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Arthrodesis of Distal Interphalangeal Joints Using X-Fuse Implant A Five-Year Retrospective Study of 64 Fingers

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Introduction: **Arthrodesis is the gold standard for treating distal interphalangeal arthropathy of the long fingers (IPD) and interphalangeal arthropathy of the thumb (IP). While many surgical techniques have been documented to have high consolidation rates (80–100%), none appeared to be superior to the others. In 2008, the intramedullary X-Fuse implant (Stryker, Switzerland) demonstrated favorable clinical and radiographic outcomes in a limited study with short-term follow-up. Building upon these findings, this study aimed to evaluate the objective and subjective findings of arthrodesis of IPD and IP using the X-Fuse® implant over a medium-term period.**

Patients and methods: **We retrospectively included 53 patients (49 women and 4 men) who underwent arthrodesis of the IPD or IP joint surgery between May 2012 and January 2021. All surgeries were performed by senior hand surgeons at the same hospital, employing identical surgical techniques. Afterward, patients were immobilized for 6 weeks postoperatively. For analyses, data were extracted from patients' medical records.**

Results: **A total of 64 arthrodeses were assessed (with 6 patients lost to follow-up). The average follow-up period was 59.8 (±28) months. The mean QuickDASH score at the last review was 17.1 (±17), and the mean visual analog scale score was 0.64 (±1.6). Notably, more than 90% of patients reported good or excellent satisfaction with the surgery, and radiographic fusion was achieved in over 90% of cases, with an average fusion period of 12.9 weeks (±1.3). However, six cases of pseudarthrosis were documented, with only one requiring revision surgery due to symptoms.**

Discussion: **X-Fuse® implant arthrodesis yields satisfactory clinical and radiographical outcomes, providing good long-term stability and low complication rates. This technique is considered reliable and reproducible for patients with primary osteoarthritis, inflammatory conditions, and post-traumatic arthropathies.**

Keywords: Arthrodesis, Interphalangeal, X-Fuse, Intramedullary, Arthropathy, Pseudarthrosis.

INTRODUCTION

Digital osteoarthritis is a prevalent condition, affecting 29 – 76% of the global population[1]. It commonly affects the distal interphalangeal joints of the long fingers (IPD) and the interphalangeal joints of the thumb (IP). Furthermore, these joints can also be affected by inflammatory arthropathies such as rheumatoid arthritis and psoriatic arthritis[2,3]. Given that advanced joint damage leads to pain, stiffness, deformity, and interference with activities of daily living, when medical treatment fails, surgery becomes the gold standard intervention[4]. Initially, Swanson proposed the use of silicone prostheses, but instability issues led to the abandonment of this technique[5,6].

Over the years, arthrodesis has emerged as the primary surgical approach for addressing pain, deformity, and instability in affected joints[7]. The goal of this procedure is to achieve fusion in a functional position, providing patients with a pain-free, stable, and functional joint[8]. While various surgical techniques, including the use of pins, screws, and plates, have been developed for arthrodesis, with each demonstrating good consolidation rates (80 – 100%)[9-12], none have demonstrated clear superiority over others. Moreover, each method presents technical challenges and potential complications associated with material removal[13]. To address this issue, intramedullary implants like the X-Fuse® implant (Stryker, Selzach, Switzerland), made of nitinol (a nickel-titanium alloy), were recently introduced to facilitate arthrodesis without the need for subsequent

material removal[14]. Initial studies have shown promising functional outcomes using QuickDash, with consolidation rates comparable to those of other techniques. However, these findings are based on small patient cohorts and short-term follow-up periods[15,17].

Thus, this study aimed to evaluate the medium-term clinical and radiographic outcomes of patients who underwent arthrodesis of the IPD or IP joints using the X-Fuse® implant.

MATERIAL AND METHODS

Study population

This retrospective study was conducted at a single center and included 53 patients who underwent surgery between May 2012 and February 2021. These patients underwent one or more IPD or IP arthrodeses using the X-Fuse® implant at a university hospital specializing in hand surgery. Inclusion criteria comprised patients with arthropathy unresponsive to well-managed medical treatment and a minimum follow-up period of one year postoperatively. Arthropathy etiologies included primary osteoarthritis, inflammatory conditions, or trauma (such as mallet finger or flexor pollicis longus rupture). In our center, we do not use this implant but, K-wires, in cases of previous wound or infection at the DIP joint. In cases where a patient underwent multiple arthrodeses, each implant was treated as an independent event.

The exclusion criteria encompassed patients under protective measures, those deprived of liberty, and those who declined participation in the study.

Surgical technique

Three highly skilled surgeons (level 3, according to the classification by Tang et al.[18]) performed the surgeries under locoregional anesthesia. Notably, a consistent approach was employed for all patients, involving a dorsal H-shaped incision method. Following the exposure of the bony surfaces, the heads of the proximal phalanges (P2) and middle phalanges (P3) were excised using an oscillating saw. The diaphyseal shafts were then prepared using ancillary rasps and burs. Subsequently, the phalanges were prepared, and the trial implant was positioned under scope control. The trial implants were available in four sizes: small, standard, large, and extra-large and each could be placed at three different angles: 0°, 15°, and 25°. For aesthetic reasons, the DIP joints of the long fingers are fused in extension. The thumb, on the other hand, is fused at 15° of flexion for better function.Once the trial implant was positioned correctly, the definitive implant was inserted. Final scopic assessments were performed from the front and lateral views. Following the surgery, the operated IPD was immobilized using a rigid segmental splint for a duration of 6 weeks.

Primary outcome

Clinical outcomes were extracted from patients' medical records. During follow-up consultations, patients were evaluated for pain using a visual analog scale (VAS) with scores ranging from 0 to 10 and for the resultant impact on their daily activities using the Quick-DASH score, which ranges from 0 to 100[19]. Additionally, patients were asked to rate their overall satisfaction with the surgery on a scale of poor, moderate, good, or excellent. Subgroups were established based on the etiology of the arthropathy, and the average QuickDASH score was calculated for each subgroup. Radiographic assessment was conducted using frontal and lateral radiographs obtained during follow-up visits. Data collection and radiographic analyses were performed by an independent surgeon.

Secondary outcome

The secondary outcomes included complications observed during the postoperative follow-up, such as nail dystrophy, cold sensitivity, pseudarthrosis, and infection.

Statistical analysis

Quantitative variables are presented as means and standard deviations, while qualitative variables are expressed as percentages. The mean QuickDASH score was compared between subgroups using the Kruskal–Wallis test with a significance threshold set at $p < 0.05$.

All statistical analyses were performed using GraphPad Prism software version 8.0.2 (GraphPad Software, San Diego, CA, USA).

Ethics

Data collection was conducted in accordance with French legislation governing the protection of health data. This study was approved by our local ethics committee (approval no. 23.134).

RESULTS

A total of 53 patients (71 fingers) were enrolled in this study. However, six patients were lost to follow-up (did not attend the appointment) and subsequently excluded from the analysis. Ultimately, data from 47 patients were included, accounting for 64

surgical procedures. Table I presents the clinical and demographic characteristics of the included patients.

Primary outcome

Our cohort had an average follow-up duration of 59.8 (±28) months, with the shortest follow-up period being 12 months and the longest 126 months. The mean QuickDASH score was 17.1 (±17). Patients were categorized into subgroups based on the etiology of their condition (Table II). However, no statistically significant difference was observed in the mean Quick-DASH score across different etiologies (p = 0.57). Furthermore, the mean VAS score for patients was 0.65 (±1.6).

Regarding patient satisfaction, 37 patients (58%) reported excellent satisfaction, 23 (36%) had good satisfaction, 2 (3%) expressed moderate satisfaction, and 2 (3%) were dissatisfied.

The radiographic fusion rate was 21.5% at 6 weeks postoperatively, which increased to 61.5% at 12 weeks, and at the final follow-up, radiographic fusion had been achieved in 90.7% of cases.

Table I. — Characteristics of the population.

Variables (47 patients, 64 arthrodesis)	
Age at surgery *	63,3 years (10,5)
Sex **	
Men	3 (5)
Women	61 (95)
Etiology **	
Primitive arthrosis	47 (73,5)
Rheumatoid arthritis	11 (17,5)
Inflammatory arthritis	2 (3)
Mallet finger	1 (1,5)
Post-traumatic arthrosis	2 (3)
FPL injury	1 (1,5)
Finger **	
D1	12 (19)
D2	24 (37,5)
D3	21 (33)
D4	4 (6)
D5	3 (4,5)
Implant **	
SM	
0°	8 (13)
15°	1 (1,5)
ST	
0°	41 (64)
15°	3 (4,5)
25°	1 (1,5)
L	
0°	2 (3)
15°	6 (9,5)
XL	
15°	2 (3)
* mean (standard deviation); ** number (percent).	

Notably, fusion was typically achieved at an average of 12.9 (±9) weeks postoperatively (Figure 1).

Secondary Outcome

Approximately 23% of the arthrodeses exhibited postoperative complications. Among these, six cases of pseudarthrosis were identified, with five being painless and not requiring reoperation (Figure 2). However, one case of painful pseudarthrosis necessitated re-intervention 6 months after the initial surgery. Table III summarizes the complications reported in our study.

DISCUSSION

Arthrodesis of the IPD and IP using an X-Fuse implant emerges as a reliable and reproducible technique. Our findings revealed this approach effectively alleviates pain and yields satisfactory long-term functional outcomes.

In the treatment of arthropathies that resist conservative treatment[4], various techniques have been employed. Initially, Kirschner wires were utilized[9], demonstrating a fusion rate of over 90%[10,20,21]. However, this method was associated with a high incidence of infections[7]. Subsequently, compression screws emerged as an alternative[22]. These screws were widely used because of their high fusion rates (80–95%) and relatively straightforward installation process[11,23,24]. Despite these advantages,

Table II. — Mean Quick-DASH depending on the etiology.

Etiology	Quick-DASH*
Primitive arthrosis	17,3 (15,7)
Rheumatoid arthritis	18 (24,7)
Inflammatory arthritis	15,91 (0)
Mallet finger	0 (-)
Post-traumatic arthrosis	14,7 (8,03)
FPL injury	22,73 (-)
*Mean (standard deviation).	

Table III. — Post-operative complications.

Complication (n=64)	n (%)
Pseudarthrosis	6 (9,2%)
With revision surgery	1 (1,5%)
Without revision surgery	5 (7,7%)
Cold sensitivity	3 (4,6%)
Pericicatricial pain	2 (3%)
Nail dystrophy	2 (3%)
Tuft dysesthesia	2 (3%)

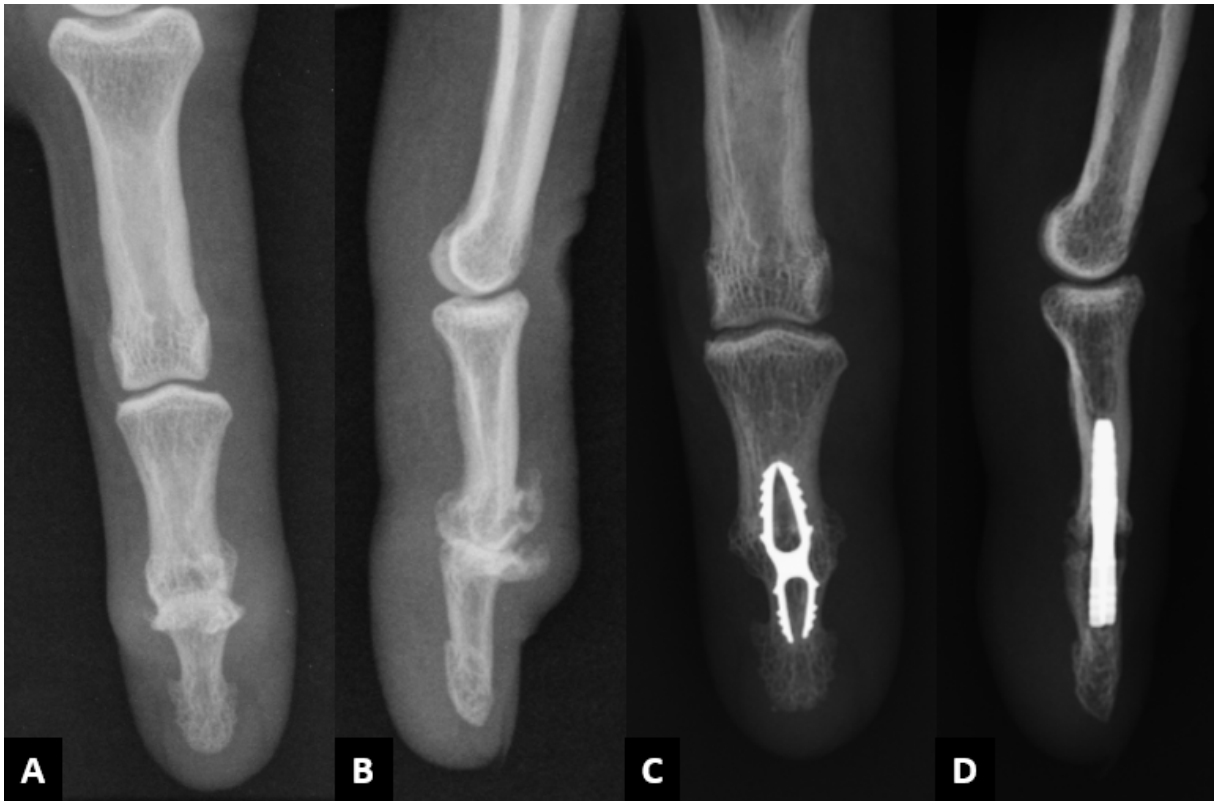

Fig. 1 — A, B: Preoperative radiographs of a degenerative DIP that underwent arthrodesis with X-Fuse and radiographs at 7 years of follow-up (C, D). The patient is pain-free, and no complications occurred.

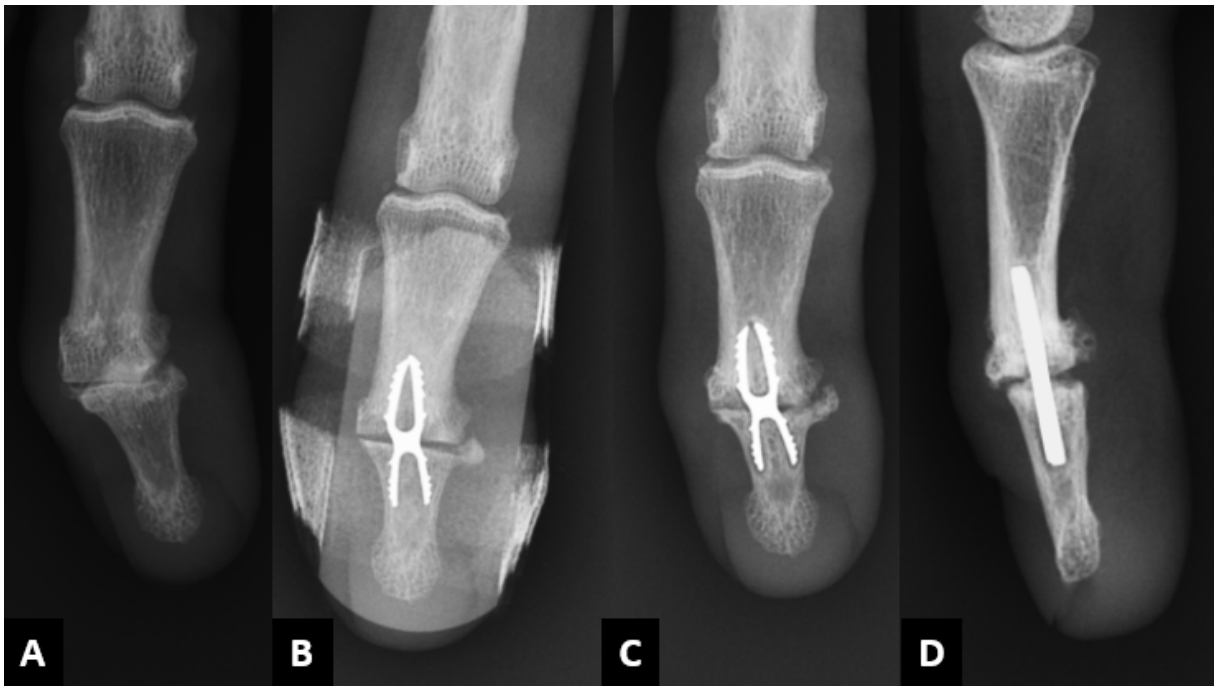

Fig. 2 — A: Preoperative radiograph, B: Immediate postoperative, C, D: At two years of follow-up showing pseudarthrosis of the arthrodesis. The patient did not experience any limitations or pain, and no revision was performed.

a common complication associated with these screws is discomfort due to the distal prominence of the hardware[13]. Consequently, second-generation screws, lacking a head, were introduced to address this issue[25-27]. However, the hardware-related discomfort remains incompletely resolved. Intramedullary implants such as Lync® (Novastep)[28] and X-Fuse® [14] were recently designed to mitigate these complications.

In this study, our findings revealed a radiographic fusion rate of 90.7%, which aligns with other arthrodesis techniques (80–100%)[11,29] and comparable to previous studies utilizing the X-Fuse® implant (89–96%)[14,17]. The mean time to fusion in our cohort was 12.9 weeks, slightly longer than that reported for the Acutrak screw (10 weeks)[25] but similar to cerclage techniques (12 weeks)[30]. The fusion rates and timelines observed with the X-fuse were deemed satisfactory. At the final follow-up, patients who underwent arthrodesis with the X-Fuse® implant reported being clinically pain-free, with a mean VAS score of 0.64. This result is consistent with the findings by Villani et al. using the SCRU2 screw (VAS: 1.1)[29] and De Almeida with the X-Fuse implant (VAS: 0.5)[17]. Additionally, at the last follow-up, the mean QuickDASH score for the overall population was 17.1, indicating minimal impairment in their quality of life. This result closely resembles the mean QuickDASH scores reported by Olivier et al. using screws[15,31] and Ameline et al. using the X-Fuse implant[15,17]. Notably, there was no significant difference when comparing QuickDASH scores between subgroups with different etiologies.

Our results showed a high satisfaction rate of 93% (good or excellent) among patients who underwent arthrodesis with the X-Fuse® implant, consistent with the findings reported by De Almeida et al. in 2018[17]. Interestingly, only four series of arthrodeses involving the use of X-Fuse® implant for IPD and IP of the thumb have been published since 2013. However, the mean follow-up periods reported in these studies were shorter compared to ours. Our study, with extensive data collection, provided a longer mean follow-up duration (59.8 months), confirming the favorable clinical outcomes observed previously. However, despite the favorable results, we observed a complication rate of 21% for all causes combined, slightly higher than that reported in other studies using the X-Fuse implant, ranging from 12% [16] to 20%[17]. We considered that this elevated complication rate in our study could be attributed to the longer follow-up period and inclusion of a greater number of arthrodesis procedures. Cold sensitivity and tuft dysesthesia were reported by patients as complications after two years of follow-up. This may be explained by the fact that before this delay, it was considered a normal event.

Jakubek et al. reported only one case of revision in their series[16], while De Almeida et al. reported two cases of infection[17]. In contrast, our findings revealed six cases of pseudarthrosis, with only one (1.5%) requiring revision surgery, highlighting a radioclinical discrepancy. Additionally, two cases (3%) of pulpal dysesthesia were reported during the follow-up, a low rate possibly explained by the intramedullary positioning of the material, reducing the likelihood of migration in contrast to screws and pins. Furthermore, unlike screws and pins, which may lead to cold sensitivity and nail deformities, as described by Olivier et al. in 2008[31], no cases of infection or skin necrosis were observed in this study; the two complications commonly associated with pin or screw arthrodesis[7].

Technically, X-fused implants offer several advantages. Firstly, the positioning for arthrodesis can be chosen in full extension or slight flexion, a flexibility not possible with screws that require arthrodesis in full extension[32]. Secondly, the manufacturer has designed implants of various sizes, including a very small implant (i.e., XtraSmall), enabling arthrodesis of the small finger without creating conflicts between the material and the distal phalanx. This is particularly relevant in the presence or future placement of a proximal interphalangeal joint prosthesis. Lastly, the major advantage of this implant is the elimination of the need for a second operation to remove the material, unlike pins. Despite these benefits, a significant limitation of this implant is the requirement for sufficient bone stock to maintain the material in the medullary cavity.

This study has some limitations. Firstly, its retrospective nature and single-center design may introduce biases that could impact the generalizability of our findings. Selection bias may be present due to the criteria for patient inclusion and exclusion, and the availability of data within medical records could also affect the comprehensiveness of our analysis. Secondly, the absence of pre-operative data precluded the possibility of comparing the pre-and postoperative outcomes, limiting the ability to assess the true efficacy of the surgical intervention. Lastly, we did not investigate the cost associated with the X-Fuse®, which could be a crucial factor in the choice of equipment used for arthrodesis procedures.

CONCLUSION

Arthrodesis of the IPD and IP using an X-Fuse implant emerges as a reliable and reproducible

technique. Notably, it effectively alleviates pain and yields satisfactory long-term functional outcomes. Additionally, our findings suggest that arthrodesis utilizing the X-Fuse® implant is comparable to other techniques reported in the literature while also mitigating certain complications associated with alternative methods.

Author contributions:

Renault A.: conceptualization, investigation, formal analysis, methodology, Writing – original draft, Writing – review and editing.

Maximen J.: data curation, formal analysis, methodology, Writing – original draft, Writing – review and editing

Ebalard M.: supervision, validation.

Mevel G.: methodology, supervision.

Ropars M.: project administration, software, resources, supervision.

Dreano T.: supervision, validation, project administration, Writing – original draft.

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