A CROS SECTIONAL STUDY ON RAYS AMPUTATION IN PATIENTS WITH DIABETIC FOOT ULCER IN TERTIARY CENTRE

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Abstract:
Background: Diabetic foot ulcer (DFU) is one of the most serious complications of diabetes mellitus and remains a leading cause of non-traumatic lower-limb amputation. Ray amputation is an established limb-salvage procedure for patients with localized infection, gangrene, or osteomyelitis. However, postoperative wound healing is influenced by several clinical factors, particularly glycaemic control and vascular status. This study evaluated wound healing outcomes following ray amputation and identified factors associated with postoperative recovery.
Methods: A hospital-based observational cross-sectional study was conducted in the Department of General Surgery, Shri Sathya Sai Medical College and Research Institute, Tamil Nadu, India. A total of 100 adult diabetic foot ulcer patients who underwent ray amputation and attended postoperative follow-up between 3 and 6 months were included. Demographic characteristics, HbA1c category, Doppler vascular status, comorbidities, wound healing status, and recovery duration were recorded. Wound healing was categorized as healed, delayed healing, or non-healed. Data were analysed using SPSS software, and associations between categorical variables were assessed using the Chi-square test. A p-value <0.05 was considered statistically significant.
Results: The mean age of the study participants was **54.07 ± 14.45 years**, and **69%** were males. Complete wound healing was observed in **42%** of patients, delayed healing in **33%**, and non-healed wounds in **25%**. A highly significant association was observed between **HbA1c category and wound healing** (**p <0.001**), with patients having HbA1c <7% demonstrating the highest healing rates, whereas poorly controlled diabetes (HbA1c >8%) was associated with delayed healing and non-healed wounds. Doppler vascular status also showed a significant association with wound healing (**p = 0.030**), with better healing among patients with normal vascular studies. Mean recovery duration differed significantly among healing groups (**p <0.001**), measuring **7.62 ± 1.10 weeks** in healed wounds, **12.45 ± 1.48 weeks** in delayed healing, and **19.40 ± 2.16 weeks** in non-healed wounds.
Conclusion: Ray amputation is an effective limb-salvage procedure for diabetic foot ulcer patients. **Glycaemic control and vascular status are the strongest predictors of postoperative wound healing.** Optimising HbA1c levels, routine Doppler vascular assessment, multidisciplinary diabetic foot care, meticulous wound management, and structured postoperative follow-up may improve healing outcomes, shorten recovery duration, and reduce progression to major lower-limb amputation.

Keywords: Diabetic foot ulcer; Ray amputation; Limb salvage; Wound healing; Glycated haemoglobin; HbA1c; Doppler ultrasonography; Peripheral arterial disease; Diabetes mellitus.

Introduction

Diabetes mellitus (DM) is one of the fastest-growing non-communicable diseases worldwide and represents a major global public health challenge. The increasing prevalence of diabetes, driven by urbanization, sedentary lifestyles, obesity, and population aging, has resulted in a substantial rise in chronic microvascular and macrovascular complications. Early diagnosis and effective glycaemic control remain essential strategies for preventing long-term complications and reducing the burden of diabetes-related morbidity and mortality worldwide [1].
Among the various complications of diabetes, diabetic foot ulcer (DFU) is one of the most serious and disabling conditions. Approximately 15–25% of individuals with diabetes develop a foot ulcer during their lifetime, and DFUs remain the leading cause of non-traumatic lower-extremity amputations globally. These ulcers result from a complex interaction between peripheral neuropathy, peripheral arterial disease,

repetitive trauma, infection, and impaired wound healing, frequently culminating in limb-threatening complications requiring surgical intervention [2].

The pathophysiology of impaired wound healing in diabetes is multifactorial. Persistent hyperglycaemia promotes chronic inflammation, oxidative stress, endothelial dysfunction, impaired collagen synthesis, reduced fibroblast activity, altered cytokine signalling, and defective angiogenesis. These abnormalities delay tissue repair, increase susceptibility to infection, and prolong wound healing following surgical procedures, thereby increasing the likelihood of recurrent ulceration and amputation [3].

Peripheral arterial disease (PAD) is another major contributor to poor healing outcomes in diabetic foot disease. Diabetes accelerates atherosclerosis, leading to diffuse arterial narrowing, reduced tissue perfusion, chronic limb ischaemia, and impaired oxygen delivery to healing tissues. Consequently, patients with coexisting PAD have delayed wound healing, higher infection rates, and significantly greater risks of limb loss compared with diabetic patients without vascular compromise [4].

Peripheral diabetic neuropathy further aggravates the problem by causing loss of protective sensation, altered plantar pressure distribution, foot deformities, and repetitive unnoticed trauma. Changes in plantar biomechanics increase focal pressure over weight-bearing areas, predisposing patients to ulcer recurrence even after successful treatment. Appropriate off-loading and pressure redistribution therefore remain critical components of diabetic foot management [5].

When conservative management fails or localized gangrene, osteomyelitis, or extensive soft-tissue infection develops, surgical intervention becomes necessary. Minor amputations, including ray amputation and transmetatarsal amputation, are commonly performed as limb-salvage procedures to eradicate infection while preserving maximum foot length and ambulatory function. Previous studies have demonstrated that appropriately selected patients undergoing transmetatarsal or ray amputations can achieve satisfactory functional outcomes while avoiding major limb loss [6].

In India, diabetic foot disease poses unique challenges because of delayed presentation, barefoot walking, poor foot-care awareness, inadequate footwear, socioeconomic limitations, and restricted access to specialized podiatric care. Poor knowledge regarding preventive foot care has been identified as an important modifiable risk factor contributing to ulcer development, recurrence, and amputation among Indian diabetic patients, emphasizing the need for structured education and preventive strategies [7].

Successful postoperative wound healing depends not only on adequate surgical debridement but also on meticulous wound care. Appropriate wound-bed preparation, infection control, moisture balance, pressure off-loading, nutritional optimization, and regular follow-up are essential for preventing delayed healing and progression to more proximal amputations. Comprehensive wound-care principles therefore play a central role in limb preservation following diabetic foot surgery [8].

Patients with significant peripheral arterial disease often require vascular assessment before definitive limb-salvage surgery. Systematic reviews have demonstrated that timely revascularization substantially improves tissue perfusion, enhances wound healing, reduces major amputation rates, and improves long-term limb salvage in diabetic foot ulcer patients with vascular insufficiency [9].

Modern multidisciplinary management integrates vascular intervention, surgical debridement, appropriate antibiotic therapy, advanced wound-care techniques, pressure off-loading, glycaemic optimization, and rehabilitation. Multimodal treatment algorithms have demonstrated encouraging outcomes in preserving limbs among patients with complex diabetic heel ulcers and other advanced diabetic foot lesions, highlighting the importance of coordinated multidisciplinary care [10].

Despite these advances, delayed wound healing and non-healing following ray amputation continue to pose significant clinical challenges. Institution-specific evidence regarding healing outcomes and factors influencing recovery remains limited, particularly in Indian tertiary care centres. Therefore, the present study was undertaken to evaluate wound healing outcomes following ray amputation in patients with diabetic foot ulcers and to identify the clinical factors associated with successful postoperative recovery.

MATERIALS AND METHODS

This hospital-based observational cross-sectional study was conducted in the Department of General Surgery, Shri Sathya Sai Medical College and Research Institute, Tamil Nadu, India. The study included 100 consecutive patients with diabetic foot ulcers who underwent ray amputation and attended postoperative follow-up between 3 and 6 months after surgery. Patients aged 18 years or older with documented diabetic foot ulcers managed by ray amputation and with complete postoperative follow-up records were eligible for inclusion. Patients with incomplete clinical records, those who underwent major lower-limb amputation during the follow-up period, and those lost to follow-up were excluded from the study.

Data were collected using a structured case record form from hospital medical records, operative notes, investigation reports, and follow-up documentation. The variables studied included demographic characteristics (age and gender), glycaemic control assessed using glycated haemoglobin (HbA1c) categories, Doppler vascular status (normal or abnormal), associated comorbidities including hypertension, chronic kidney disease and peripheral neuropathy, smoking status, history of previous foot ulcer or amputation, wound healing outcome, and postoperative recovery duration.

The primary outcome measure was wound healing status, which was categorized as healed, delayed healing, or non-healed based on clinical assessment during follow-up. The secondary outcome measure was postoperative recovery duration, calculated as the time from ray amputation to complete wound healing.

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS). Continuous variables were summarized as mean ± standard deviation, while categorical variables were expressed as

frequencies and percentages. Associations between wound healing status and categorical variables were assessed using the Chi-square test. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 100 patients with diabetic foot ulcers who underwent ray amputation were included in the study. The mean age of the participants was **54.07 ± 14.45 years** (range: 30–79 years), and the majority were males (**69%**), while females constituted **31%** of the study population. Regarding glycaemic control, **31%** of patients had well-controlled HbA1c levels (<7%), **35%** had moderately controlled HbA1c levels (7–8%), and **34%** had poorly controlled HbA1c levels (>8%). Normal Doppler vascular findings were observed in **54%** of patients, whereas **46%** had abnormal vascular studies. Peripheral neuropathy was present in **63%** of patients, hypertension in **48%**, chronic kidney disease in **15%**, previous foot ulcer or amputation in **35%**, and **53%** of patients had a history of current or former smoking. The most common ulcer type was neuropathic (**41%**), followed by ischaemic (**35%**) and neuro-ischaemic ulcers (**24%**).

With respect to wound healing outcomes, **42%** of patients achieved complete wound healing, **33%** experienced delayed wound healing, and **25%** had persistent non-healed wounds during the follow-up period. A highly significant association was observed between **HbA1c category and wound healing status** (**$p < 0.001$**). Patients with well-controlled diabetes (HbA1c <7%) demonstrated the highest proportion of complete wound healing, whereas patients with poorly controlled diabetes (HbA1c >8%) showed significantly higher rates of delayed healing and non-healed wounds.

Doppler vascular status was also significantly associated with wound healing (**$p = 0.030$**). Patients with normal Doppler findings had better wound healing outcomes compared with those demonstrating abnormal vascular status, indicating the important role of adequate limb perfusion in postoperative recovery.

No statistically significant associations were observed between wound healing status and ulcer type (**$p = 0.577$**), hypertension (**$p = 0.257$**), chronic kidney disease (**$p = 0.476$**), peripheral neuropathy (**$p = 0.700$**), smoking status (**$p = 0.149$**), or previous history of foot ulcer/amputation (**$p = 0.349$**).

Postoperative recovery duration differed significantly among the three wound healing groups (**$p < 0.001$**). Patients with complete wound healing had the shortest recovery time (**7.62 ± 1.10 weeks**), whereas those with delayed healing required **12.45 ± 1.48 weeks**, and patients with non-healed wounds had the longest recovery duration (**19.40 ± 2.16 weeks**). These findings indicate that good glycaemic control and preserved vascular status are important determinants of successful wound healing and faster postoperative recovery following ray amputation in patients with diabetic foot ulcers.

Table 1. Demographic Characteristics of the Study Participants (N = 100)

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	Mean ± SD	**54.07 ± 14.45**	—
	Median	55.00	—
	Minimum	30	—
	Maximum	79	—
Gender	Male	69	69.0
	Female	31	31.0

Table 2. Baseline Clinical Characteristics of the Study Participants (N = 100)

Variable	Category	Frequency (n)	Percentage (%)
HbA1c category	Well controlled (<7%)	31	31.0
	Moderately controlled (7–8%)	35	35.0
	Poorly controlled (>8%)	34	34.0
Doppler vascular status	Normal	54	54.0
	Abnormal	46	46.0
Hypertension	Present	48	48.0
	Absent	52	52.0
Chronic Kidney Disease	Present	15	15.0
	Absent	85	85.0

Table 3. Ulcer-related Characteristics and Wound Healing Outcome (N = 100)

Variable	Category	Frequency (n)	Percentage (%)
Peripheral neuropathy	Present	63	63.0
	Absent	37	37.0
Smoking status	Current smoker	26	26.0
	Former smoker	27	27.0
	Non-smoker	47	47.0
Previous foot ulcer / amputation	Present	35	35.0
	Absent	65	65.0
Ulcer type	Neuropathic	41	41.0
	Ischaemic	35	35.0

	Neuro-ischaemic	24	24.0
Wound healing status	Complete healing	42	42.0
	Delayed healing	33	33.0
	Non-healed	25	25.0

Table 4. Association Between HbA1c and Doppler Status with Wound Healing

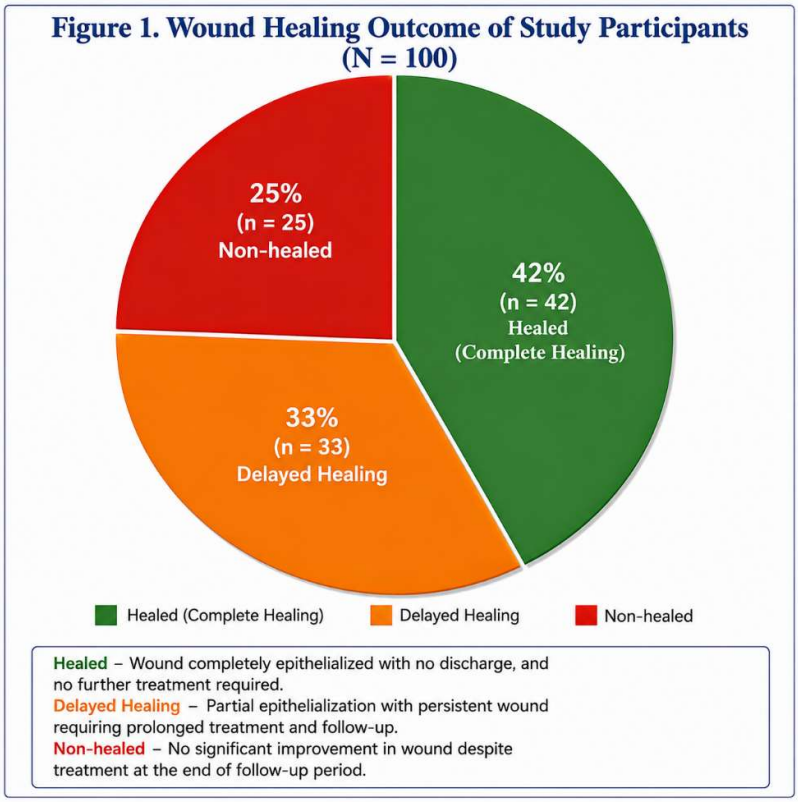
Variable	Category	Delayed Healing n (%)	Complete Healing n (%)	Non-healed n (%)	p-value
HbA1c	<7%	9 (27.3)	20 (47.6)	2 (8.0)	
	7–8%	7 (21.2)	16 (38.1)	12 (48.0)	
	>8%	17 (51.5)	6 (14.3)	11 (44.0)	**<0.001**
Doppler	Normal	13 (39.4)	29 (69.0)	12 (48.0)	
	Abnormal	20 (60.6)	13 (31.0)	13 (52.0)	**0.030**

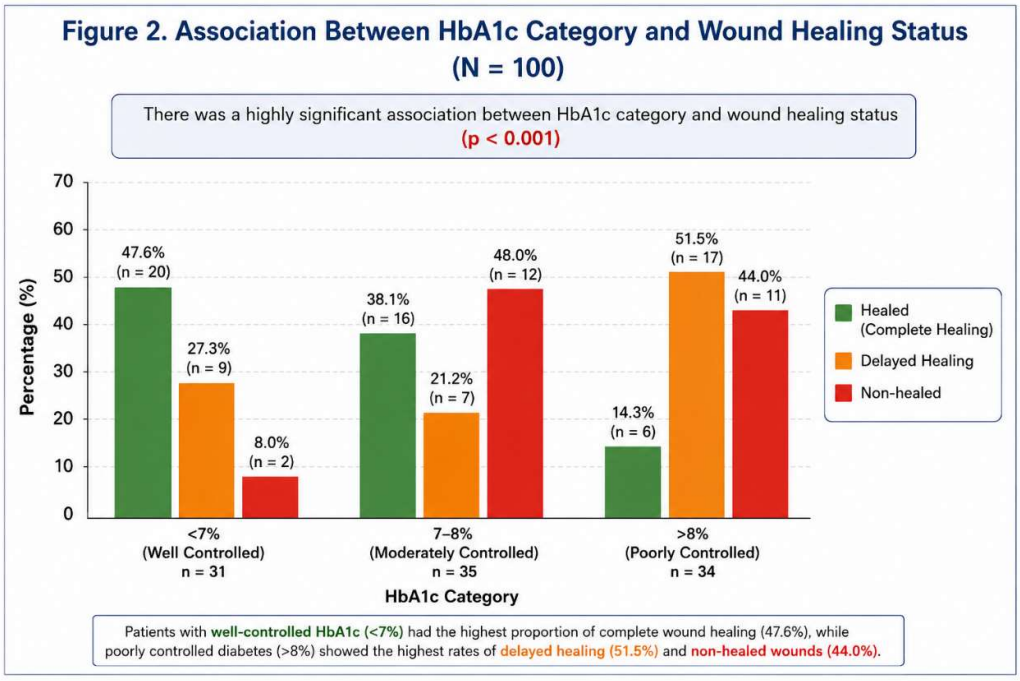
Table 5. Association of Other Clinical Variables with Wound Healing Status

Variable	p-value	Statistical Significance
Type of ulcer	0.577	Not Significant
Hypertension	0.257	Not Significant
Chronic Kidney Disease	0.476	Not Significant
Peripheral Neuropathy	0.700	Not Significant
Smoking	0.149	Not Significant
Previous Foot Ulcer / Amputation	0.349	Not Significant

Table 6. Comparison of Recovery Duration According to Wound Healing Status

Wound Healing Status	Mean Recovery Duration (Weeks)	Standard Deviation
Complete healing	**7.62**	1.103
Delayed healing	**12.45**	1.481
Non-healed	**19.40**	2.160
Overall	**12.16**	4.935
p-value	**<0.001**	Significant





DISCUSSION

The present study evaluated wound healing outcomes following ray amputation among 100 patients with diabetic foot ulcers and identified the clinical factors associated with postoperative recovery. Complete wound healing was achieved in 42% of patients, while 33% experienced delayed healing and 25% had persistent non-healed wounds. The study further demonstrated that poor glycaemic control and abnormal vascular status were the only factors significantly associated with poor wound healing, whereas hypertension, chronic kidney disease, peripheral neuropathy, smoking, ulcer type, and previous ulcer history were not significantly associated with healing outcomes. These findings indicate that metabolic optimisation and adequate limb perfusion remain the principal determinants of successful limb salvage following ray amputation.

The present study demonstrated that wound healing following ray amputation was significantly influenced by vascular status. Patients with normal Doppler findings experienced superior healing outcomes, whereas abnormal Doppler findings were associated with delayed healing and persistent non-healed wounds ($p = 0.030$). These findings indicate that adequate peripheral perfusion is essential for successful postoperative recovery. Similarly, **Schirmer et al. [11]** reported that restoration of vascular supply through vascular surgery and microsurgical techniques significantly improved wound healing and reduced major amputations in patients with chronic diabetic foot ulcers. Their findings support the present study by emphasizing that impaired vascularity compromises tissue oxygenation, angiogenesis, and collagen synthesis, thereby delaying wound repair. The significant association observed in our study further highlights the importance of routine preoperative Doppler evaluation and timely vascular optimization before undertaking limb-salvage procedures.

In the present study, complete wound healing was achieved in 42% of patients, whereas 33% experienced delayed healing and 25% remained non-healed during follow-up. Although postoperative off-loading techniques were not specifically evaluated, the healing outcomes suggest that effective wound care and pressure redistribution remain important determinants of recovery. **Dalla Paola et al. [12]** demonstrated that surgical off-loading significantly enhances healing by reducing plantar pressure and preventing repetitive trauma at the operative site. Their study reported improved healing rates and reduced ulcer recurrence following appropriate off-loading procedures. The comparatively lower complete healing rate observed in our study may be attributable to variations in glycaemic control, vascular status, and patient compliance with postoperative care. Nevertheless, both studies consistently demonstrate that successful wound healing depends on appropriate pressure redistribution following ray amputation.

Our study identified glycaemic control as the strongest predictor of wound healing. Patients with well-controlled HbA1c (<7%) showed the highest proportion of complete healing, whereas poorly controlled diabetes (HbA1c >8%) was significantly associated with delayed healing and non-healed wounds ($p <0.001$). Although **Suh et al. [13]** primarily evaluated advanced reconstructive techniques using supermicrosurgery for diabetic foot defects, they emphasized that reconstruction alone cannot overcome the adverse effects of uncontrolled diabetes. They reported that meticulous glycaemic optimisation, adequate vascularity, and careful patient selection were prerequisites for successful reconstruction and durable wound healing. These observations closely correspond with the present findings, where metabolic control emerged as the most important determinant of postoperative recovery regardless of surgical intervention.

The present study also demonstrates that limb preservation can be successfully achieved in a considerable proportion of diabetic foot ulcer patients through ray amputation when appropriate patient selection and postoperative care are ensured. **Godoy-Santos et al. [14]** described successful diabetic limb salvage using bone allograft and free flap reconstruction in patients with complex diabetic foot defects. Their report concluded that combining aggressive infection control, meticulous debridement, vascular optimisation, and reconstructive surgery preserved limb function while avoiding major amputation. Although our study evaluated conventional ray amputation rather than advanced reconstructive procedures, both studies share the common objective of preserving a functional limb whenever feasible. Our findings suggest that favourable healing outcomes can be obtained with standard limb-salvage surgery when glycaemic control and vascular status are adequately optimized.

In the present study, one-quarter of patients (25%) developed persistent non-healed wounds despite undergoing ray amputation, reflecting the complexity of diabetic wound management. **Jianda et al. [15]** evaluated proximal tibial cortex transverse distraction as an alternative treatment for large diabetic heel ulcers and demonstrated significantly improved tissue perfusion, granulation tissue formation, and wound healing. Their findings indicate that enhancing local vascularity may improve healing in patients with severe or refractory diabetic wounds. Compared with their study, our patients underwent conventional surgical management without adjunctive vascular stimulation techniques, which may partly explain the persistence of non-healed wounds in a subset of cases. These findings suggest that selected high-risk patients with impaired vascularity may benefit from adjunctive limb-salvage strategies in addition to standard ray amputation.

The present study demonstrated that **42%** of patients achieved complete wound healing, while **33%** had delayed healing and **25%** developed persistent non-healed wounds. Recovery duration increased significantly with worsening healing status (**$p <0.001$**), with mean recovery times of **7.62 ± 1.10 weeks** for healed wounds, **12.45 ± 1.48 weeks** for delayed healing, and **19.40 ± 2.16 weeks** for non-healed wounds. **Yoon et al. [16]** reported that the use of 3D bioprinted autologous adipose tissue accelerated granulation tissue formation and improved healing in diabetic foot ulcers requiring limb salvage. Their study achieved superior healing through advanced regenerative techniques, whereas our study evaluated conventional ray amputation under routine clinical practice. Despite differences in treatment modality, both studies demonstrate that enhanced tissue regeneration substantially improves wound healing and shortens recovery.

The present study supports ray amputation as an effective limb-salvage procedure, with **42%** of patients achieving complete healing without progression to major amputation. **Kumar et al. [17]** reported that ray resection preserves limb function and provides satisfactory postoperative outcomes when performed with appropriate patient selection and meticulous surgical technique. Although their study involved upper-limb ray resection, both studies demonstrate that preservation of anatomical alignment and adequate soft-tissue management contribute to favourable functional recovery while avoiding more extensive amputations.

Our findings indicate that satisfactory healing following ray amputation depends primarily on adequate vascularity and glycaemic control rather than the surgical procedure alone. **Puhaindran et al. [18]** similarly demonstrated that successful ray amputation requires complete removal of diseased tissue while preserving maximum functional tissue to achieve favourable healing outcomes. Although their study focused on hand tumours, the underlying surgical principle of achieving adequate clearance with preservation of function closely resembles the objective of diabetic foot ray amputation performed in our patients.

The present study demonstrated complete healing in **42%** of patients despite the presence of multiple comorbidities. **Filippo et al. [19]** reviewed outcomes following single-ray amputation and concluded that preservation of adjacent structures improves functional recovery and patient satisfaction. Similar to their observations, our study indicates that ray amputation remains an effective limb-preserving procedure when performed before extensive tissue destruction develops. However, delayed presentation and poor metabolic control contributed to delayed healing in a considerable proportion of our patients.

Our results also showed that poor glycaemic control (**HbA1c >8%**) was significantly associated with delayed healing and non-healed wounds (**p <0.001**). **Mackay et al. [20]** described a modified ray resection technique that minimizes soft-tissue tension and facilitates wound healing by preserving tissue viability. While their study focused on operative technique, our findings suggest that even optimal surgical procedures may not overcome the adverse effects of uncontrolled diabetes unless metabolic optimisation is achieved before and after surgery.

Recovery duration in the present study varied significantly according to healing status, with non-healed wounds requiring the longest postoperative care (**19.40 ± 2.16 weeks**). **Melikyan et al. [21]** reported favourable functional outcomes following ray amputation when meticulous postoperative rehabilitation and wound management were provided. Their findings agree with our observation that successful postoperative care is essential for improving healing and reducing prolonged recovery following limb-salvage surgery.

The present study demonstrated that ulcer type, hypertension, chronic kidney disease, peripheral neuropathy, smoking, and previous ulcer history were **not significantly associated** with wound healing (**p >0.05**). **Bhat et al. [22]** similarly concluded that successful outcomes following single-digit ray amputation depend predominantly on appropriate surgical planning and postoperative rehabilitation rather than isolated patient characteristics. Although their study evaluated hand surgery, both studies emphasize that patient optimisation and surgical technique remain more important than individual demographic variables in determining final outcomes.

Persistent non-healed wounds occurred in **25%** of our patients despite limb-salvage surgery. **Yammine et al. [23]** demonstrated that preservation or resection of the metatarsal head influences postoperative ulcer recurrence and wound healing following diabetic toe amputation. Their findings indicate that operative technique directly affects long-term healing, supporting our observation that careful surgical planning is necessary to minimise delayed healing and subsequent complications.

Our study also identified prolonged recovery among patients with delayed and non-healed wounds, reflecting the increased burden of diabetic foot disease. **Oham et al. [24]** reported that recurrent diabetic foot ulcers remain common after apparently successful treatment and identified poor glycaemic control, neuropathy, and previous ulceration as major predictors of recurrence. Although previous ulcer history was not statistically significant in our study (**p = 0.349**), both studies highlight the importance of structured postoperative surveillance to prevent recurrent ulceration and further limb loss.

Finally, the present study demonstrated that optimisation of glycaemic control and vascular status significantly improved wound healing outcomes following ray amputation. **Chang et al. [25]** reported that an integrated surgical wound management protocol combining meticulous debridement, vascular optimisation, infection control, and multidisciplinary care significantly enhanced wound healing and limb preservation in diabetic foot patients. Their findings strongly support the present study, which similarly demonstrates that comprehensive multidisciplinary management, strict HbA1c optimisation, routine Doppler assessment, and structured follow-up are essential for improving healing rates and reducing progression to major lower-limb amputation.

Overall, the present study confirms that **glycaemic control (p <0.001)** and **vascular status (p = 0.030)** are the principal determinants of wound healing after ray amputation. These findings are consistent with contemporary literature and reinforce the importance of multidisciplinary diabetic foot care, early vascular assessment, metabolic optimisation, and evidence-based postoperative wound management to maximise limb salvage and improve long-term patient outcomes.

LIMITATIONS

The present study has certain limitations that should be considered while interpreting the findings. First, this was a **single-centre hospital-based study**, which may limit the generalisability of the results to other healthcare settings and patient populations. Second, the **cross-sectional observational design** precludes the establishment of causal relationships between clinical variables and wound healing outcomes. Third, although the sample size of **100 patients** was adequate for evaluating the primary objectives, it may have been insufficient to detect significant associations with less common risk factors and subgroup analyses. Finally, several important prognostic variables, including **Wagner ulcer grade, severity of infection, microbiological profile, nutritional status, duration of diabetes, body mass index, anaemia, revascularisation history, and long-term recurrence rates**, were not evaluated. Future prospective multicentre studies with larger sample sizes and longer follow-up are warranted to validate these findings and identify additional predictors of wound healing following ray amputation.

CONCLUSION

The present study demonstrates that **ray amputation is an effective limb-salvage procedure** for appropriately selected patients with diabetic foot ulcers, with **42%** of patients achieving complete wound healing during follow-up. The study identified **poor glycaemic control (p <0.001)** and **abnormal Doppler vascular status (p = 0.030)** as the two major determinants of delayed wound healing and persistent non-healed wounds. Patients with well-controlled HbA1c levels and normal vascular status experienced significantly better healing outcomes and shorter recovery durations, whereas poorly controlled diabetes and vascular insufficiency were associated with prolonged wound healing and increased postoperative morbidity.

These findings emphasise that successful limb salvage extends beyond the surgical procedure itself and requires comprehensive perioperative optimisation. **Strict HbA1c control, routine vascular assessment using Doppler ultrasonography, early identification of peripheral arterial disease, meticulous wound care, effective infection control, appropriate pressure off-loading, patient education, and multidisciplinary diabetic foot management** are essential to improve wound healing, shorten recovery time, preserve limb function, and reduce progression to major lower-limb amputation. Further large-scale prospective multicentre studies incorporating ulcer severity, infection grading, nutritional assessment, and long-term follow-up are recommended to strengthen the evidence and optimise clinical management strategies for patients undergoing ray amputation for diabetic foot ulcers.

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