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RESEARCH ARTICLE

IMPACT OF BIG TOE AMPUTATION ON FOOT BIOMECHANICS

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Abstract

Background: The big toe plays an important role in foot biomechanics. During walking, it poses twice the total pressure of the other four toes. It has a significant contribution in windlass mechanism needed for push off; its amputation will change intensely in foot biomechanics. **Aim:** Comparing the peak-pressures and pressure-time-integral on the foot with unilateral amputations of the big toe with preservation of the 1st metatarsal, with the patients' contralateral-intact-foot. **Subjects and methods:** Ten diabetic patients with unilateral amputations of the big toe of at least 4-years duration were evaluated with the in-shoe-pressure-measurement-system[a] in their diabetic footwear and plate-form[b] while they walk bare feet. We compared peak-pressures and pressure-time-integral under all metatarsals, lesser toes, mid-foot and heel in unilateral amputations of the big toe and contralateral-intact-foot using Wilcoxon's-matched-pairs signed-rank test. **Results:** Using in-shoe-pressure-measurement-system[a], peak-pressures and pressure-time-integral were significantly higher under 1st metatarsal-head, lesser toes in the unilateral amputations of the big toe compared with contralateral-intact-foot, and non-significant changes were found under the lesser metatarsals and midfoot. Heel showed higher pressure on the contralateral-intact-foot, but the results were statistically insignificant. While using plate-form[b], peak-pressures and pressure-time-integral were significantly higher under 1st metatarsal-head, 3rd, 4th and 5th toes in the unilateral amputations of the big toe compared with contralateral-intact-foot with non-significant changes over other regions. **Conclusion:** Big toe amputation significantly altered pressure distribution of the foot with increased foot pressure in forefoot area that contributes to an increased risk of re-ulceration and re-amputation that necessitate in shoe intervention with custom made insoles.

INTRODUCTION

The big toe plays an important role in foot biomechanics. During walking, it poses twice the total pressure of the other four toes **(Tanaka et al., 1996).** Since the great toe is passively dorsi-flexed, the longitudinal arch of the foot is raised, the rearfoot supinated, the leg externally rotated, and the plantar aponeurosis tensed **(Hicks, 1954)**; This is called windlass mechanism and is of great importance since it tenses the plantar fascia thus forming a rigid lever of the foot for push-off **(Chou et al., 2009).** If the mechanism is altered, the timing and effectiveness of push-off would be affected. Therefore, great toe amputation will change intensely in foot biomechanics. An objective of this project is to determine the pressure redistribution occurring after big toe amputation that can predispose to foot ulceration.

Subjects and methods

Ten patients with big toe amputation attending Mansoura diabetic foot clinic for monthly checkup were invited to participate in the study. Patients aged 63 ± 5 years old, 8 of them were males with mean duration of diabetes 15 years. They had unilateral amputations of the big toe (UABT) of at least 4-years duration with no ipsilateral foot deformity or ulcers and with normal contralateral foot. All patients had history of hard callus followed by ulcer at the first metatarsal head (MTH) and one of the two females had history of non-traumatic ulcer of 5th toe.

They were evaluated with the in-shoe pressure measurement system[a] (ISP) in their diabetic footwear and with the plate form[b] (PF) while they walk with bare feet. We compared the peak pressures (PP) and pressure time integral (PTI) under all metatarsals, lesser toes, mid-foot and heel in UABT with preservation of the 1st MTH, with the patient's contralateral intact foot (CIF) using Wilcoxon's matched pairs signed-rank test.

Results

Using in-shoe pressure measurement system, PP and PTI were significantly higher under 1st MTH, lesser toes in the UABT compared with CIF, and non-significant changes were found under the lesser metatarsals and mid-foot. Heel showed higher pressure on the CIF, but the results were statistically insignificant as shown in table 1 and fig.6.

While using the plate form, PP and PTI were significantly higher under 1st MTH (p=0.01) and (p=0.02), 3rd toe (p=0.008) and (p=0.04), 4th and 5th toes together (p=0.01) and (p=0.02), respectively in the UABT compared with CIF with non-significant changes over the 2nd toe, lesser metatarsals, mid-foot and the Heel as shown in table 1 and fig.6.

Table 1 Median peak pressure and pressure time integral using in-shoe pressure measurement system

Region	Peak pressure (kp) using ISP Median (range)		P value	Pressure time integral (kp.s) using ISP median (range)		P value
	UABT	CIF		UABT	CIF	
1st MTH	202(108-420)	81(7-227)	0.02	55(19-81)	35(1-99)	0.01
2nd toe	164(69-344)	56(22-63)	0.01	59(11-101)	10(3-21)	0.03
3rd toe	100(57-219)	98(15-136)	0.03	38(28-100)	19(9-35)	0.01
4th,5th toe	91(76-219)	41(5-128)	0.05	35(17-100)	18(6-24)	0.03

ISP: in-shoe pressure measurement system
UABT: unilateral amputations of the big toe
CIF: contralateral intact foot

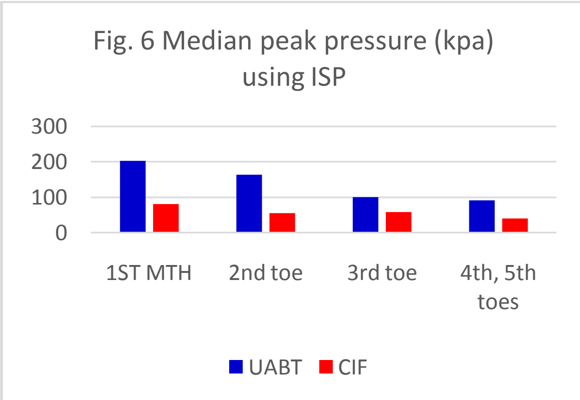
Fig.1 Cairo toe


Fig.2 Greville Chester toe


Fig. 3 Windlass mechanism


Fig. 4 Planter pressure assessment using in-shoe pressure measurement system


Fig. 5 Planter pressure assessment using plat form



ISP: in-shoe pressure measurement system
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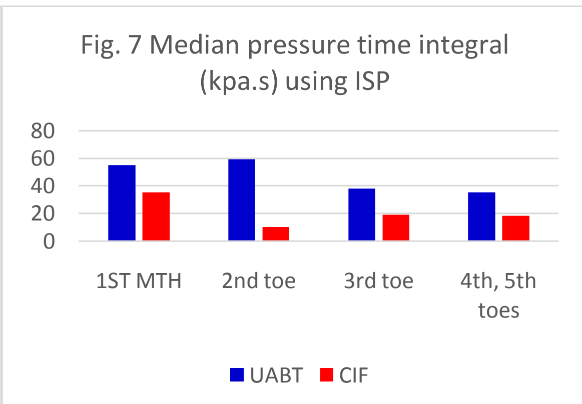

ISP: in-shoe pressure measurement system
UABT: unilateral amputations of the big toe
CIF: contralateral intact foot

Discussion

The big toe plays an important role in foot biomechanics. During walking, it poses twice the total pressure of the other four toes, also it has a pivotal role in the windlass mechanism which tenses the plantar fascia thus forming a rigid lever of the foot for push-off. If the mechanism is altered by big toe amputation the timing and effectiveness of push-off would be affected. Our study aims to study the planter pressure redistribution that occur after big toe amputation.

Conclusion

Big toe amputation significantly alter the pressure distribution of the foot with increased foot pressure in forefoot area that contributes to an increased risk of re-ulceration and re-amputation especially, at the first MTH area, that necessitate custom made insoles to be done following big toe amputation.

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a. Tekscan F-scan device
b. Tekscan Mat scan device