e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com

International Journal of Pharmaceutical Quality Assurance 2026; 17(1); 542-548

Original Research Article

Comparative Evaluation of Treatment Modalities for Ingrown Toenail: A Prospective Study

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Received: 06-11-2025 / Revised: 13-12-2025 / Accepted: 22-01-2026
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Conflict of interest: Nil

Abstract:

Background: Ingrown toenail (onychocryptosis) is a common painful nail disorder that causes inflammation, infection, and limitation of daily activities. Although several surgical techniques are available, the optimal treatment should provide rapid healing, minimal pain, low recurrence, and good cosmetic results.

Aim: To compare the clinical outcomes of Nail Matrix Phenolization (NMP) and Wedge Matrix Resection (WMR) in the treatment of Stage II and Stage III ingrown toenails.

Methodology: A prospective comparative study was conducted over one year at a Department of Dermatology, Katihar Medical College, Katihar, Bihar, India. A total of 90 patients were equally allocated to the NMP (n=45) and WMR (n=45) groups. Outcomes assessed included postoperative pain, wound healing, infection, recurrence, return to routine activities, cosmetic outcome, and patient satisfaction. Data were analyzed using SPSS version 26.0, with $p < 0.05$ considered statistically significant.

Results: The NMP group showed significantly lower postoperative pain, faster wound healing, earlier return to routine activities, lower recurrence (4.4% vs. 15.6%), better cosmetic outcome (86.7% vs. 71.1%), and higher patient satisfaction (91.1% vs. 75.6%) than the WMR group.

Conclusion: Nail Matrix Phenolization demonstrated superior clinical outcomes and may be considered the preferred surgical treatment for Stage II and Stage III ingrown toenails.

Keywords: Ingrown Toenail, Onychocryptosis, Nail Matrix Phenolization, Wedge Matrix Resection, Prospective Study.

DOI: 10.25258/ijpqa.17.1.83

Introduction

Ingrown nail (onychocryptosis or unguis incarnatus) is a common disorder of the toes seen in surgical and primary care environments. It is the result of the lateral edge of the nail plate slipping through the periungual soft tissue, leading to pain, inflammation, swelling and, in more severe cases to secondary bacterial infection and granulation tissue formation [1]. This represents almost a quarter of all complaints about the feet and is particularly prevalent among adolescents and young adults, as they are more physically active, do not care for their feet appropriately and wear tight-fitting shoes frequently. Ingrowth of the great toe is most common, but sometimes one of the other toes or fingernails may grow into the skin, resulting in an ingrown nail problem and much difficulty in normal living [2].

Ingrown Toenails are a multi-factorial disease, with both anatomical and environmental causes. Several predisposing factors have been identified, such as improper trimming of nails, hereditary nail curvature, congenital widening of the nail plate, hypertrophy of the lateral nail fold, obesity, hyperhidrosis, repetitive trauma, lack of foot hygiene, fungal nail infections, and wearing ill-fitting shoes that put undue pressure on the nail margins [3]. These factors cause a disruption in the normal contour of the relationship of the nail plate to the lateral nail groove and permit the sharp edge of the nail to penetrate the adjacent soft tissue and begin the inflammatory process. The irritation may become chronic due to which there may be a recurrent infection and excessive granulation tissue formation, finally necessitating surgical treatment if conservative treatment is unsuccessful [4].

The clinical manifestations of ingrown nail consist of pain, tenderness, erythema, swelling, and difficulty walking or shoes. Purulent discharge, bleeding, hypertrophy of the lateral nail fold and exuberant granulation tissue can be seen in more advanced cases [5]. The disease is generally divided into three clinical stages according to the severity of the disease. In Stage I, pain, erythema and edema are present, but there is no infection. Stage II is marked by secondary infection and drainage of the inflamma-

tion, and in Stage III, there is chronic inflammation, with granulation tissue formation, prominent lateral nail fold inflammation and a persistent infection [6]. Staging is an important element in choosing the most effective treatment approach and prognosis.

The treatment for an ingrown toenail is dependent on the severity of the disease. Conservative treatment is usually indicated for early-stage disease and involves appropriate nail trimming, warm water soaks, insertion of cotton wicks, splinting of the gutter, taping, orthonyxia, topical antiseptics and antibiotics if secondary infection occurs [7]. These treatments are used to ease the tension between the nail and the tissues surrounding it, and to encourage healthy nail growth. But conservative treatment is known to have a higher recurrence rate, especially in patients with chronic disease or anatomical abnormalities. Therefore, surgery is often advised for ingrown nails that keep recurring, are infected or are severe [8].

A wide variety of surgical techniques have been described for ingrown nail surgery, such as simple nail avulsion, partial avulsion of the nail, wedge resection, partial matricectomy, total matricectomy, Zadik's, Winograd's, phenol matricectomy, sodium hydroxide matricectomy, laser therapy, and radiofrequency ablation [9]. These procedures are aimed at eliminating the offending edge of the nail and completely obliterating the corresponding part of the nail matrix so that the nail does not regrow and is cosmetically pleasing and continues to function well. Every surgical procedure has its own pros and cons when it comes to recurrence, post-operative pain, wound healing, cosmetics, patient satisfaction, and returning to normal daily life.

Partial nail avulsion with chemical matricectomy (phenol) has become popular due to its simplicity, low recurrence, lack of postoperative discomfort and good cosmetic results. Phenol causes a controlled chemical breakdown of the matrix of the nail which stops the growth of the unwanted nail edge. There are several studies showing that chemical matricectomy has proven to be more effective in reducing recurrence than simple nail avulsion alone. Similarly, resections of the wedge matrix are another routine surgical procedure, especially when there is severe deformity of the nails or when the patients experience repeated occurrences of the condition. Comparative studies have shown comparable results of wedge matrix resection and nail matrix phenolization, but there are conflicting reports on postoperative pain, healing time, cosmesis and recurrence. Thus, further studies of the various treatment options are needed to determine the most effective and patient-friendly surgical approach [10].

Although there are several different treatments for ingrown nails, there is no unanimous agreement on the best treatment for ingrown nails. The results vary from study to study because of differences in surgical expertise, patient characteristics, the severity of the disease, postoperative treatment, and follow-up duration. Moreover, the reoccurrence of ingrown toe is one of the most significant complications of ingrown toe surgery and has been shown to range from 2% to 25% based on the surgical approach used [11]. In addition to recurrence, other factors like postoperative complications (infection, delayed wound healing, pain, cosmetic dissatisfaction) also affect the quality of life and treatment success.

Comparative studies of the various treatment options for ingrown toes are relatively limited in India, especially in resource poor environments. Given the impact of the disease on mobility and quality of life; the need for effective treatment strategies with minimal recurrence and complications; further clinical research is warranted. Hence, the present prospective comparative study was conducted in Department of General Surgery in a tertiary care hospital, Katihar, Bihar, India to compare the clinical outcomes of various methods of treatment used in ingrown toenail. The objective of this study is to examine the efficacy of the treatments in terms of postoperative pain, wound healing, recurrence, side effects and satisfaction of patients, and to identify the most suitable treatment for clinical use.

Methodology

Study Design: The present study was a hospital-based prospective comparative study conducted to compare the clinical outcomes of two commonly used surgical treatment modalities for ingrown toenail, namely Nail Matrix Phenolization (NMP) and Wedge Matrix Resection (WMR). The effectiveness of both procedures was evaluated in terms of postoperative pain, wound healing, recurrence, infection, cosmetic outcome, return to routine activities, and patient satisfaction.

Study Area: The study was conducted in the Department of Dermatology, Katihar Medical College, Katihar, Bihar, India.

Study Duration: The study was carried out over a period of one year

Sample Size: A total of 90 patients diagnosed with ingrown toenail were included in the study.

- Group A (Nail Matrix Phenolization): 45 patients.
- Group B (Wedge Matrix Resection): 45 patients.

Study Population: The study population comprised patients attending the Dermatology Outpatient Department with clinically diagnosed Stage II or Stage III ingrown toenail (onychocryptosis). Patients fulfilling the eligibility criteria and providing written informed consent were enrolled consecutively. Both male and female patients aged 18 years and above

were included. Each participant underwent one of the two surgical treatment modalities and was followed prospectively throughout the study period to assess postoperative outcomes.

Data Collection: After obtaining written informed consent, demographic and clinical information was collected using a predesigned structured case record form. Details including age, gender, occupation, affected toe, side involved, duration of symptoms, previous treatment history, associated risk factors, and clinical stage of ingrown toenail were recorded. A detailed local examination was performed to assess pain, erythema, edema, infection, granulation tissue, and hypertrophy of the lateral nail fold. Patients were allocated equally to one of the two treatment groups. During follow-up, data regarding postoperative pain, wound healing time, postoperative infection, recurrence, cosmetic appearance, return to daily activities, and overall patient satisfaction were documented at 2, 4, 8, and 16 weeks using a standardized assessment proforma.

Inclusion Criteria

Patients fulfilling the following criteria were included in the study:

- Patients aged 18 years and above.
- Clinically diagnosed with Stage II or Stage III ingrown toenail.
- Patients are willing to undergo surgical treatment.
- Patients provide written informed consent.
- Both male and female patients.

Exclusion Criteria

Patients with the following conditions were excluded:

- Stage I ingrown toenail managed conservatively.
- Previous surgery on the affected toe.
- Diabetes mellitus.
- Peripheral vascular disease.
- Severe immuno-compromised conditions.
- Active osteomyelitis or severe foot infection requiring extensive surgery.
- Bleeding disorders or patients receiving anticoagulant therapy.
- Patients unwilling to participate in the study.

Procedure: After confirming the diagnosis of Stage II or Stage III ingrown toenail, all patients underwent routine preoperative evaluation and were operated on an outpatient basis under digital local anesthesia (2% lidocaine with epinephrine) with application of a rubber digital tourniquet under strict aseptic precautions. Patients were equally allocated into two treatment groups. In Group A (Nail Matrix Phenolization), approximately 3–4 mm of the affected lateral nail plate was excised, granulation tissue was curetted, and 88% phenol was applied to the exposed germinal matrix for 2 minutes, followed by irrigation with 70% isopropyl alcohol to neutralize residual phenol. In Group B (Wedge Matrix Resection), the affected lateral nail plate, hypertrophied nail fold, granulation tissue, and germinal matrix were surgically excised, and the wound was closed with interrupted sutures whenever required. After completion of the procedure, a sterile paraffin gauze dressing was applied, and all patients received standard postoperative care, including oral non-steroidal anti-inflammatory drugs for pain relief and antibiotics whenever clinically indicated. Patients were advised to keep the affected foot elevated, minimize walking during the initial postoperative period, perform daily dressing changes after removal of the first dressing, and maintain proper wound hygiene. Follow-up examinations were conducted at 2, 4, 8, and 16 weeks after surgery to assess postoperative pain, wound healing, infection, recurrence, cosmetic outcome, return to routine activities, and overall patient satisfaction.

Statistical Analysis: The collected data were entered into Microsoft Excel and analyzed using the Statistical Package for the Social Sciences (SPSS) version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), whereas categorical variables were presented as frequencies and percentages. Comparisons between the two treatment groups were performed using the Independent Student's t-test or Mann–Whitney U test for continuous variables depending on the distribution of data. Categorical variables such as recurrence, infection, wound healing, and patient satisfaction were analyzed using the Chi-square test or Fisher's exact test wherever appropriate. A p-value of less than 0.05 was considered statistically significant. This statistical approach was used to determine the comparative effectiveness and safety of the two treatment modalities for ingrown toenail.

Result

Table 1 shows the baseline demographic and clinical characteristics of the study participants. A total of 90 patients were included, with 45 patients each in the Nail Matrix Phenolization (NMP) and Wedge Matrix Resection (WMR) groups. The mean age was 31.8 ± 10.4 years in the NMP group and 32.6 ± 9.8 years in the WMR group, with no statistically significant difference ($p = 0.689$). Male participants constituted 60.0% of the NMP group and 57.8% of the WMR group, while females accounted for 40.0% and 42.2%, respectively ($p = 0.830$). The right great toe was affected in 55.6% of patients in the NMP group and 53.3% in the WMR group. The mean duration of symptoms was 5.4 ± 2.3 months and 5.7 ± 2.6 months, respectively ($p = 0.591$). These findings indicate that both treatment groups were comparable at baseline.

Table 1: Baseline Demographic and Clinical Characteristics of the Study Participants (N = 90)			
Variables	**Group A (NMP) (n=45)**	**Group B (WMR) (n=45)**	**p-value**
Age (years), Mean ± SD	31.8 ± 10.4	32.6 ± 9.8	0.689
Male, n (%)	27 (60.0)	26 (57.8)	0.83
Female, n (%)	18 (40.0)	19 (42.2)	
Right Great Toe, n (%)	25 (55.6)	24 (53.3)	0.826
Left Great Toe, n (%)	20 (44.4)	21 (46.7)	
Duration of Symptoms (months), Mean ± SD	5.4 ± 2.3	5.7 ± 2.6	0.591

Table 2 presents the distribution of disease severity among the study participants. In the NMP group, 28 patients (62.2%) had Stage II ingrown toenail and 17 patients (37.8%) had Stage III disease. Similarly, in the WMR group, 27 patients (60.0%) were diagnosed with Stage II disease, while 18 patients (40.0%) had Stage III disease. No statistically significant difference was observed between the two groups regarding disease stage ($p = 0.829$), demonstrating a similar severity distribution before treatment.

Table 2: Distribution of Disease Severity According to Clinical Stage			
Clinical Stage	**Group A (n=45)**	**Group B (n=45)**	**p-value**
Stage II	28 (62.2%)	27 (60.0%)	0.829
Stage III	17 (37.8%)	18 (40.0%)	

Table 3 compares the early postoperative outcomes between the two treatment modalities. The mean postoperative pain score on Day 3 was significantly lower in the NMP group (2.8 ± 1.1) compared to the WMR group (4.1 ± 1.3) ($p < 0.001$). The average wound healing time was also significantly shorter in patients treated with NMP (16.5 ± 3.4 days) than in those treated with WMR (21.8 ± 4.2 days) ($p < 0.001$). Postoperative infection occurred in 2 patients (4.4%) in the NMP group and 6 patients (13.3%) in the WMR group; however, this difference was not statistically significant ($p = 0.138$). Patients undergoing NMP returned to their routine daily activities significantly earlier (8.9 ± 2.1 days) compared to those undergoing WMR (12.6 ± 2.9 days) ($p < 0.001$). These findings suggest that Nail Matrix Phenolization provides better early postoperative recovery than Wedge Matrix Resection.

Table 3: Comparison of Early Postoperative Outcomes Between the Two Treatment Groups			
Outcome	**Group A (NMP)**	**Group B (WMR)**	**p-value**
Pain Score (VAS) Day-3 (Mean ± SD)	2.8 ± 1.1	4.1 ± 1.3	**<0.001**
Wound Healing Time (days), Mean ± SD	16.5 ± 3.4	21.8 ± 4.2	**<0.001**
Postoperative Infection, n (%)	2 (4.4%)	6 (13.3%)	0.138
Return to Routine Activity (days), Mean ± SD	8.9 ± 2.1	12.6 ± 2.9	**<0.001**

Table 4 summarizes the late clinical outcomes observed during follow-up. Recurrence of ingrown toenail was reported in only 2 patients (4.4%) treated with NMP compared with 7 patients (15.6%) treated with WMR, showing a statistically significant difference ($p = 0.043$). Spicule formation occurred in 1 patient (2.2%) in the NMP group and 5 patients (11.1%) in the WMR group, although the difference was not statistically significant ($p = 0.090$). An excellent cosmetic outcome was achieved in 86.7% of patients in the NMP group compared to 71.1% in the WMR group ($p = 0.048$). Similarly, patient satisfaction was significantly higher among patients treated with NMP (91.1%) than those treated with WMR (75.6%) ($p = 0.045$). These findings indicate superior long-term clinical outcomes with Nail Matrix Phenolization.

Table 4: Comparison of Late Clinical Outcomes			
Variables	**Group A (NMP)**	**Group B (WMR)**	**p-value**
Recurrence, n (%)	2 (4.4%)	7 (15.6%)	0.043
Spicule Formation, n (%)	1 (2.2%)	5 (11.1%)	0.09
Excellent Cosmetic Outcome, n (%)	39 (86.7%)	32 (71.1%)	0.048
Patient Satisfaction, n (%)	41 (91.1%)	34 (75.6%)	0.045

Table 5 presents the overall treatment outcomes between the two surgical procedures. Complete recovery was achieved in 42 patients (93.3%) in the NMP group compared with 36 patients (80.0%) in the

WMR group, demonstrating a statistically significant difference (p = 0.048). Minor postoperative complications were observed in 3 patients (6.7%) undergoing NMP and 9 patients (20.0%) undergoing WMR (p = 0.046). The overall treatment success rate was significantly higher in the NMP group (95.6%) than in the WMR group (82.2%) (p = 0.037). These results indicate that Nail Matrix Phenolization is associated with higher treatment success and fewer postoperative complications compared with Wedge Matrix Resection.

Table 5: Overall Comparison of Treatment Success

Outcome	Group A (NMP) (n=45)	Group B (WMR) (n=45)	p-value
Complete Recovery	42 (93.3%)	36 (80.0%)	**0.048**
Minor Complications	3 (6.7%)	9 (20.0%)	**0.046**
Overall Treatment Success	43 (95.6%)	37 (82.2%)	**0.037**

Discussion

This prospective comparative study aimed to assess and compare the clinical results of Nail Matrix Phenolization (NMP) and Wedge Matrix Resection (WMR) in the treatment of Stage II and III ingrown nails. The results revealed that both surgical methods were effective for ingrown toenail treatment, but Nail Matrix Phenolization yielded better results in regard to postoperative pain, wound healing, recurrence, cosmetic appearance and patient satisfaction. These results indicate that phenolization is a safe, effective and reliable therapy for patients with moderate to severe ingrown nails" [12].

The demographic data for the two treatment groups were similar. The average age of the respondents was about 32 years, with men being marginally affected compared to females. Both groups were well matched prior to intervention in terms of distribution of severity of disease, side of involvement and duration of symptoms, respectively. This comparability reduced the selection bias and allowed the comparison of the outcomes of the surgery to be done reliably between the two surgical techniques [13].

The significantly less postoperative pain experienced by patients undergoing Nail Matrix Phenolization was one of the most significant results of the present study. The average score on the 3rd postoperative day was 2.8 ± 1.1 for the NMP group and 4.1 ± 1.3 for the WMR group. The reason for the decreased postoperative pain after phenolization may be that there is no extensive surgical removal of tissue and the destruction of the nail matrix by phenol. The reduction in postoperative discomfort allows earlier ambulation, better patient compliance and promotes the overall healing process. These results have been confirmed by other comparative studies in which patients that had undergone phenolization had less post-operative pain than those that had received wedge resection or other traditional surgical techniques [14].

The present study also showed that patients receiving Nail Matrix Phenolization had significantly quick healing of the wound. The mean recovery period was 16.5 ± 3.4 days for the NMP group, and 21.8 ± 4.2 days for the WMR group. Earlier return to daily activities and decreased burden of wound care after surgery are achieved because of faster wound healing. Similarly, patients who received phenolization had a significantly earlier recovery from normal daily activities (8.9 ± 2.1 days) than those with wedge matrix resection (12.6 ± 2.9 days). These results reflect the current trend of treatment through minimally invasive surgical methods with optimal results and minimal disability following surgery [15].

The number of patients with postoperative infections was 4.4% for the Nail Matrix Phenolization group and 13.3% for the Wedge Matrix Resection group. While the difference was not statistically significant, the lower infection rate may be due to the antiseptic effect of phenol and the relatively minimal tissue trauma of phenolization. The low rates of infection that were observed in both treatment groups may also have been due to appropriate postoperative wound care, strict adherence to proper surgical technique, and the patient's ability to follow the dressing instructions [16].

One of the most significant prognostic factors for successful long-term results of an ingrown nail surgery is recurrence. The results of the present study showed that 4.4% of patients who underwent Nail Matrix Phenolization had recurrence, while 15.6% of patients who underwent Wedge Matrix Resection had recurrence, which was statistically significant. These results suggest that chemical destruction of germinal matrix is an effective method of preventing regrowth of the offending nail margin. Spicule formation also occurred less often after phenolization (2.2%) than wedge resection (11.1%) indicating that the nail matrix destruction was more complete in the phenolization group. This decreases the rate of recurrences and the likelihood of developing spicules, which decreases the likelihood of repeat surgical procedures and increases the success rate [17] .

Cosmetic outcome and patient satisfaction are important factors to consider when dealing with ingrown toepads, especially in young and active patient population. The present study demonstrated that superior cosmetic results were obtained in 86.7% of the patients who received Nail Matrix Phe-

nolization treatment, while 71.1% of the patients who received Wedge Matrix Resection treatment had an excellent cosmetic result. Similarly, phenolization group had significantly higher patient satisfaction (91.1%) than wedge resection group (75.6%). The overall satisfaction was higher for patients treated with Nail Matrix Phenolization [18] as a result of improved cosmetic appearance, decreased post-operative pain, faster healing and decreased recurrency rates.

The success rate of overall treatment was also significantly better for the Nail Matrix Phenolization group (95.6%) than for the Wedge Matrix Resection group (82.2%) and fewer complications occurred after phenolization. These results suggest that NMP is a more reproducible clinical response and less toxic. It is technically easy, has a low operating time and it is performed safely in an outpatient setting, a factor which makes it particularly useful in routine surgical practice [19].

The mechanism of action of Nail Matrix Phenolization could be a possible explanation for the superior results seen. When using 88% phenol, controlling chemical destruction of the germinal matrix by denaturing proteins does not allow re-growth of the lateral nail plate. On the other hand, Wedge Matrix Resection involves complete removal of the matrix and if there is any left behind, it can either lead to recurrence or spicules will form. Furthermore, the little tissue dissection required during phenolization reduces surgical trauma, which in turn reduces pain, healing time and cosmetic appearance [20].

Although these promising results were found, the present study has some limitations. It was carried out in one tertiary care center with a small number of patients (90) and may not be easily generalized. Additionally, the follow-up period was short (one year) and long-term follow-up may yield more detailed data on late recurrence. Larger multicentric randomized controlled trials with longer follow-up are recommended to more thoroughly compare the different surgical modalities and provide guidelines for the treatment of ingrown nails. Overall, the results of the present study indicate that Nail Matrix Phenolization is a more effective treatment compared to Wedge Matrix Resection, with lower levels of post-operative pain, quicker healing, lower reoccurrence rates, better cosmetic outcomes, higher satisfaction, and higher treatment success rates.

Conclusion

The present prospective comparative study found that both Nail Matrix Phenolization (NMP) and Wedge Matrix Resection (WMR) were effective surgical procedures for Stage II and III ingrown toenails, with significantly better clinical outcomes for Nail Matrix Phenolization. The patients who received NMP had a reduced pain score after surgery, shorter healing time, quicker return to normal daily activities, lower rates of recurrence, better cosmetic outcomes, higher patient satisfaction, and higher overall success rate compared with WMR. Overall, these results indicate that Nail Matrix Phenolization is a safe, effective, minimally invasive and reliable treatment modality with superior short- and long-term results. However, further research is needed to confirm the findings of these studies, and to establish standard practices for treatment.

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