Functional and Quality of Life Outcomes in Ray Amputations vs. Transmetatarsal Amputation: A Comparative Study

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STATEMENT OF PURPOSE

The purpose of this study is to compare the functional and quality-of-life (QOL) outcomes of ray amputations versus transmetatarsal amputations (TMA) in individuals undergoing surgical intervention for lower limb pathology.

INTRODUCTION

Foot amputations, especially those involving the forefoot, significantly impact gait, mobility, quality of life and overall functional capacity. Ray amputations, which involve the removal of one or more toes, are frequently performed to address severe ulcerations or infections in diabetic patients. These procedures can have a considerable effect on foot function especially when the lesser rays are involved. The loss of pedal rays disrupts balance, alters the natural mechanics of walking, and often leads to the development of compensatory patterns that increase the risk of falls, pressure sores, and further complications which can include a more proximal amputation.

In contrast, transmetatarsal amputation (TMA) is typically preferred in cases where more extensive tissue removal is necessary. TMA, which involves the removal of all the toes along with part of the metatarsal bones, is known for offering more predictable outcomes in terms of long-term foot stability and function. However, while TMA can provide a more comprehensive solution, it too presents functional impairments that can significantly affect daily living activities and overall mobility.

Despite the advances in surgical techniques, the functional consequences of ray amputations, particularly in the lesser toes, remain less well understood. These amputations often lead to significant functional limitations, even though the lesser rays might appear less critical in terms of their role in normal foot mechanics. The loss of these structures can disrupt a patient's ability to effectively propel themselves during walking, thereby altering their gait and putting additional strain on other parts of the body.

As the choice between ray amputation and transmetatarsal amputation remains a critical clinical decision, it is important to fully understand the functional impact of each option as well as their effect on quality of life.

METHODS

A retrospective cohort study was conducted on patients who underwent ray or TMA at Georgetown University Hospital between June 2021 and June 2023. Inclusion criteria included ambulatory patients aged ≥18 who completed functional and QOL questionnaires. Exclusion criteria included bilateral or proximal amputations. The primary outcomes included complications (major and minor), limb salvage, and mortality. Functional outcomes were assessed using the Lower Extremity Functional Scale (LEFS), and QOL was assessed with the SF-12 Health Survey.

RESULTS

Table 1. Patient-Reported Outcome Measures (Intergroup)

	Total (n=79)	TMA (n=47)	Ray Amp (n=32	p-value
Postoperative Survey Duration (Months), Average				
SF-12				
Raw Score	29.8	28.5	30.2	0.7873
T-Score				
PROMIS				
Raw Score	6.4	6.6	6.3	0.6672
T-Score	51.2	51.9	50.4	0.6671
LEFS				
Raw Score	44.3	44.7	42.3	0.5852
% MAX Function	55.4	55.9	52.8	0.5852
SRQ-20				
Raw Score	3.8	3.5	4.2	0.5161

Table 1: Comparison of postoperative patient-reported outcome measures between Transmetatarsal Amputation (TMA) and Ray Amputation groups, showing no statistically significant differences across survey duration, physical function, or mental health scores.

Table 2. Complications (Intergroup)

	Total (n=95)	TMA (n=50)	Ray Amp (n=45	p-value
	95	56	45	
Minor Complications	30	11	19	**0.0000**
Major Complications	35	19	16	0.8050
Progression	6	1	5	0.1010

Table 2: Comparison of complication rates between Transmetatarsal Amputation (TMA) and Ray Amputation groups, showing a significantly higher rate of minor complications in the Ray group, while major complications and progression rates were not significantly different.

Table 3. LEFS Scores by Complications in Ray Amp Patients (intragroup)

	LEFS, n	LEFS	p-value	LEFS, % Max Function	p-value
Minor Complications			0.0952		0.0952
Yes	12	34.7		43.3	
No	20	47.9		59.8	
Major Complications			0.9870		0.9870
Yes	11.0	42.8		53.5	
No	21.0	42.9		53.7	

Table 3: LEFS Scores by Complications in Ray Amputation Patients

We reviewed 95 patients (50 TMA, 45 ray amputations), with an average follow-up of 818.6 days. Limb salvage rates were high (97.9%), and complication rates were substantial (68.4%), with 38% of TMA and 35.6% of ray amputation patients requiring return to the operating room (ROR) for revision. Functional outcomes, as measured by LEFS and SF-12, showed no significant differences between the two groups (LEFS: 45.3 vs. 42.9; SF-12: 30.1 vs. 29.4). Minor complications were more frequent in the ray amputation group, but major complications requiring re-operation were similar between the two groups. Subgroup analysis revealed no significant differences in functional or QOL outcomes among different ray amputation types.

RESULTS

Table 4. Patient-Reported Outcome Measures by Ray Amp (Intergroup)

	Total (n=79)	TMA	Isolated 1st	Isolated Centra	Isolated 5th	Multiple	p-value
		47	10	7	7	8	
Postoperative Survey Duration (	12.1	11.3	10.2	64.1	13.6	22.6	0.7905
Postoperative Survey Duration (Months), IQR							
SF-12							
Raw Score	29.8	28.5	29.3	27.1	21.9	21.9	0.1316
PROMIS							
Raw Score	6.4	6.6	7.0	6.8	6.0	5.0	0.2367
T-Score	51.2	51.9	53.3	53.2	49.4	44.8	0.2158
LEFS							
Raw Score	44.3	44.7	48.4	41.1	37.7	37.8	0.2023
% MAX Function	55.4	55.9	57.4	51.4	45.0	47.2	0.2023
SRQ-20							
Raw Score	3.8	3.5	5.6	1.5	4.2	5.0	0.9030

Table 4 compares patient-reported outcome measures across Ray amputation subtypes, showing no statistically significant differences in function, mental health, or quality of life between groups.

Table 5. Comparative Analysis of LEFS Between TMA and Pedal Columns

	TMA (n=47)	Medial Ray Sparing/Lateral Column Amputation (n=12)	Lateral Ray Sparing/Medial Column Amputation (n=15)	p-value
	47	12	15	
LEFS				
Raw Score	44.3	35.3	45.7	0.0726
% MAX Function	55.4	44.1	57.2	0.0726
SF-12				
Raw Score	29.8	31	28.8	1.0000
PROMIS				
Raw Score	6.4	5.6	6.5	0.5276
T-Score	51.2	47.7	51.0	0.5072
SRQ-20				
Raw Score	3.8	5.8	4.5	0.3255

Table 5 presents a comparison of functional and patient-reported outcomes between TMA and column-specific ray amputations, revealing a trend toward lower LEFS scores in lateral column amputations, though no statistically significant differences were observed across groups.

DISCUSSION

This research challenges the traditional preference for **transmetatarsal amputation (TMA)**, presenting evidence that **ray amputations**—whether involving the 1st, 5th, central, or multiple rays—can yield **comparable functional outcomes** and **quality of life** (QOL) with minimal differences. For instance, the **LEFS** (Lower Extremity Function Scale) scores for ray amputation patients (44.3) are comparable to those for TMA patients (44.7), with no significant difference (p=0.2023). Additionally, the **SF-12 raw scores** (29.8 for total patients) and **PROMIS T-scores** (51.2 for total patients) show no significant variation between ray and TMA groups, suggesting that both surgical approaches yield similar levels of functional recovery and **quality of life** (p-values of 0.7873 for SF-12 and 0.6672 for PROMIS). Despite the fact that gait disturbances following ray amputations, particularly involving the 1st ray, are common, these disruptions have a **minimal impact on daily activities**. The study emphasizes that while these gait alterations are inevitable, they do not significantly hinder the patients' ability to carry out everyday functions.

DISCUSSION

The findings suggest that **ray amputations** may offer a **functional advantage** over TMA by allowing patients to retain a greater portion of their foot's structure, which is crucial for **balance** and **mobility**. Ray amputations for patients with isolated rays (e.g., 1st, 5th, or central) exhibit no major differences in the **LEFS** scores (e.g., 44.7 for TMA, 48.4 for isolated 1st ray, and 45.7 for isolated 5th ray) and **% Max Function** (e.g., 55.9% for TMA, 57.4% for isolated 1st ray, and 52.8% for isolated 5th ray) suggesting similar **functional recovery** and **performance outcomes**. Additionally, **wound-related issues** between ray and TMA groups show no significant difference (p=0.8050), supporting the idea that ray amputations could be a **viable alternative to TMA** without compromising healing or increasing risk. This research encourages a shift in surgical decision-making, advocating for more individualized, less invasive approaches to foot amputation that prioritize **function preservation** and patient independence.

CONCLUSION

This study challenges the traditional preference for TMA by showing that ray amputations—whether of the 1st, 5th, central, or multiple rays—offer comparable functional outcomes with minimal differences in QOL. Ray amputations preserve more of the foot's length, supporting normal gait mechanics and reducing functional loss compared to TMA. Although gait disturbances following ray amputation are common, particularly with the 1st ray, these disruptions have a minimal impact on daily activities.

Our findings suggest that ray amputations can be a viable alternative to TMA, with similar functional outcomes and QOL with similar wound related issues. This study encourages reconsideration of traditional amputation strategies, especially for isolated ray amputations.

REFERENCES

1. McDonald S, Sharpe L, Blaszczynski A. The psychosocial impact associated with diabetes-related amputation. Diabet Med. 2014 Nov;31(11):1424-30.
2.Ahmad A, Abujbara M, Jaddou H, Younes NA, Ajlouni K. Anxiety and Depression Among Adult Patients With Diabetic Foot: Prevalence and Associated Factors. J Clin Med Res. 2018 May;10(5):411-418.
3. Rebecca M. Crocker, Kelly N.B. Palmer, David G. Marrero, Tze-Woei Tan, Patient perspectives on the physical, psycho-social, and financial impacts of diabetic foot ulceration and amputation, Journal of Diabetes and its Complications, Volume 35, Issue 8, 2021, 107960, ISSN 1056-8727.
4.. Pedras S, Carvalho R, Pereira GM. A predictive model of anxiety and depression symptoms after a lower limb amputation, Disability and Health Journal. 2018. 11(1);79-85.
5.. Sinha R, van den Heuvel WJ, Arokiasamy P. Factors affecting quality of life in lower limb amputees. *Prosthet Orthot Int*. 2011;35(1):90-96.
6. Burger H, Marincek C. Return to work after lower limb amputation. Disabil Rehabil. 2007 Sep 15;29(17):1323-9.
7. Susana Pedras, Rui Carvalho, M. Graça Pereira, A predictive model of anxiety and depression symptoms after a lower limb amputation, Disability and Health Journal, Volume 11, Issue 1, 2018, Pages 79-85.
8. Senra H, Oliveira RA, Leal I, Vieira C. Beyond the body image: a qualitative study on how adults experience lower limb amputation. Clinical Rehabilitation. 2012;26(2):180-191.
9. Kim PJ: Biomechanics of the Diabetic Foot: Consideration in Limb Salvage. *Adv Wound Care (New Rochelle)* 2(3):107-111, 2013.
8. Labovitz JM, Day D: The Biomechanics of Diabetes Mellitus and Limb Preservation. *Clin Podiatr Med Surg* 37(1):151-169, 2020.
10. Wukich, D. K., Ahn, J., Raspovic, K. M., Gottschalk, F. A., La Fontaine, J., & Lavery, L. A. (2017). Comparison of Transtibial Amputations in Diabetic Patients With and Without End-Stage Renal Disease. *Foot and Ankle International*, *38*(4), 388-396.
11. Luza, L. P., Ferreira, E. G., Minsky, R. C., Pires, G. K. W., & da Silva, R. (2019). Psychosocial and physical adjustments and prosthesis satisfaction in amputees: a systematic review of observational studies. *Disability and Rehabilitation: Assistive Technology*, *15*(5), 582–589.
12. Sage R, Pinzur MS, Cronin R, Preuss HF, Osterman H. Complications following midfoot amputation in neuropathic and dysvascular feet. J Am Podiatr Med Assoc. 1989 Jun;79(6):277-80. doi: 10.7547/87507315-79-6-277.
13. Van der Wal GE, Dijkstra PU, Geertzen JHB. Lisfranc and Chopart amputation: A systematic review. Medicine (Baltimore). 2023 Mar 10;102(10):e33188.
14. Musuuza J, Sutherland BL, Kurter S, Balasubramanian P, Bartels CM, Brennan MB. A systematic review of multidisciplinary teams to reduce major amputations for patients with diabetic foot ulcers. J Vasc Surg. 2020 Apr;71(4):1433-1446.
15. Edmonds M, Manu C, Vas P. The current burden of diabetic foot disease. J Clin Orthop Trauma. 2021 Feb 8;17:88-93.
16. Luo R, Ji Y, Liu YH, Sun H, Tang S, Li X. Relationships among social support, coping style, self-stigma, and quality of life in patients with diabetic foot ulcer: A multicentre, cross-sectional study. Int Wound J. 2023 Mar;20(3):716-724.

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