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Original Article

Union rates in hallux interphalangeal joint arthrodesis: A retrospective review of a reproducible surgical technique

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Abstract

Objective: To assess the radiographic union rate and complications following hallux interphalangeal joint arthrodesis (HIPJA) using a single reproducible surgical technique and report on possible technique tips to improve the union rate.

Methods: A retrospective review of all HIPJAs performed by four foot and ankle orthopedic surgeons was conducted. The surgical technique, patient factors, indications, reoperation rate, complications, and radiographic evidence of arthrodesis were collected. Radiographic union was defined as two cortical continuations or trabecular bridging, absence of hardware failure, and the absence of lytic gapping at the arthrodesis site.

Results: Thirty-five primary HIPJA procedures were identified with radiographic follow-up until union or non-union was confirmed. Our cohort demonstrated a 97.1% radiographic union rate with a mean time to union of 20 weeks. There were three reoperations: two cases (5.7%; 95% CI, 0.7%-19.2%) for removal of painful hardware and one case (2.9%; 95% CI, 0.07%-14.9%) for revision of a symptomatic non-union. Because only one non-union occurred, the study was not powered to identify independent predictors of non-union.

Conclusion: This cohort showed a mean above-radiographic union rate with a consistent surgical technique, meticulous joint preparation, and a single large intramedullary differential pitch screw for fixation. Radiographic union took longer than expected, with a mean of 20 weeks.

Level of Evidence IV; Retrospective Case Series.

Keywords: Fractures, ununited; Arthritis, Joint arthrodesis.

Introduction

Hallux interphalangeal joint arthrodesis (HIPJA) has not received the same attention as the metatarsophalangeal joint (MTPJ) arthrodesis in the orthopedic literature. Although less common, it is mostly performed for pain, deformity, or dysfunction[1]. This procedure can be performed as a standalone procedure in cases of primary, inflammatory, post-traumatic arthritis, or as part of the Jones procedure[2] to treat clawing of the hallux and other angular deformities[3].

Thorud et al.[4] reviewed HIPJA fixation techniques, complications, and reoperation rates at four academic institutions and reported significant differences in complication rates among the four institutions: 33%, 52%, 80%, and 90%, respectively. This large interinstitutional variation was attributed to differences in pre-operative patient health at each institution. The authors emphasized the importance of surgeon experience, hospital care, and postoperative protocols. Likewise, comparing the large cohorts in the studies by Thorud et al.[4] (152 patients) and Braswell et al.[3] (227 patients), complications differed significantly: Infection rates (16.5% vs 4%), wound dehiscence (12.5% vs 3.5%), and hardware removal (17.9% vs 6.6%). Thorud et al.[4] reported that 5 of the 41(12%) revision surgeries ended in amputation.

Study performed at the Netcare Linksfield Hospital, Johannesburg, South Africa.

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Further research is needed to reduce complication rates and variability by identifying a standardized surgical technique—including approach, joint preparation, fixation, and post-operative protocol—that produces reproducible, favorable outcomes for HIPJA.

A recent study by Braswell et al.[3] of 227 patients, the largest number of HIPJA at a single institution to date, again highlighted the difficulty of achieving union of the hallux interphalangeal joint (HIPJ) even with modern implants and techniques. They reported a 25.5% non-union rate, of which 53.4% of those patients required reoperation. In a systematic review by So et al.[5], the non-union rate reached 28.3% in 313 HIPJAs[5]. This high reported non-union rate is concerning, and further research is required to improve outcomes.

The objective of this study is to assess the radiographic union rate and complications following hallux interphalangeal joint arthrodesis (HIPJA) using a single reproducible surgical technique and report on possible technique tips to improve the union rate.

Methods

A retrospective review was conducted on the surgical database to identify all consecutive patients who underwent primary HIPJA from 2008 to 2024 by a group of four foot and ankle surgeons using the same surgical technique. Inclusion criteria included patients older than 18 years, with complete clinical notes and adequate radiographic follow-up. A total of 35 patients met the inclusion criteria, with 16 males and 19 females, with a mean age of 55 years (range 18 to 74). No patients were excluded. Mean follow-up was 3.6 years; median follow-up was 1.2 years (IQR, 0.3-5.0 years), with a range of 0.2-17 years (Table 1). The study was conducted after approval by the Institutional Review Board.

Table 1. Patient demographics and comorbidities (n = 35)

Variable	Value
Mean age at time of surgery	55 (range 18-74) years
Follow-up	Mean: 3.6 (range 0.2-17) years Median: 1.2 (IQR, 0.3-5.0) years
Sex, n (%)	
Male	16 (46%)
Female	19 (54%)
Side	
Left	17 (49%)
Right	18 (51%)
Diabetes, n (%)	8 (23%)
Peripheral neuropathy, n (%)	10 (29%)
Neuromuscular condition, n (%)	9 (26%)
Inflammatory arthritis, n (%)	9 (26%)
Active tobacco use, n (%)	1 (3%)

IQR: Interquartile range.

All patients in our study were treated with the same surgical technique and postoperative protocol. An L-shaped incision is made across the interphalangeal joint on the dorsal skin and proximally along the medial border of the phalanx. An elliptical excision of excessive skin and capsule can be performed in flexion deformities over the interphalangeal joint (Figure 1). Meticulous soft tissue handling, with preservation of a full-thickness tissue flap and the use of blunt hand-held retractors, is of utmost importance. The capsule and extensor hallucis longus are cut transversely, leaving enough distal tissue for reattachment and closure. Once the joint is exposed, the proximal phalanx condyle is cut flat and perpendicular to the shaft of the proximal phalanx using an oscillating saw with irrigation, while protecting the soft tissue. The base of the distal phalanx is then carefully exposed, being aware not to injure the germinal zone of the nail bed. The base of the distal phalanx is then resected to achieve a reciprocal flat cut to match the proximal phalanx (Figure 2). In the setting of a varus or valgus malalignment, an appropriate wedge resection is taken from the proximal phalanx. In cases of severe contracture, the flexor hallucis longus tendon can be released through the prepared joint. The joint is then reduced to confirm correct alignment prior to fixation. The proximal and distal joint surfaces are then perforated using a

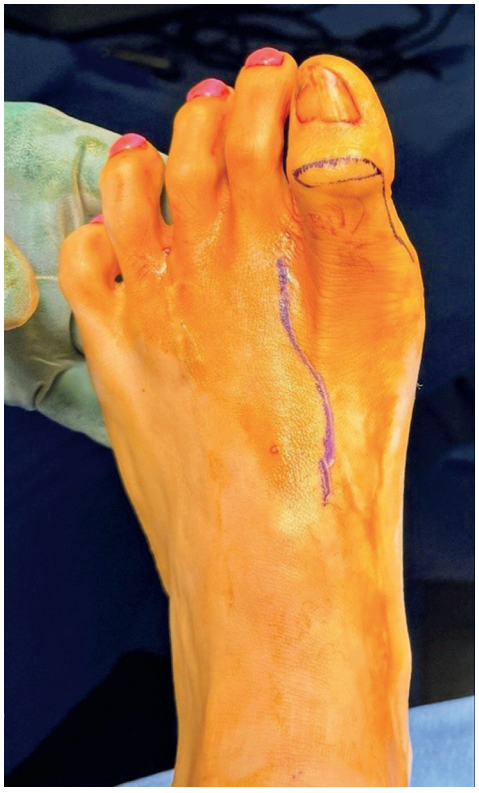

Figure 1. An L-shaped incision is made across the interphalangeal joint (elliptic excision of excessive skin can be done) and proximally along the medial border of the phalanx.

1.6 mm drill bit to allow marrow elements into the fusion site (Figure 3). Avoid using a guide wire, as it may cause thermal necrosis. The guidewire for fixation is then passed antegrade through the distal phalanx to exit at the central tip of the toe, clear of the nail bed. The joint is reduced to a neutral position in the sagittal plane with 0-5 degrees of valgus[6], and the guidewire is advanced retrograde up to 4 mm from the MTPJ. A second wire can be placed to ensure rotational stability during preparation and screw insertion. The screw length is then measured, and a 4.5-5.5 mm differential-pitch titanium headless compression screw (4.7-5.5 mm Acutrak 2®, Acumed, USA or 4.5-5.5 mm Monster® Screw Paragon 28 Inc, Englewood, CO, USA) is inserted, taking care to not injure the soft tissue at the tip of the toe. The screw head should be countersunk adequately to prevent irritation and achieve compression (Figure 4). Autogenous bone grafting is used selectively when a bone defect or concern regarding bone quality is identified intraoperatively. Autogenous bone graft is routinely harvested from the distal tibia when required and inserted prior to fixation. Our team prefers to routinely use autogenous bone rather than allograft bone. The wound is closed in layers. A wool and crepe bandage dressing is applied and the foot placed in a forefoot off-loader shoe for the first six weeks. The patients are advised to have strict bed rest and elevation for the first two weeks. Wound inspections are performed at week 1, 2 and 6. After six weeks, the patient may resume normal daily activities in supportive sports shoes and perform non-impact exercises such as cycling, yoga, pilates and swimming. High-impact exercises are resumed after 12 weeks based on radiographic union and symptoms.

Foot weight-bearing radiographs are performed at week 6, 10, 15, 20, and three-monthly thereafter until radiographic union or non-union is confirmed. Radiographic union was defined as two cortical continuations or trabecular bridging at the arthrodesis site, absence of hardware failure, and the absence of lytic gapping of the joint[3]. A non-union was defined as the absence of trabecular bony bridging at the

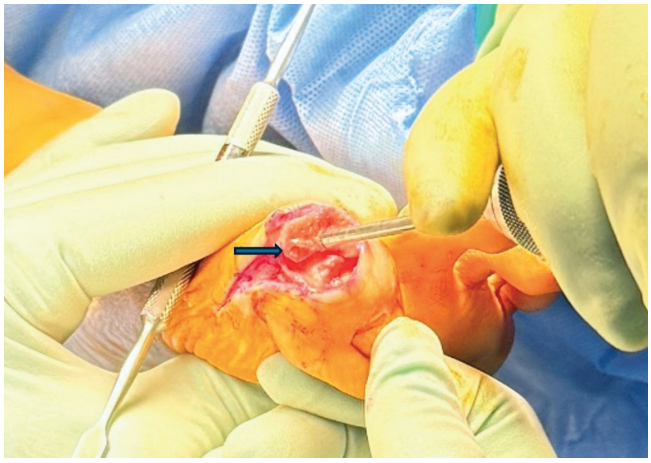

Figure 3. The prepared joint surfaces are then drilled using a 1.6 mm drill bit to form a vascular channel to allow bone marrow elements into the fusion site.

Figure 2. (A) The condyles of the proximal phalanx are exposed and the soft tissues protected with a McDonald dissector. (B) The condyles of the proximal phalanx of the hallux are excised using a small oscillating saw with irrigation. (C) The base of the proximal phalanx is carefully exposed so as not to damage the germinal layer of the nail bed. (D) The base of the distal phalanx is then resected to achieve a reciprocal flat cut to match the proximal phalanx.

fusion site and/or hardware failure after a minimum follow-up of six months[7]. All patient radiographs were independently reviewed by the authors, with reviewers blinded to clinical outcome data, to assess for fusion of the HIPJ. Interobserver reliability was not formally assessed, and disagreements were resolved by consensus. Clinical symptoms of a possible non-union included persistent swelling, erythema, and pain at the fusion site, which were documented if present. All reported complications were documented. Patient demographics, tobacco use, and comorbidities were collected from clinical records and recorded. All associated procedures and prior ipsilateral hallux MTPJ fusion were documented.

For statistical analyses, continuous variables were summarized using means and standard deviations and medians with interquartile ranges. Categorical variables were summarized using frequencies and percentages. The primary outcome was radiographic union. Given the small cohort size and the single non-union event, the analysis was primarily descriptive with no multivariable modeling possible. An exact 95% confidence interval was calculated for the observed union proportion.

Results

Patient co-morbidities, tobacco use, ipsilateral MTPJ fusions, and additional procedures are reported in Table 1 and Table 2. The indications for HIPJA are summarized in Table 3.

Radiographic union was achieved in 34 of 35 procedures (97.1%; 95% CI, 85.1%-99.9%). Three patients (8.6%; 95% CI, 1.8%-23.1%) underwent reoperation. One patient (2.9%; 95% CI, 0.07%-14.9%) developed a non-union. Given the small, heterogeneous cohort and single non-union, the study was underpowered for multivariate analysis to assess potential risk factors for developing a non-union. The non-union occurred in a 72-year-old male non-smoker known with gout, hypothyroidism, and neuropathy who had IPJ arthritis secondary to gout. An identical surgical technique was utilized, but a 4 mm Paragon 28 Mini-monster® screw was used at the initial surgery. He was noted to have florid gouty crystals throughout the joint at the time of primary surgery despite medical treatment. The patient presented at 28 weeks with a painful non-union and was subsequently revised to a larger screw with autogenous bone grafting. He achieved union at 24 weeks after the revision surgery (Figure 5). Two cases (5.7%; 95% CI, 0.7–19.2%) required reoperation

Table 2. Associated procedures and prior MTPJ fusion

Associated procedures	
Lesser toe correction	10 (29%)
Bunionette correction	2 (6%)
Ankle instability ligament reconstruction	2 (6%)
Previous MTPJ fusions	5 (14%)

MTPJ: Metatarsophalangeal joint.

Table 3. Indications for HIPJA

Indication	n (%)
Angular deformity	16 (46%)
Inflammatory arthritis	9 (26%)
Post-traumatic arthritis	4 (11%)
Primary osteoarthritis	3 (9%)
Charcot arthropathy	2 (6%)
Post-infective arthritis	1 (3%)
Total	35 (100%)

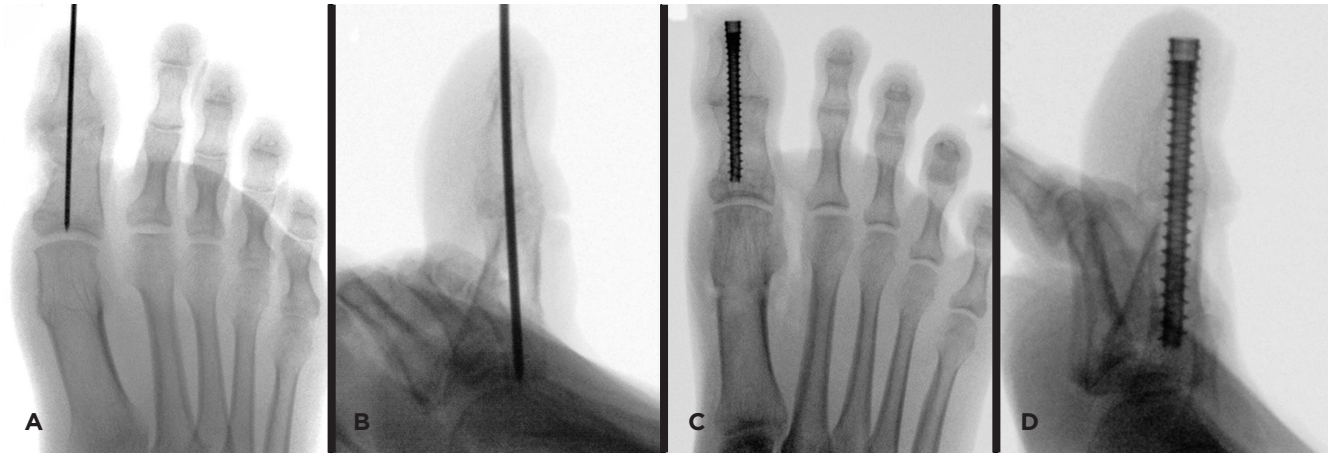

Figure 4. (A-B) Intra-operative fluoroscopic anteroposterior and lateral view of the hallux showing reduction of the prepared interphalangeal joint and placement of the guidewire in the center of the phalanges. (C-D) Intra-operative fluoroscopic anteroposterior and lateral view of the hallux showing fixation of the interphalangeal joint with a 4.5-5.5 mm differential-pitch titanium headless compression screw, achieving good compression.

for screw removal due to symptomatic hardware irritation after confirmed union. Notably, only 20% (7/35) of patients achieved union before week 15, and the mean time to union was 20 weeks or longer (Figure 6 and 7). Autogenous bone grafting was performed in 2 of 35 procedures (5.7%), primarily in cases with bone defects (Table 4).

Figure 5. (A) Patient with symptomatic non-union at 28 weeks. (B) Patient achieved union 24 weeks after revision with a larger screw and autogenous bone grafting.

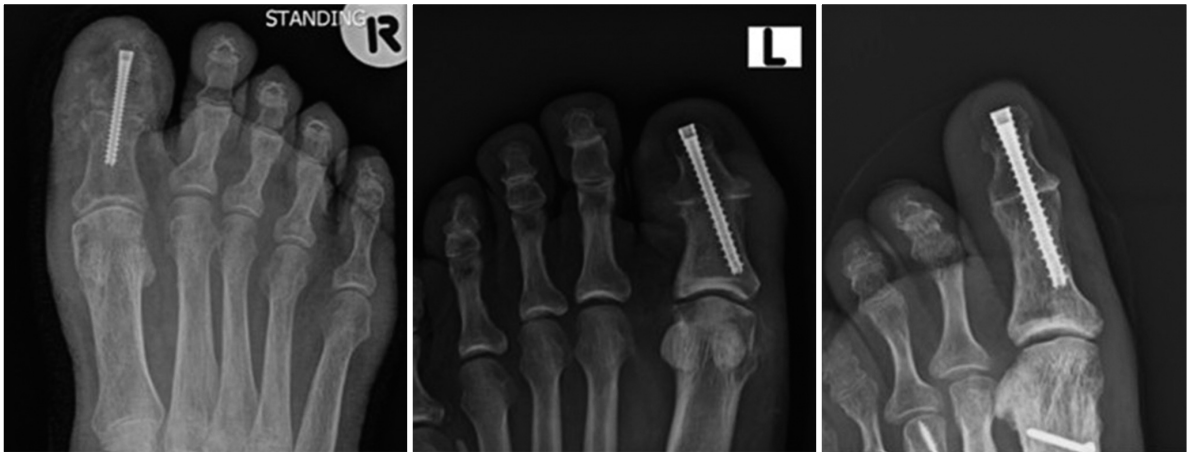

Figure 6. Radiographs of three patients showing no clear union at 10 weeks after surgery.

Figure 7. The same three patients at final follow-up showing union at 80, 208, and 216 weeks, respectively.

Discussion

The high reported incidence of non-union of HIPJA is concerning, with little guidance in the literature on preventing this complication. Complications after HIPJA are multifactorial and should be assessed and addressed accordingly. The complication most consistently reported as unacceptably high is non-union, which ranges from 25%-30%[4,5]. Our long-term follow-up study showed a non-union rate of only 2.9%. It is important to identify possible factors that may improve the union rate of HIPJA. In our sample, two patients (5.7%; 95% CI, 0.7%-19.2%) underwent reoperations for symptomatic hardware, both of which had screw removal after confirmed union. One patient (2.9%; 95% CI, 0.07%-14.9%) required fusion revision for a symptomatic non-union. Overall, our 8.6% (3/35) reoperation rate compares favorably with the literature (21%-27%)[3,4].

The indication for doing a HIPJA has been reported to play an important role as a risk for developing a non-union. Braswell et al.[4] reported that deformity correction had a higher risk of developing a non-union than arthritis or trauma. Deformity correction was the most common indication in our study (16/35), with all cases achieving a successful union. The one non-union in our cohort had secondary arthritis due to poorly controlled gout. Thitiboonsuwan et al.[8] reported that prior adjacent hallux MTPJ fusion increases time to union by 4.8 times and the risk of non-union due to increased weight-bearing on the IPJ post-MTPJ fusion[3,8,9]. Five patients with prior ipsilateral hallux MTPJ fusion achieved a successful union.

Soft tissue handling, joint preparation, and fixation device/technique are surgeon-related factors that contribute to successful HIPJA and are within the surgeon's control[4,10]. Derner and Meyr described V-shaped cuts for joint preparation, which increase contact surface area for fusion and provide intrinsic frontal-plane stability, although they are technically more demanding. Oblique screws would be placed perpendicular to the cut surfaces, avoiding the proximity of the nail bed, but at the cost of using a smaller screw[11]. In our opinion, this technique is technically demanding to perform without compromising the soft tissue and germinal layer of the nail bed when preparing the distal phalanx. We prefer flat cuts and routinely use a small oscillating saw with saline irrigation to minimize thermal necrosis for joint preparation.

Multiple fixation methods have been described since the original description of K-wire fixation, which resulted in unacceptably high non-union rates (32%-44%)[5,10]. Modern fixation methods include compression staples and single or double screw fixation with reportedly improved success in achieving union[4,12]. A systematic review by So et al.[5] has shown that single screw fixation resulted in improved union rates and fewer infections as compared to K-wire fixation. Cross screw configurations had significantly higher wound dehiscence, infections, and reoperations, but fairly similar union rates in a study by Thorud et al.[4] Hyer et al.[12] reported that using two parallel 3 mm headless screws had a higher rate and shorter time to fusion as compared to a single 4 mm screw. Despite the reported improvement in union rate with modern fixation devices, the reported non-union rate is still as high as 30%, which is exceptionally high by modern-day standards (Table 5)[3,5]. The optimal screw size for fixation of

Table 4. Summary of screws used, bone grafting and reoperations

Variable	n / n	Percentage
Screws used		
4.7 mm Acutrak screw	31 / 35	88.6%
4.0 mm Paragon Mini Monster screw	4 / 35	11.4%
Autogenous bone grafting	2 / 35	5.7%
Reoperations	3 / 35	8.6%
Removal of symptomatic hardware	2 / 35	5.7%
Revision for non-union	1 / 35	2.9%

Table 5. Summary comparing fixation constructs and union rates in the literature

Study	Fixation construct	No. of HIPJA	Union rate	Non-union rate
Shives and Johnson, 1980	K-wire	101	56%	44%
Shives and Johnson, 1980	Longitudinal mini-cancellous compression screw	20	90%	10%
Thorud et al., 2016	Single intramedullary screw	74	77%	23%
Thorud et al., 2016	Crossed screws	13	76.9%	23.1%
Thorud et al., 2016	K-wire	10	40%	60%
Hyer et al., 2017	Single 4.0 mm intramedullary screw	7	71.4%	28.6%
Hyer et al., 2017	Two 3.0 mm headless intramedullary screws	32	78.1%	21.9%
So et al., 2018	K-wire fixation, pooled literature	158	67.7%	32.3%
So et al., 2018	Single-screw fixation, pooled literature	121	84.3%	15.7%
So et al., 2018	Crossed-screw fixation, pooled literature	17	82.4%	17.6%
Braswell et al., 2023	Predominantly single screw fixation ± additional fixation	227	74.5%	25.5%
Present study	4.7 mm Acutrak screw (31/35) or 4.0 mm Paragon screw (4/35)	35	97.1%	2.9%

HIPJA: Hallux interphalangeal joint arthrodesis.

the HIPJA has not been assessed in the available literature[4,6]. In our case series, the non-union was fixed with only a 4 mm screw, which may have contributed to failure due to inferior stability. Since the most common technique is a single screw fixation of a flat cut (poor rotational stability) joint surface, using a larger screw may add additional compression and stability to the fusion site[4,6]. Some authors have suggested revising the non-union cases with a larger screw[13]. We now routinely use at least a 4.5 mm screw with a variable pitch, which may give better compression at the fusion site than a standard fully or partially threaded screw. In larger patients or revision cases, we try using a 5.5 mm or larger screw if we can safely insert the screw without risk of fracturing the distal phalanx (Figure 5).

Smoking[14-17], diabetes[4], obesity[4], and peripheral neuropathy[4] are patient factors that could impact union or reoperation rates. Modifiable patient risk factors have been assessed in the literature, but no correlation has been identified with non-union rate. In our study, although a much smaller sample size (35 patients), the incidence of diabetes was 23% (8/35) and peripheral neuropathy was 29% (10/35), similar to other larger studies such as Braswell et al.[3] and Thorud et al.[4] (23% and 32%, respectively). The incidence of active smokers was also not significantly different (2.9% vs 6.2%). Our patient with the non-union was a non-smoker but had neuropathy due to spinal pathology. Due to the small cohort, we are unable to comment on the correlation between comorbidities and the risk of developing a non-union. Patient compliance with postoperative protocols is also important for achieving a successful union; however, this factor is outside the surgeon's control, except by educating the patient about its importance. Unfortunately, it is not possible to measure and report compliance once the patient is at home.

Based on our outcomes and the available literature, we suggest the following to help reduce the incidence of HIPJA non-union. Regarding the surgical technique: practice meticulous soft tissue handling, ensure adequate exposure (L-shaped incision instead of an isolated elliptical incision over IPJ) to allow for good joint preparation, drill the joint surface with a 1.5-2 mm drill, and bone graft any voids with autogenous bone graft. Consider using the largest differential pitch headless compression screw, which can be safely inserted without compromising the phalanx, to achieve optimal compression and stability. Post-operatively immobilize the foot in a non-weight-bearing forefoot shoe for six weeks.

Our study showed that radiographic union can take longer than expected (a mean of 20 weeks or more), as reported by Thitiboonsuwan et al. (8). If the patient is asymptomatic, follow up for six months before diagnosing a non-union. Studies have reported that 47%-74% of patients with fibrous unions had acceptable patient-reported outcome scores and did not require revision[5,9]. Some of these reported asymptomatic non-unions had short follow-up, and if these patients were followed longer, radiographic union may have occurred.

Limitations of this study include its retrospective nature, a relatively small cohort size, and lack of patient-reported outcomes after the HIPJA. Radiographic assessment was performed retrospectively by the authors. The small cohort, heterogeneous indications, and only one non-union event do not allow multivariable analysis to assess potential risk factors for non-union. This retrospective review was performed due to the concerningly high reported non-union rate of HIPJA. The lack of prospective, large studies, together with the reported high incidence of non-union, emphasizes the need for more research on this topic, including patient-reported outcomes and multivariable analysis to further evaluate clinical outcomes and risk factors for non-union following HIPJA. Our hope is that this study will stimulate further research.

Conclusion

The non-union rate of the hallux interphalangeal joint arthrodesis ranges from 0% to 43%[3], while the incidence of non-union in other foot joints is usually less than 13%[18-20]. Although not all non-unions require revision, it remains a concern[3]. This retrospective case series had a 97.1% radiographic union rate using a reproducible surgical technique consisting of meticulous joint preparation and fixation using a single large intramedullary differential pitch screw. Radiographic union took longer than expected, with a mean of 20 weeks. Larger prospective comparative studies incorporating patient-reported outcomes are required to assess risk factors associated with HIPJA non-union.

Authors' contributions: Each author contributed individually and significantly to the development of this article: FJ *(https://orcid.org/0000-0001-7045-1681) Assisted with surgeries, data collection, interpreted the results of the study, bibliographic review, survey of the medical records, formatting of the article, and approved the final version; JJ *(https://orcid.org/0000-0003-1448-4272) Interpreted the results of the study, participated in the review process, performed the surgeries, formatting of the article, and approved the final version; MW *(https://orcid.org/0000-0002-7999-9069) Performed the surgeries, participated in the review process, formatting of the article, and approved the final version; NP *(https://orcid.org/0000-0002-5566-7588) Interpreted the results of the study, participated in the review process, performed the surgeries, formatting of the article, and approved the final version; PN *(https://orcid.org/0000-0003-4639-0326) Conceived and planned the activities that led to the study, interpreted the results of the study, participated in the review process, performed the surgeries, formatting of the article, and approved the final version. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Salleh R, Beischer A, Edwards WH. Disorders of the hallucal interphalangeal joint. Foot Ankle Clin. 2005;10(1):129-40.
2. Faraj AA. Modified Jones procedure for post-polio claw hallux deformity. J Foot Ankle Surg. 1997;36(5):356-9.
3. Braswell MJ, Hysong AA, Macknet DM, Jones CP, Ford SE, Ellington JK. Outcomes After Hallux Interphalangeal Joint Arthrodesis. Foot Ankle Int. 2023;44(12):1213-8.
4. Thorud JC, Jolley T, Shibuya N, Lew E, Britt M, Butterfield T, et al. Comparison of Hallux Interphalangeal Joint Arthrodesis Fixation Techniques: A Retrospective Multicenter Study. J Foot Ankle Surg. 2016;55(1):22-7.
5. So E, Wilson MD, Chu AK, Prissel MA. Incidence of Nonunion of the Hallux Interphalangeal Joint Arthrodesis: A Systematic Review. J Foot Ankle Surg. 2018;57(4):776-80.
6. James WC, Davis WH. Hallux Interphalangeal Joint Arthrodesis: Indications and Technique. Tech Foot Ankle Surg. 2004;3(3):153-7.
7. Füssenich W, Seeber GH, van Raaij TM, van Lingen CP, Zuurmond RG, Stevens M, et al. Factors Associated With Nonunion in Arthrodesis of the First Metatarsophalangeal Joint: A Multicenter Retrospective Cohort Study. Foot Ankle Int. 2023;44(6):508-15.
8. Thitiboonsuwan S, Kavolus JJ 2nd, Nunley JA 2nd. Hallux Interphalangeal Arthrodesis Following First Metatarsophalangeal Arthrodesis. Foot Ankle Int. 2018;39(10):1178-82.
9. Brodsky JW, Zide JR, Kim KES, Charlick DA, Daoud Y, Bohl DD. Arthrodesis of Ipsilateral Hallux Metatarsophalangeal and Interphalangeal Joints. Foot Ankle Orthop. 2021;6(1): 2473011420983815.
10. Shives TC, Johnson KA. Arthrodesis of the interphalangeal joint of the great toe--an improved technique. Foot Ankle. 1980;1(1):26-9.
11. Derner R, Meyr AJ. Hallux Interphalangeal Joint Arthrodesis. J Foot Ankle Surg. 2009;48(3):408-10.
12. Hyer C, Wakefield E, Olson J. Retrospective Comparative Analysis of Hallux Interphalangeal Joint Fusion Fixation Constructs. Foot Ankle Orthop. 2017;2(3):2473011417S0002.
13. Westberry DE, Shull ER, Layton B. Great Toe Interphalangeal Fusion for Hallux Valgus Interphalangeus Deformity in Young Patients. J Pediatr Orthop. 2024;44(3):179-83.
14. Heyes G, Weigelt L, Molloy A, Mason L. The influence of smoking on foot and ankle surgery: a review of the literature. Foot (Edinb). 2021;46:101735.
15. Kim JH, Patel S. Is It Worth Discriminating Against Patients Who Smoke? A Systematic Literature Review on the Effects of Tobacco Use in Foot and Ankle Surgery. J Foot Ankle Surg. 2017;56(3):594-9.
16. Dhodapkar MM, Oghenesume OP, Halperin SJ, Modrak M, Yoo BJ, Grauer JN. Adverse Events After Ankle Fracture Open Reduction Internal Fixation Among Patients With and Without Documented Cannabis and Tobacco Use. Foot Ankle Int. 2023;44(10):941-8.
17. Beahrs TR, Reagan J, Bettin CC, Grear BJ, Murphy GA, Richardson DR. Smoking Effects in Foot and Ankle Surgery: An Evidence-Based Review. Foot Ankle Int. 2019;40(10):1226-32.
18. Weigelt L, Redfern J, Heyes GJ, Butcher C, Molloy A, Mason L. Risk Factors for Nonunion After First Metatarsophalangeal Joint Arthrodesis With a Dorsal Locking Plate and Compression Screw Construct: Correction of Hallux Valgus Is Key. J Foot Ankle Surg. 2021;60(6):1179-83.
19. Younger ASE, Veljkovic A, Wing K, Penner MJ, Qian H, Wong H. Rates of Nonunion for Different Joints after Foot And Ankle Surgery: A Review of 2301 Fusions. Foot Ankle Orthop. 2019; 4(4):2473011419S00452.
20. Cardoso DV, Veljkovic A. General Considerations About Foot and Ankle Arthrodesis. Any Way to Improve Our Results? Foot Ankle Clin. 2022;27(4):701-722.