

Incidence of re-amputation following partial first ray amputation associated with diabetes mellitus and peripheral sensory neuropathy: a systematic review

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Diabetes mellitus with peripheral sensory neuropathy frequently results in forefoot ulceration. Ulceration at the first ray level tends to be recalcitrant to local wound care modalities and off-loading techniques. If healing does occur, ulcer recurrence is common. When infection develops, partial first ray amputation in an effort to preserve maximum foot length is often performed. However, the survivorship of partial first ray amputations in this patient population and associated re-amputation rate remain unknown. Therefore, in an effort to determine the actual re-amputation rate following any form of partial first ray amputation in patients with diabetes mellitus and peripheral neuropathy, the authors conducted a systematic review. Only studies involving any form of partial first ray amputation associated with diabetes mellitus and peripheral sensory neuropathy but without critical limb ischemia were included. Our search yielded a total of 24 references with 5 (20.8%) meeting our inclusion criteria involving 435 partial first ray amputations. The weighted mean age of patients was 59 years and the weighted mean follow-up was 26 months. The initial amputation level included the proximal phalanx base 167 (38.4%) times; first metatarsal head resection 96 (22.1%) times; first metatarsal-phalangeal joint disarticulation 53 (12.2%) times; first metatarsal mid-shaft 39 (9%) times; hallux fillet flap 32 (7.4%) times; first metatarsal base 29 (6.7%) times; and partial hallux 19 (4.4%) times. The incidence of re-amputation was 19.8% (86/435). The end stage, most proximal level, following re-amputation was an additional digit 32 (37.2%) times; transmetatarsal 28 (32.6%) times; below-knee 25 (29.1%) times; and LisFranc 1 (1.2%) time. The results of our systematic review reveal that one out of every five patients undergoing any version of a partial first ray amputation will eventually require more proximal re-amputation. These results reveal that partial first ray amputation for patients with diabetes and peripheral sensory neuropathy may not represent a durable, functional, or predictable foot-sparing amputation and that a more proximal amputation, such as a balanced transmetatarsal amputation, as the index amputation may be more beneficial to the patient. However, this remains a matter for conjecture due to the limited data available and, therefore, additional prospective investigations are warranted.

Keywords: *diabetic foot; hallux; ulceration; osteomyelitis; metatarsal; resection*

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Diabetes mellitus with peripheral sensory neuropathy is associated with a high risk for developing ulcerations to the distal aspect of the foot (1–24). Peak ambulatory forces are known to occur about the first ray, leaving this region prone to repetitive stresses and eventual breakdown (1). Ulcerations at this level pose distinct barriers to conservative therapies due to the difficulty in properly offloading the wounds until healed

nor keep them healed over time; inability to provide sufficient daily foot hygiene in debilitated patients; and compromised distal vascular inflow. Accordingly, many of these patients progress towards an amputation (2).

The most appropriate index partial foot amputation level is difficult to accurately determine. However, in general, this involves complete resection of all necrotic, nonviable tissue while creating the most functional,

durable, weight bearing residual foot that can be protected in a variety of shoe-gear types with or without bracing. Routinely, to preserve length and integrity to the remaining foot structures, for pathology about the hallux and first metatarsal, the most distal level of resection is usually chosen resulting in a partial first ray amputation. However, recent studies have questioned the reliability of this amputation level (3–9). In some circumstances, it has been shown that a more proximal index amputation level reduces the risk of re-ulceration and need for progressive levels of re-amputation (25). To further investigate this topic, the authors undertook a systematic review of electronic databases to identify relevant material relating to the incidence of re-amputation following partial first ray amputation associated with diabetes mellitus and peripheral sensory neuropathy but without critical limb ischemia.

Methods

The authors performed a systematic review of electronic databases and relevant peer-reviewed sources including Infotrieve-Pubmed/MEDLINE (<http://www4.infotrieve.com/newmedline/search.asp>). The authors hand searched each identified manuscript for pertinent references. Only manuscripts that involved any form of partial first ray amputation associated with diabetes mellitus and peripheral neuropathy were included.

The authors performed the above systematic review with no restriction on date or language, using an inclusive text word query 'First ray' OR 'Hallux' AND 'Amputation' OR 'Resection' AND 'Diabetes' AND 'Neuropathy' where the all upper-case words represent the Boolean operators employed. Every manuscript was reviewed in their entirety and consensus was met for final inclusion with the lead author being the moderator.

Results

The search for potentially eligible information for inclusion in the systematic review yielded a total of 24 references. All references identified were obtained and reviewed by the authors in September 2010 with additional papers being identified and obtained in May 2011. After considering all of the potentially eligible references, five (20.8%) met our inclusion criteria and were included in this study. Specifically, one evidence-based medicine level I study (4) and four level IV studies met our inclusion criteria (2, 3, 5, 6) (Table 1). The methodological quality of the included studies was generally fair, although one study was designed to be prospective with randomization of patients.

A total of 435 patients with a weighted mean age of 59 years and a weighted mean follow-up of 26 months, were included. The index amputation level included the proximal phalanx base 167 (38.4%) times; first metatarsal head resection 96 (22.1%) times; first metatarsal-phalangeal

joint disarticulation 53 (12.2%) times; first metatarsal mid-shaft 39 (9%) times; hallux fillet flap 32 (7.4%) times; first metatarsal base 29 (6.7%) times; and partial hallux 19 (4.4%) times. The incidence of re-amputation was 19.8% (86/435). The end stage, most proximal level, following re-amputation was an additional digit 32 (37.2%) times; transmetatarsal 28 (32.6%) times; below-knee 25 (29.1%) times; and LisFranc 1 (1.2%) time.

Discussion

The purpose of this systematic review was to evaluate the incidence of re-amputation following partial first ray amputation associated with diabetes mellitus and peripheral neuropathy. The goal of any amputation is complete eradication of nonviable tissue optimizing the host's healing potential while reducing the risk for further breakdown and the need for repeated surgical intervention. To obtain this goal, the level of amputation at initial intervention needs to be chosen with due diligence (3–9, 25). As shown in this study, at a mean follow-up of only 26 months, one out of every five patients who undergo a partial first ray amputation will require a more proximal level re-amputation due to the development of a neuropathic ulceration. Interestingly, the additional level of resection did not occur more proximally along the first ray itself but rather involved a separate digit 32 (37.2%) times, transmetatarsal level 28 (32.6%) times, below-knee level 25 (29.1%) and LisFranc level 1 (1.2%) time.

Weaknesses of this study include the fact that the search for manuscripts that met the inclusion criteria was performed through electronic databases. It is possible that pertinent references may have been inadvertently overlooked or excluded. Moreover, the search did not include a number of potential electronic databases. A more expansive search may have yielded supplementary references for inclusion. Furthermore, the data included in this systematic review spanned nearly 30 years during which the approaches available to treat diabetic neuropathic foot ulceration as well as forefoot amputations has undergone significant change.

However, review of the incidence of amputation is not appreciably different between the earliest and most recent manuscript included in our systematic review. In addition, the inclusion criteria were quite narrow. This produced a small number of manuscripts for evaluation. Many studies included partial first ray amputations along with an additional digit or other surgical intervention. Also, contralateral limb surgery was also performed along with the initial amputation in many studies. Finally, it is possible that some amputations were the result of critical limb ischemia and not solely peripheral sensory neuropathy. This would obviously affect both index amputation healing as well as level of subsequent amputation. With such variety in the description of the procedure, the authors believed it was necessary to define

Table 1. Study data included in this systematic review

Author (Year)	Patients (Number)	Age (Range)	Sex	Original amputation level	More proximal amputations (%)	End stage amputation level (Number; %)	Follow-up (Months) [Range]
Sizer (3) (1972)	206	56.8	N/A	Proximal Phalanx Base (166) 1st Metatarsal Head (40)	8 (3.9%) 7 (3.4%) Total: 15 (7.3%)	Transmetatarsal (15; 7.3%)	N/A
Johnson (4) (1987)	1	29	1M	Proximal Phalanx Base	0	N/A	9
Murdoch (5) (1997)	90	56.2 (31–83)	70M	Partial Hallux (19)	14 (15.6%)	Digital (9; 10%) Transmetatarsal (2; 2.22%) Below Knee (3; 3.33%)	36
		58.7 (45–74)	20F	1st MPJ Disarticulation (36)	24 (26.7%)	Digital (10; 11.11%) Transmetatarsal (5/5.56%) Below Knee (9; 10%)	
				1st Metatarsal Head Resection (12)	7 (7.8%)	Digital (5; 5.6%) Transmetatarsal (1; 1.1%) Below Knee (1; 1.1%)	
				Midshaft (22)	9 (10%)	Digital (2; 2.2%) Transmetatarsal (2; 2.2%) Below Knee (5; 5.6%)	
				Metatarsal Base (1)	0		
				Total: 54 (60%)			
Dalla-Paola (6) (2003)	89	66.3	63M 26F	1st Metatarsal Head (44) Midshaft (17) Metatarsal Base (28)	8 total (8.99%)	Digital (6; 6.7%) Transmetatarsal (1; 1.1%) LisFranc (1; 1.1%)	16.4 [7–28]
Ahmed (7) (2010)	49/49	58	92M	Fillet Flap Hallux (32)	0	Transmetatarsal (2; 4.1%)	N/A
			30F	1st MPJ Disarticulation (17)	9 (18.4%) Total: 9 (18.4%)	Below Knee (7; 14.3%)	

F, female; M, male; MPJ, metatarsal-phalangeal joint; N/A, not applicable.

narrow inclusion criteria to assure that one procedure was critically analyzed. This did, however, result in a smaller number of manuscripts to be included in the review.

After a systematic review of peer-reviewed literature, the incidence of re-amputation following partial first ray amputation associated with diabetes mellitus and peripheral neuropathy was determined to be 19.8%. This reveals a relatively high rate of re-amputation in a high-risk subset of patients and additional reviews should be undertaken to further evaluate the continued utility of the partial first ray amputation associated with diabetes mellitus with peripheral neuropathy. Furthermore, reviews evaluating the utility and durability of the more proximal level amputations, such as a well-balanced transmetatarsal amputation (25–29), need to be initiated. Only then can a critical comparison, preferably prospective and through appropriately weighted design, be undertaken to define which level of amputation in the distal foot results in the lowest incidence of ulceration and/or re-amputation while maintaining the highest level of function.

Conclusion

A systematic review of electronic databases to determine the incidence of re-amputation following first ray amputation associated with diabetes mellitus and peripheral sensory neuropathy was undertaken. Based on the inclusion criteria, a total of five studies (20.8%) were included in the analysis. All of the studies had been published in peer-reviewed journals, although they were of methodologically fair design. The results of these studies reveal a high incidence of re-amputation of 19.8%. Therefore, given the available data, additional prospective investigations are warranted, especially in evaluation and comparison of various levels of partial foot amputation.

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