Foot Pressures in Feet after Mitchell Osteotomy for Hallux Valgus

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Abstract

The purpose of this study was to employ a Pedar in-sole pressure system to identify the foot pressure distribution after Mitchell osteotomy for hallux valgus, and to find out the changes after surgery through comparing foot pressure in the affected side of patients with those in the unaffected side during level walking. Twelve patients who had a Mitchell procedure to correct hallux valgus deformities were examined with foot pressure measurement system at an average of 7.67 months (range, two to twenty-seven months) after the operation. The average age of the patients was forty-eight years (range, twenty to sixty-five years). The result showed that an increase in supporting time in feet with hallux valgus during walking. The contact areas of feet with hallux valgus were similar with the normal feet. In feet with hallux valgus, peak pressures, maximum peak pressure, pressure-time integrals and force-time integrals under the hindfoot and lateral midfoot had a significant increase. Inverse results shown in forefoot and toes. It meant the hallux valgus foot for average of 7.67 months follow up after Mitchell osteotomy bears higher load on the hindfoot and lateral midfoot regions. After osteotomy correction of the hallux valgus, the peak pressures under the metatarsal heads were observed in the second and third metatarsal heads in most cases. They were similar with the normal feet.

Keywords: Mitchell osteotomy, Hallux Valgus, Foot, Pressure

Introduction

Mitchell osteotomy is one of the commonest and appropriate operations done for hallux valgus [4-5,7-9,11,14]. In 1945 Hawkins, Mitchell and Hedrick modified the Homam technique to give us what we commonly refer to today as the Mitchell osteotomy. This is a lateral displacement angulation osteomy of the distal first metatarsal fixed with sutures and accompanied by medial eminence resection and application of the medical capsule. Mitchell osteotomy is appropriate for mild to moderate deformities. Research shows that most people who have Mitchell osteotomy corrections are satisfied with the results [4-5,7-9,11,14]. However, a number of problems can arise. The big toe is usually stiffer than before and slightly weaker with the correction. In some people the big toe slowly tilts back toward the original position and occasionally this is bad enough to need to have the operation redone. The foot tends to swell up quite a lot after surgery. People vary in how quickly this swelling disappears after an operation and 6 months is not all that unusual. This looks like a lot of possible problems, but in fact most people do not get them and are satisfied with their surgeries.

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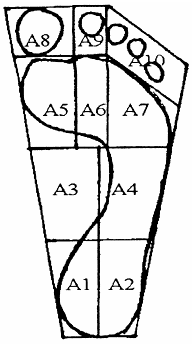
There is a review of the etiology and pathogenesis of hallux valgus by Myerson et. al. (2000) [12] in Foot and Ankle Clinics. They emphasize that the causes are not fully understood but that the following are relevant in the cause. The first is inherited tendency. It is possibly expressed as generalized hypermobility. The second is shoes. Hallux valgus occurs in unshod cultures, but much less commonly than in those who wear shoes. The third is hypermobility. The generalised joint laxity is commoner in people with hallux valgus than without, although this does not prove cause and effect. The fourth is inflammatory arthritis. Inflammatory arthritis can lead to joint laxity and allows deformity to occur readily.

As in normal feet, the pressure patterns of forefoot with hallux valgus were varied: peak pressures were under the first metatarsal head, under the second and/or third metatarsal heads, under the first, second, and/or third metatarsal heads[15]. Peak pressures of hallux valgus feet were larger than those of the normal foot[15]. The peak pressure under the 1st and 2nd metatarsal heads in the foot with hallux valgus was increased significantly[15]. The peak pressure under the great toe was decreased with an increasing hallux valgus angle, and both of them were in negative correlation [13].



A1: Medial heel area
A2: Lateral heel area
A3: Medial midfoot area
A4: Lateral midfoot
A6: Second metatarsal area
A7: Lateral metatarsal area
A8: Great toe area
A9: Second toe area
A10: Lateral toe area

Figure 1. Each footprint was divided into 10 regions to enable analysis of the pressure.

Table 1. The length of the follow up, the age of the patient, type of additional procedures performed, and anthropometric data in 12 patients with hallux valgus treated with a mitchell osteotomy.

Case Number	Age (years)	Gender	Height (cm)	Body Weight (kg)	Surgical duration (Month)	Afected Side	Surgery Type
1	55	F	168	70	2	B	Mitchell osteotomy (B) & 2nd Metatarsal osteotomy (L't)
2	24	F	158	62	2	B	Mitchell osteotomy
3	62	F	158	67	6	R	Mitchell osteotomy
4	53	F	156	51	2	L	Mitchell osteotomy
5	65	F	159	51	6	B	Mitchell osteotomy
6	46	F	158	49	17	B	Mitchell osteotomy
7	59	F	148	59	4	R	Mitchell osteotomy
8	50	F	153	51	4	R	Mitchell osteotomy
9	49	F	154	60	9	L	Mitchell osteotomy
10	43	F	160	52	27	L	Mitchell osteotomy
11	20	F	161	46	7	B	Mitchell osteotomy
12	51	F	155	62	6	L	Mitchell osteotomy
Mean	48		157	57	7.67		
SD	14		5	8	7.35		

In feet with hallux valgus showing peak pressures under the first metatarsal heads, the hallux valgus angle and the intermetatarsal angle were larger than those in feet showing peak pressures on the second and/or third metatarsal heads.

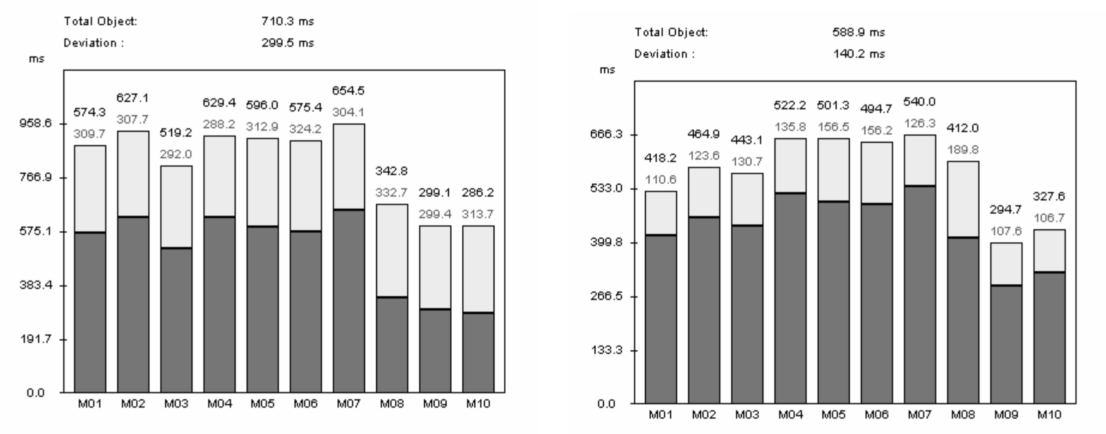
Plantar pressure measurement technology may provide the clinician with valuable objective information for monitoring the effects of therapeutic intervention on the foot. The use of this technology is described in the preoperative and postoperative assessment of patients undergoing various hallux valgus surgeries [2,6,15,16]. The purpose of this study was to employ a Pedar in-sole pressure system to identify the foot pressure distribution after Mitchell osteotomy for hallux valgus, and to find out the changes after surgery through comparing foot pressure in the affected side of patients with those in the unaffected side during level walking.

Methods

Twelve patients comprising 17 feet with hallux valgus treated by Mitchell osteotomy were recruited for the study. Remained 7 normal feet were used to be the comparison group. A full history of each patient was obtained, followed by a careful biomechanical examination of the foot by the same examiner. Body weight, standing height and foot length of each subject was measured before the experiment. Foot length was measured during standing from a vertical heel border to the most anterior point on the longest toe. Four sizes shoes of the same trade-mark and pattern were used in the experiment. These shoes were sport shoes for jogging. The Pedar insole system (Gmbh, Munich, Germany) was used to collect pressure data from the EMED insole, 2mm thick, with individual sensors occupying an area of $17mm^2$. The EMED insole had 99 capacitance sensors and for collecting data at a sampling rate of 50 HZ. It could accurately and reproducibly measure the plantar foot pressures in shoes during a gait cycle [3,10]. We set up the foot pressure measurement system first, and took subjects' history and measure their anthropometric data. Before testing, subjects were asked to practice walking many times. Dynamic data were collected in five seconds ten times. There were ten steps chosen from those original data to analyze. Each footprint was divided into 10 regions (see Fig. 1) to enable analysis of the loading time, force, area and pressure in relation to the anatomical structures. The force time integral is a product of force and time and this is called impulse. Mann-Whitney's U test is used to compare the parameters in the different group. Differences were considered significant when the P value was less than 0.05.

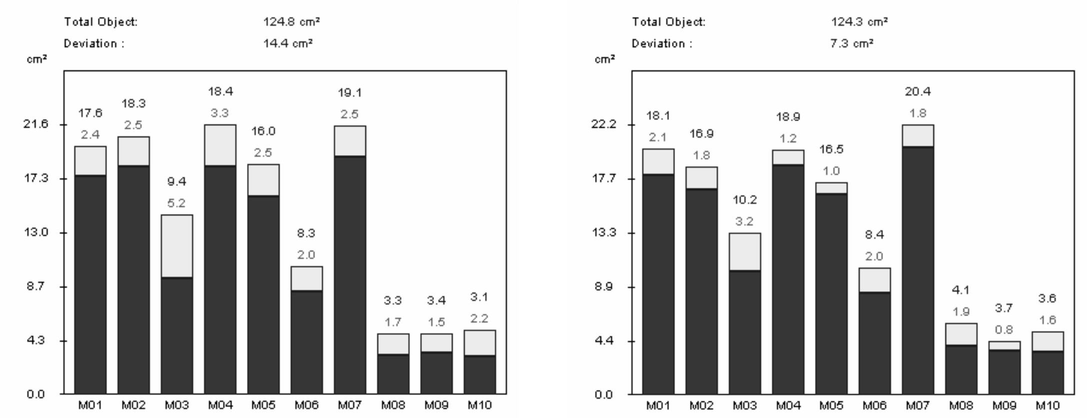
Results

Seventeen feet in 12 patients with hallux valgus treated with Mitchell osteotomy were followed up for 2-27 months (average 7.67 month). The average age of the patients was forty-eight years (range, twenty to sixty-five years). The length of the follow up, the age of the patient, type of additional procedures performed, and anthropometric data in 12 patients with hallux valgus treated with Mitchell osteotomy for each case were listed in Table 1. Fig. 2 showed that a significant increase in supporting time in feet with hallux valgus during walking ($p<0.05$, Mann-Whitney's U test). The



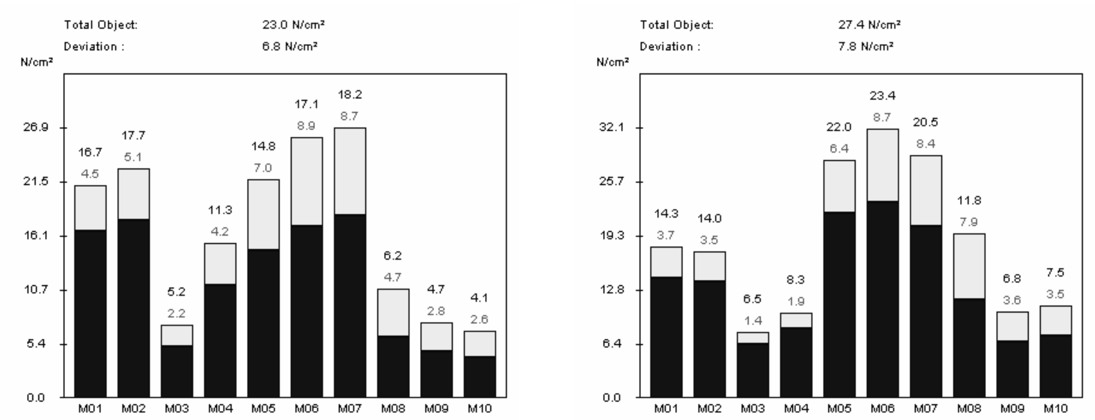
(a) (b)

Figure 2. Regional contact time for subjects in level walking. (a) Hallux valgus foot (710.3±299.5 ms); (b) normal foot (588.9 ±140.2 ms).



(a) (b)

Figure 3. Regional contact areas for subjects in level walking. (a) Hallux valgus foot (124.8±14.4 cm^2); (b) normal foot (124.3±7.3 cm^2). The contact areas of feet with hallux valgus were similar with the normal feet.



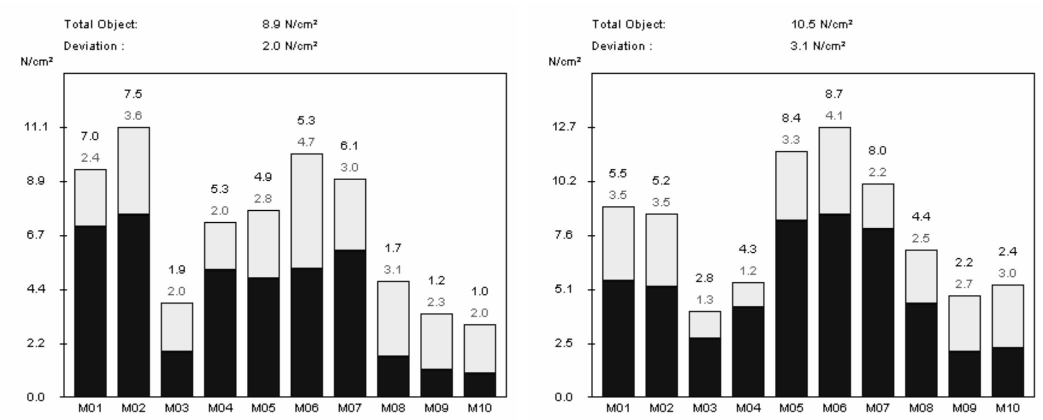
(a) (b)

Figure 4. Regional peak pressure for subjects in level walking. (a) Hallux valgus foot; (b) normal foot.

contact areas of feet with hallux valgus were similar with the normal feet (see Fig. 3). In feet with hallux valgus, peak pressures, maximum peak pressure, pressure-time integrals and force-time integrals under the hindfoot (M01 and M02) and lateral midfoot (M04) had a significant increase ($p<0.05$, Mann-Whitney's U test, Figs. 4-7). Inverse results shown in forefoot (M05-M07) and toes (M08-M10). The forefoot pressures of feet with hallux valgus after Mitchell osteotomy were divided into four patterns as in normal feet: in Type A, peak pressures were under the first metatarsal head; in Type B, peak pressures were under the second metatarsal head; in Type C, peak pressures were under the the second and third metatarsal heads; in Type D, peak pressures were under the third and/or fourth and/or fifth metatarsal heads. Peak pressures of hallux valgus after osteomy were smaller in each type than those of the normal feet (Table 2). After osteotomy correction of the hallux valgus, the peak pressures under the metatarsal heads were observed in the second and third metatarsal heads in most cases (56%). They were similar with the normal feet (Table 2). In normal feet, there were 22% showing the peak

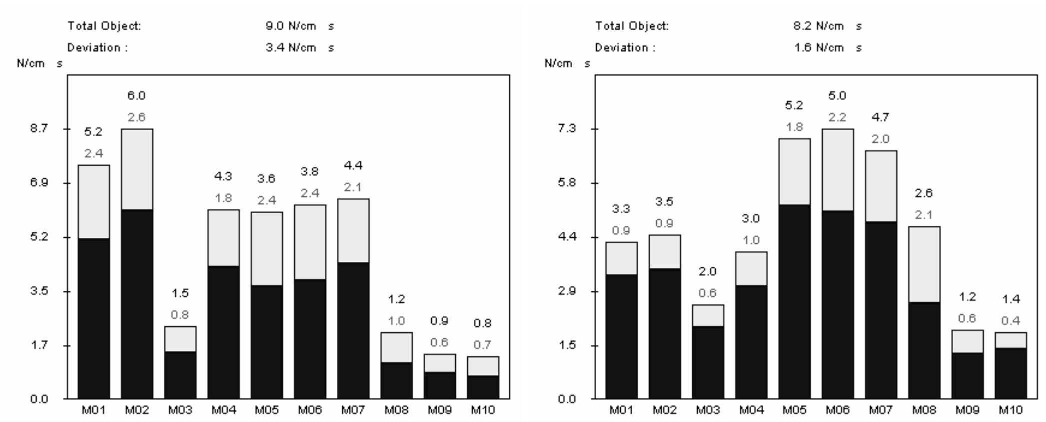
Table 2. The percentage of each peak pressure patterns of normal feet and feet after Mitchell osteomy with hallux valgus. The four pressure patterns of the forefoot were under the first metatarsal head, the second metatarsal head, the second and third metatarsal heads, third and/or forth and/or fifth metatarsal heads.

	Hallux Valgus Feet		Normal Feet	
	Percentage	Peak pressure (N/cm^2)	Percentage	Peak pressure (N/cm^2)
Type A: 1st Metatarsal Head	25%	15.6±5.0	22%	24.1±4.5
Type B: 2nd Metatarsal Head	10%	17.9±6.7	20%	25.5±6.2
Type C: 2nd~3nd Metatarsal Head	56%	19.3±5.5	58%	21.6±6.5
Type D: 3nd~5th Metatarsal Head	9%	19.2±5.3	0%	



(a) (b)

Figure 5. Regional maximum peak pressure for subjects in level walking. (a) Hallux valgus foot; (b) normal foot.



(a) (b)

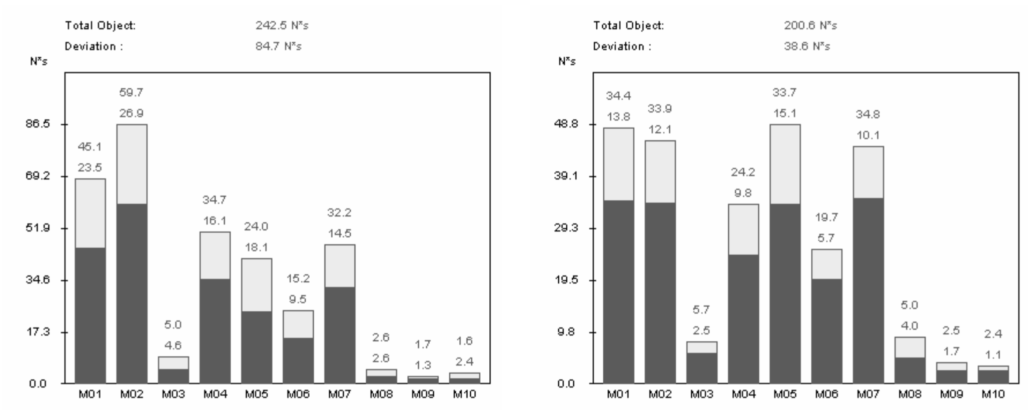
Figure 6. Regional pressure-time integrals for subjects in level walking. (a) Hallux valgus foot; (b) normal foot.

pressure (averaged 24.1 N/cm^2) observed in the first metatarsal head, 20% (averaged 25.5 N/cm^2) in the second metatarsal head, 58% (averaged 21.6 N/cm^2) in the second and third metatarsal heads, and none in the third and/or fourth and/or fifth metatarsal heads. For the 17 feet in which the Mitchell osteomy were done, there were 25% (averaged 15.6 N/cm^2) showing the peak pressure observed in the first metatarsal head, 10% (averaged 17.6 N/cm^2) in the second metatarsal head, 56% (averaged 19.3 N/cm^2) in the second and third metatarsal heads, 9% (averaged 19.2 N/cm^2) in the third and/or fourth and/or fifth metatarsal heads.

Discussion

Regional peak pressures under the first metatarsal head averaged 14.8 N/cm^2 after surgery and 22.0 N/cm^2 in normal feet (see Fig. 4). The pressures under the second metatarsal head averaged 17.1 N/cm^2 after surgery and 23.4 N/cm^2 in normal feet. The pressures under the lateral metatarsal heads averaged 18.2 N/cm^2 after surgery and 20.5 N/cm^2 in normal feet. It meant the hallux valgus foot after Mitchell osteomy for 2-27 months bears lower load on the metatarsal head regions.

As the study of Yamamoto et al[15] in 1996, the pressure patterns of feet with hallux valgus before treatment were varied. The peak pressures were under the first metatarsal head (12%), under the second and/or third metatarsal heads (82%) , under the first, second, and/or third metatarsal heads (6%). In normal subjects, there were 20%, 67.5% and 12.5% showing each pattern in Yamamoto et. al's study. It showed that the peak



(a) (b)

Figure 7. Regional force-time integrals for subjects in level walking. (a) Hallux valgus foot ; (b) normal foot.

pressures of hallux valgus feet (4.1 kgf/cm^2) were larger than those of the normal foot (2.1 kgf/cm^2) in his study[15]. Before surgery, patients seemed to have significantly increased peak pressure in the second and third metatarsal head regions in feet with hallux valgus during walking[1,15]. The early results of this study with short-term to medium-term followup demonstrate the decrease in the peak pressure around the intermetatarsal area and shifts the peak pressure to the hindfoot and lateral midfoot areas. The patients tend to walk with a self-protective pattern after hallux valgus surgery. They avoid using the first metatarsal head for weight bearing for many months after Mitchell osteotomy. This explains why the peak pressure shifts to the hindfoot and lateral midfoot areas. This phenomenon may diminish gradually with time.

From the impulse equation, $Ft= m (v-u)$, it is apparent that the force required to produce a given change of velocity of an object (F: force, t: time, m: mass, v: terminal velocity, u: initial velocity). When the mass of object is constant, the greater impulse would provide the greater change of velocity. The smaller impulse provided smaller ability of forward progression. Therefore, we should pay attention to the greater force-time integrals and pressure-time integrals of two rearfoot areas and lateral midfoot area in the feet after osteotomy surgery. Excessive pressure and force, and increased time in pressure or force are important factors related with foot injuries.

With average 7.67-month followup, the correction seems to hold with no significant recurrence of the deformity. The results demonstrate the effectiveness of this surgical procedure with proximal realignment in a subset of patients with moderate to severe hallux valgus. Longer-term followup with a larger group of patients is needed in future research, but these early results are meaningful for the clinician in providing reliable correction of hallux valgus.

Acknowledgements

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