influence in future trials. These were the reasons for conducting this study. We analysed the differences in day-to-day clinical practice of several orthopaedic surgeons. In contrast to all previously published articles, statistical

Table 2 Multivariate analyses: results of the linear regression models (LAS linear analogue scale, NWB time duration of therapy with a non-weight-bearing cast)

	B-coefficient	Standard error	β -coefficient	p -value
Gender:				
Ankle score	5.042	8.307	0.113	0.548
LAS pain	-0.388	0.994	-0.079	0.699
LAS comfort	0.396	0.890	-0.084	0.659
Age:				
Ankle score	0.167	0.209	0.147	0.430
LAS pain	-0.031	0.025	-0.251	0.218
LAS comfort	0.018	0.022	0.150	0.429
Fracture type:				
Ankle score	-5.701	8.917	-0.103	0.527
LAS pain	0.911	1.068	0.149	0.400
LAS comfort	-1.237	0.955	-0.211	0.204
Follow-up time:				
Ankle score	0.029	0.012	0.375	0.019 ^a
LAS pain	-0.001	0.001	-0.266	0.115
LAS comfort	0.003	0.001	0.310	0.052 ^b
NWB time:				
Ankle score	-6.183	3.056	-0.326	0.050 ^a
LAS pain	0.364	0.366	0.174	0.328
LAS comfort	-0.577	0.327	-0.289	0.088 ^b

^aSignificant p -values (<0.05)

^b p -value <0.1

analysis was performed using multiple regression models (logistic or linear, as appropriate). This is the only way to better understand the intertwining influence of different variables on the variability of the outcome parameters.

The osseous anatomy of the proximal MT5 has contributed to subdividing fractures in this area into three fracture types [9]. The first type can be described as an avulsion fracture of a variable-sized portion of the tuberosity or styloid process. The second type is the Jones fracture, an acute transverse fracture of the junction of the diaphysis and the metaphysis (within 1.5 cm of the tuberosity) without extension distal to the intermetatarsal articulation. The third fracture is a diaphyseal stress fracture, a fracture of the shaft, preceded by prodromal symptoms [13].

According to Jones, the mechanism of a Jones fracture usually involves body pressure on an inverted foot while the heel is raised. Kavanaugh et al., however, ascribed the injury to vertical mediolateral forces on the fifth metatarsal and not to inversion [8]. Inversion injuries commonly cause avulsion fractures at the base of the fifth metatarsal secondary to the pull of the peroneus brevis, whereas repetitive microtrauma may cause a stress fracture [12]. Unfortunately, in this study the data required to analyse the causal mechanism were not available. The finding that the women were significantly older than the men might suggest different fracture mechanisms in men and women.

In the literature, the list of possible conservative treatments for acute avulsion fractures is long, ranging from tapes to semirigid and traditional casts with different lengths of immobilisation periods [1, 2, 9, 13, 17]. For acute Jones fractures, the conservative treatment consists of casting and NWB [10, 13, 16]. In cases of symptomatic delayed or non-union of a Jones fracture [1, 4, 8, 13], a Jones fracture in athletes [8, 10, 13, 14, 18], or a displaced intraarticular avulsion fracture [9, 10, 14, 16], treatment using open reduction and fixation can be performed.

Delayed and non-union are frequently reported after conservative treatment of Jones fractures, especially if the NWB period was shorter than 6–8 weeks [1, 6–8, 16, 18]. In our series, this was also the case in three out of six patients with a relatively asymptomatic delayed union at the end of their treatment.

By its nature, regression analysis provides the strongest evidence about which variables are linked to the different measures of outcome and to what extent. The most important factor allowing the prediction of outcome is the length of the NWB period. It is significantly associated with a decrease in total ankle score, with a higher incidence of reported stiffness, and marginally significantly with a decrease of the analogue comfort scale and with a worse work and ADL level.

From these findings, we can infer that the period during which the patient bears no weight on the afflicted foot should be kept to a minimum as far as acute avulsion fractures are concerned. Theoretically, it cannot be concluded from our series that early weight bearing results in a better clinical outcome, i.e. that a causal relationship exists between early weight bearing and a good outcome.

Table 3 Multivariate analyses: results of the logistic regression models (*ADL* activities of daily living, *NWB time* duration of therapy with a non-weight-bearing cast)

	B-coefficient	Standard error	Wald coefficient	<i>p</i> -value	Exp(B)
Gender:					
Shoe problems	-1.562	1.399	1.247	0.264	0.210
Cosmetic problems	-2.358	1.370	2.962	0.085 ^b	0.095
Stiffness ^a	-0.799	1.068	0.560	0.454	0.450
Stairs ^a	-8.446	77.475	0.012	0.913	0.000
Work, ADL ^a	-8.537	46.643	1.033	0.855	0.000
Running ^a	-9.127	116.028	0.006	0.937	0.000
Jumping ^a	-7.552	45.167	0.028	0.867	0.001
Age:					
Shoe problems	0.022	0.032	0.471	0.493	1.022
Cosmetic problems	-0.054	0.032	2.782	0.095 ^b	0.947
Stiffness ^a	-0.038	0.030	1.556	0.212	0.963
Stairs ^a	-0.001	0.050	0.000	0.987	0.999
Work, ADL ^a	-0.012	0.039	0.091	0.763	0.988
Running ^a	0.024	0.042	0.321	0.571	1.024
Jumping ^a	0.066	0.050	1.765	0.184	1.069
Fracture type:					
Shoe problems	1.273	1.425	0.798	0.372	3.570
Cosmetic problems	-1.300	1.364	0.908	0.341	0.273
Stiffness ^a	0.548	1.160	0.223	0.637	1.729
Stairs ^a	3.681	1.834	4.031	0.045 ^c	39.705
Work, ADL ^a	0.645	1.431	0.203	0.652	1.906
Running ^a	0.352	1.506	0.055	0.815	1.422
Jumping ^a	3.169	1.557	4.143	0.042 ^c	23.787
Follow-up time:					
Shoe problems	-0.006	0.003	4.380	0.036 ^c	0.994
Cosmetic problems	0.001	0.002	0.103	0.748	1.001
Stiffness ^a	-0.004	0.002	3.259	0.071	0.996
Stairs ^a	-0.005	0.004	1.662	0.197	0.995
Work, ADL ^a	-0.003	0.003	1.350	0.245	0.997
Running ^a	0.002	0.003	0.248	0.618	1.002
Jumping ^a	-0.001	0.002	0.088	0.767	0.999
NWB time:					
Shoe problems	0.646	0.636	1.032	0.310	1.908
Cosmetic problems	0.674	0.477	1.994	0.158	1.961
Stiffness ^a	1.274	0.636	4.018	0.045 ^c	3.577
Stairs ^a	0.434	0.703	0.381	0.537	1.543
Work, ADL ^a	1.157	0.793	2.129	0.145	3.180
Running ^a	7.909	60.412	0.17	0.896	2722.25
Jumping ^a	0.440	0.539	0.667	0.414	1.553

^aThese parameters are part of the ankle score^b*p*-values <0.1^cSignificant *p*-values (<0.05)

The possibility exists that patients who have a good capacity for healing bear weight earlier. Because these patients could not be identified retrospectively by X-ray or other criteria and because many authors advocate weight bearing for avulsion fractures after oedema and pain subside, with good results, it can reasonably be assumed that the shortest possible NWB period results in the best clinical outcome [1, 2, 9, 13, 17]. The fact that this variable so strongly influences the global score, the comfort, and the

reported stiffness after a mean follow-up of 70 weeks is surprising, yet important.

Gender and age seem to be less important in predicting outcome because they were only marginally significantly associated with a single subparameter (cosmetic problems) and not with the overall result.

Likewise, the fracture type had no influence on the global outcome. This is surprising because our univariate analyses (stratification by fracture type) showed a significant association of Jones fractures with a longer NWB

period, and our regression analysis showed an importantly increased risk for people with Jones fractures to report problems with stair climbing and jumping. These findings might perhaps be explained by the longer NWB period prescribed by the physician because of the bad reputation of this fracture type. Jones fractures are known to have poor functional results and a high non-union and delayed union rate, especially after less than 6–8 weeks of NWB in a cast [1, 5, 13, 15, 16]. The latter is illustrated by our series. On the other hand, we could not confirm the poor functional results of Jones fractures, probably because there were only six of them. Problems with climbing stairs and jumping suggest that high-demand activities can be problematic after a Jones fracture. However, the patients in our study were not athletic. The influence of the fracture type, especially on the ability to perform sports, might be a subject for further research. But this is not a reason to exclude the Jones fractures from the current regression analyses. The purpose of this analysis was to study the influence of all factors that seemed important after univariate analysis. Furthermore, apart from a week of more NWB, the Jones fractures were not treated fundamentally differently. On the other hand, the conclusions of this series might be valid only for avulsion fractures.

In our series, strong evidence is provided that the duration of the non-weight-bearing period is the most important variable linked to final clinical outcome after an avulsion fracture of the proximal fifth metatarsal. No definite conclusions about the influence of fracture type on the final results can be made. The univariate analyses suggest, however, that its most important influence is on high-demand activities.

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