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Original article

Distal interphalangeal joint arthrodesis using the X-Fuse[®] implant: A retrospective study of 54 fingers with 24 months' follow-up

*Arthrodèse de l'articulation interphalangienne distale grâce à l'implant X-Fuse[®] :
 une revue rétrospective de 54 doigts avec un recul moyen de 24 mois*

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ARTICLE INFO

Article history:

Received 18 March 2018
 Received in revised form 8 December 2018
 Accepted 11 January 2019
 Available online 23 January 2019

Keywords:

Arthritis
 Arthrodesis
 Distal interphalangeal joint
 X-Fuse[®]

Mots clés :

Arthrose
 Arthrodèse
 Articulation interphalangienne distale
 X-Fuse[®]

ABSTRACT

We report the clinical and radiographic results of distal interphalangeal (DIP) joint arthrodesis using the X-Fuse[®] implant with a mean follow-up of 24 months (6–54). Forty-one patients (33 women and 8 men) with a mean age of 65 years were operated on. DIP joint arthrodesis was performed on 54 fingers for advanced osteoarthritis resistant to medical treatment. Pain evaluated on a visual analog scale (/10) was reduced significantly, going from 5 to 0.47. Functional DASH and PRWE-Hand Scores (/100) were improved by 33 and 36 points, respectively. Four fingers (7.4%) were sensitive to cold. No cases of nail dystrophy were reported. The fusion rate was 89%. Of the six patients (11%) who suffered a non-union, there was one case of asymptomatic fracture of the implant, without reoperation, and one case of infection, which required revision surgery. The fusion position was stable at the review visit. The repeat surgery rate was 3.7%; both cases were for infection. In light of this study, the X-Fuse[®] implant is a viable alternative to traditional arthrodesis techniques (compression screws and pins), with a similar fusion rate. This implant appears to be very well tolerated by patients, with an absence of nail dystrophy and a reduction in the risk of infection.

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R É S U M É

Nous rapportons les résultats cliniques et radiographiques de l'arthrodèse de l'articulation interphalangienne distale (IPD) des doigts longs par l'implant X-Fuse[®] au recul moyen de 2 ans. Quarante et un patients (33 femmes, 8 hommes) d'âge moyen 65 ans (50–85) ont été opérés. L'arthrodèse de l'articulation IPD était proposée en cas d'arthrose avancée résistante au traitement médical. La douleur évaluée sur l'échelle visuelle analogique (/10) avait diminué significativement, passant de 5 à 0,47. Les scores fonctionnels DASH (/100) et PRWE-hand (/100) étaient respectivement améliorés de 33 points et 36 points. Quatre doigts étaient sensibles au froid (7,4%). Aucun cas de dystrophie unguéale n'a été rapporté. Radiologiquement, le taux de consolidation était de 89% à la révision. Parmi les six patients (11%) qui présentaient une pseudarthrodèse, il y avait un cas de fracture d'implant asymptomatique sans reprise chirurgicale et un cas septique ayant nécessité une reprise chirurgicale. La position de l'arthrodèse était stable au dernier recul. Le taux de reprise chirurgicale était de 3,7% correspondant au cas de pseudarthrodèse septique et à celui d'infection précoce sur site opératoire. Au vu de cette étude, l'implant X-Fuse[®] représente une alternative fiable aux autres techniques d'arthrodèse (vis en compression et broches) avec un taux de consolidation similaire. Cet implant semble très bien toléré fonctionnellement par les patients avec une absence de dystrophie unguéale et une diminution du risque d'infection.

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1. Introduction

Distal interphalangeal (DIP) joint arthrodesis is a therapeutic solution in osteoarthritis resistant to medical treatment, irrespective of the origin, whether primary, post-traumatic or rheumatoid [1]. To this end, there are various means of internal fixation available [1–4]. The majority of recent studies report results of pinning or the use of compression screws. In terms of pain and fusion rates, none appear to be superior to the others. However, compression screws have been shown to reduce the time to fusion. Nevertheless, there are disadvantages to these screws, including their dimensions, the risk of nail dystrophy and the straight fusion position [2,5–7]. Pins have provided a means to overcome these disadvantages, but do not provide compression at the arthrodesis site and are a source of a higher number of surgical site infections [4,8]. Introduced in 2008, the intramedullary X-Fuse[®] implant (Stryker, Selzach, Switzerland) is a novel alternative for carrying out this procedure. Its advantages lie in its pure intramedullary bone position, with no cortical breach, the resulting stability and the possibility of selecting the fusion angle. Two recent studies have reported good outcomes on a clinical level, but also in terms of the fusion rate and time, with the absence of septic or nail-related complications [3,9].

The objective of our study was to report the clinical and radiographical results for the X-Fuse[®] implant at a minimum of 6 months' follow-up.

2. Patients and methods

From January 2014 to December 2016, 41 patients (33 women and 8 men) with a mean age of 65 years (50–85) were operated on at a single hospital by senior hand surgeons, all using the same surgical technique of DIP arthrodesis with X-Fuse[®] implants for primary, post-traumatic or rheumatoid arthritis (Table 1). A total of 54 implants were used. A clinical, functional and radiographic evaluation was done on all patients by an independent examiner during a routine postoperative visit.

2.1. Surgical technique

The surgeons (level 4, specialist – highly experienced [10]) made an “H-shaped” dorsal skin incision, then carried out a transverse tenotomy of the terminal band of the extensor tendon. After the joint synovectomy, which exposed the surfaces of the joints, the first step was confirmation of the osteoarthritis indication. The joint surfaces were resected. The plane of the osteotomy was defined, depending on the angle of the implant selected pre-operatively. The implant was introduced using the dedicated instrumentation, with graduated sizing rasps used to compact the cancellous bone until good stability was achieved. The position of the implant and the arthrodesis were checked using

fluoroscopy. The skin was closed with absorbable sutures, without a drain. A static dorsal splint, immobilizing just the DIP joint, was kept in place for 1 month.

2.2. Clinical evaluation

Pain was evaluated using a visual analog scale (VAS/10). Pinch strength (Kg.F) of the operated finger and the contralateral side was recorded using a Jamar[®] hydraulic pinch gage (Arthrex, Palaiseau, France). Sensitivity to the cold was evaluated subjectively, and potential nail dystrophy was investigated. Functional results were determined using standardized DASH (Disabilities of the Arm, Shoulder and Hand Score, /100) and PRWE-Hand (Patient-Rated Wrist Evaluation-Hand, /100) scores [11,12]. Patients also rated their satisfaction (“poor”, “moderate”, “good” or “excellent”).

2.3. Radiographic evaluation

Standard posteroanterior and lateral X-rays were performed on all patients immediately after surgery, at 6 weeks, 3 months and at the final follow-up visit. Fusion was evaluated at 6 weeks, 3 months and the final follow-up visit. The implant's stability was evaluated in the frontal and sagittal planes, by measuring difference in the arthrodesis position in degrees between the X-ray taken immediately after surgery and the ones taken at last follow-up visit. Finally, the difference between the angle of the implant introduced and the arthrodesis position was calculated at the final follow-up visit. The angle in the frontal plane was calculated from the diaphyseal axis of the middle and distal phalanges. The angle in the sagittal plane was calculated from the axis of the middle and distal phalanges by a line tangent to the dorsal cortex (Fig1).

2.4. Statistical analysis

Data were compared using the paired Student's *t*-test at a significance level of $P < 0.05$.

3. Results

Mean final follow-up was 24 months (6–54). The arthritis was primary in 93% of patients ($n = 50$), post-traumatic in 5.6% ($n = 3$) and rheumatoid in 1.8% ($n = 1$). Index finger was involved in 40% of

Table 1
Characteristics of the study population.

$n = 41$	
Mean age	65.3 years
Men/Women	8/33
Occupation	
Retired	28
Manual worker	11
Non-manual worker	2
Indication	
Osteoarthritis	50
Post traumatic	3
Rheumatoid arthritis	1

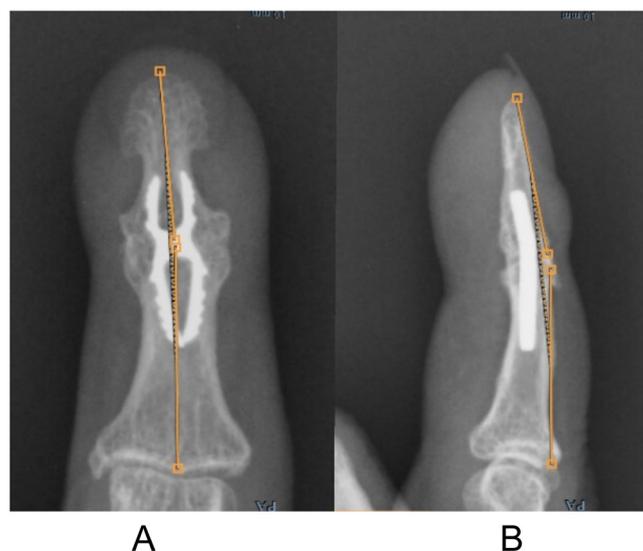


Fig. 1. Frontal (A) and sagittal (B) fusion angle measurement.

Table 2
Comparison of the clinical and radiographic results (mean) for the study population.

Clinical evaluation					
Mean	Preoperative		Final follow-up		P-value
	All procedures (n = 54 fingers)				
Pain on VAS (/10)	5		0.5		< 0.001
DASH (/100)	53.7		21		< 0.001
PRWE-Hand (/100)	49.6		13.3		< 0.001
	Successful (n = 48)	Failed (n = 6)	Successful (n = 48)	Failed (n = 6)	
Pain on VAS (/10)	5.3	5.0	0.5	0.3	^a
DASH (/100)	56.5	51.7	22.3	15.1	^a
PRWE-Hand (/100)	52.6	56	13.9	10.7	^a
Radiological evaluation					
Mean	Post-operative		Final follow-up		P-value
	All procedures (n = 54)				
Frontal tilt	3.2		4.2		0.019
Sagittal tilt	9.6		11.3		0.021
	Successful (n = 48)	Failed (n = 6)	Successful (n = 48)	Failed (n = 6)	
Frontal tilt	9.2	12.6	10.1	22.6	^a
Sagittal tilt	3	4.8	3.3	12.3	^a

^a Statistical analysis was not performed due to the small sample.

cases, middle finger in 39%, ring finger in 11% and little finger in 9.2%. In 65% of cases, the dominant hand was involved. The implant used was 0° (53%), 15° (41%) or 25° (6%) (Supplementary material online). The skin incision was healed within 2 weeks in all patients. The mean immobilization time was 5.6 weeks (4–9). Twenty-eight (68%) patients were no longer working.

3.1. Clinical evaluation

Pain was significantly reduced ($P < 0.001$), with 96% of patients having no pain or only mild pain (VAS = 0–3). Pinch strength was 86% compared with the contralateral side (3.4 kg/F). Four patients (7.5%) reported having cold sensitivity. No cases of nail dystrophy were observed. DASH and PRWE-Hand Scores were significantly improved, with an increase of 32.5 and 36.3 points, respectively. Eighty-nine percent of patients graded their satisfaction as good or excellent (Table 2).

3.2. Radiographic evaluation

The fusion rate was 50% at 6 weeks, 81% at 3 months and 89% at the last follow-up (Fig. 2). Non-union rate was 11% (six cases). In five cases, patients were asymptomatic and did not require new

surgery. In one case, a new surgery was performed because of septic non-union.

Fracture of the implant was observed in one case (1.8%). This occurred at the proximal portion, and was associated with asymptomatic, aseptic non-union, which did not require surgery (Fig. 3).

The arthrodesis position at final follow-up had changed by an average of 3.3° (0–23.3) in the sagittal plane and 2.2° (0–10.6) in the frontal plane, compared to the immediate post-operative X-rays. There was a significant difference ($P = 0.021$ and $p = 0.019$ respectively) when taking into account the whole study population. However, the difference was deemed to be non-significant when the six non-union cases were excluded ($P = 0.19$ and $P = 0.19$ respectively). For the 48 fused DIP joints, the position varied in sagittal plane by a mean of 2.6° (0–8.3) and by a mean of 1.6° in frontal plane (0–6.2) (Table 2).

The difference between the radiographic position of the arthrodesis at the last follow-up visit and the implant angle was a mean of 6.3° (0–37.7). It was not statistically significant ($P = 0.48$).

3.3. Revision surgery

Revision surgery rate was 3.7% due to two cases of infection. An early-onset superficial infection (fourth postoperative day) required new surgery. The implant was not removed, and full recovery was achieved with the use of appropriate antibiotics. The second case was one of septic non-union, for which surgery comprised of implant removal, trimming of the wound edges, introduction of an autologous cancellous bone graft and new internal fixation with pins. Implant removal was easy in the absence of a bony callus. Progress was favorable with appropriate antibiotics, and fusion was achieved within 8 weeks. Pain and infection did not reoccur (Table 3).

4. Discussion

In our study, DIP joint arthrodesis using the X-Fuse[®] implant led to pain-free outcomes, with preserved pinch grip strength, while ensuring good radiographic fusion with stability of the implant.

DIP joint arthrodesis is the most common surgical treatment for cases of painful and stiff joints following failure of medical treatment [3]. This procedure has proven to be effective to relieve pain. Although the DIP joint's mobility is permanently lost there is no consequence on function. In fact, only 15% of finger flexion mobility depends on the DIP joint [13,14].

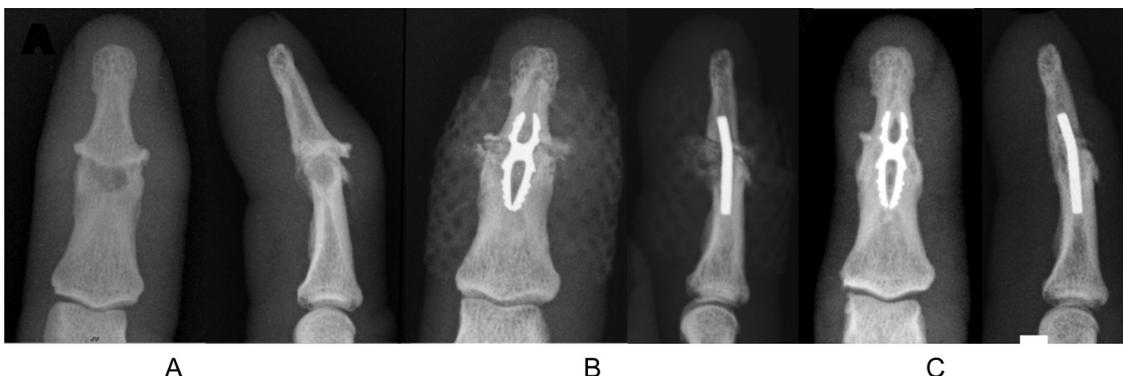


Fig. 2. Example of radiographic results of DIP arthrodesis using the X-Fuse[®] implant. Advanced primary osteoarthritis (A). Immediate postoperative status (B). Last follow-up at 30 months post-operative (C).



Fig. 3. Radiographic example of non-union, with fracture of the X-Fuse[®] implant.

Table 3
Complications found in the study population.

Complication	n (%)
Non-union	6 (11)
Asymptomatic	5 (9.3)
Symptomatic	1 (1.8)
Implant fracture	1 (1.8)
Infection	2 (3.7)
Cold sensitivity	4 (7.5)
Nail dystrophy	0
Revision surgery	2 (3.7)

There are numerous means of fixation, including Kirschner pins and compression screws, both of which have been described in a large number of studies (Supplement material online). All these studies report good clinical results, with significant pain relief. The pain on VAS (/10) varied between 0.46 and 2 [9,15,16]. This result is comparable to the one obtained in our study.

The fusion rate appears to be independent of the means of fixation used, and varies between 60% and 100% [6,7,16].

Stern et al. and Ijsselstein et al. reported an 88% (111 fingers) and 84% (143 fingers) fusion rate respectively with Kirschner pins [4,8]. The advantage of Kirschner pins is their simplicity and the ability to set the joint fusion position based on the needs of the patient. Finally, they can be adapted to the smallest of phalanges, which is difficult with other arthrodesis devices [17]. Nevertheless, the risk of infection is not negligible (4.5% to 18%) and requires that the device be removed once fusion is achieved [4,8]. In addition, protrusion of the pins requires prolonged nursing care and finger submersion is contraindicated until the pins are removed, which is a source of discomfort for the patient. The lack of compression provided by Kirschner pins also delays fusion and requires an extended immobilization period, which can increase costs [18].

The fusion rate achieved with compression screws ranges from 85% to 100% for open procedures and between 60% and 100% for percutaneous procedures [1,5–7,15,16]. This technique enables compression at the arthrodesis site, optimizes fusion and shortens the immobilization period [19]. Burying the screw reduces the risk of infection and discomfort in the fingertip. However, this fixation method requires the device to be inserted in a straight position, which may be a source of functional impairment for fine motor tasks [14,19]. Finally, the dimensions of the screw may be responsible for perioperative iatrogenic fracture and secondary nail dystrophy if the dorsal cortex is breached.

With regard to the X-Fuse[®] implant, Seitz et al. in 2013 and Ameline et al. in 2015 reported a fusion rate of 97% (32 fingers) and 95% (42 fingers), respectively [3,9]. Our rate was comparable (89%), with a larger number of fingers. These high fusion rates appear to be favored by the stability provided by use of side-arms when the implant is introduced. No cases of nail dystrophy occurred in our study. The introduction of the X-Fuse[®] has the advantage of conserving the dorsal cortex.

Two cases (3.7%) of infection required revision surgery, which had favorable outcomes. This rate is inferior to the ones found in published arthrodesis studies involving pins.

For the stability in both planes, it would appear that the arthrodesis position, defined intraoperatively by angle of the implant, remained stable following fusion. However, the angle the bones are cut must match the angle of the selected implants in order to optimize the bone mating surfaces and enhance the subsequent healing.

The X-Fuse[®] implant is available in four sizes and three angles (0°, 15° and 25°). The aim is to be able to adapt to the majority of anatomical conditions and meet patient needs regardless of the finger. The extended position is usually proposed for esthetic reasons, especially in women [14]. A slightly flexed position would be more appropriate for patients who have to undertake lots of manual tasks, especially if they involve precise manipulations [14]. We have used the more angled implant when the little finger was involved. If the patient is undecided about the fusion position, we carried out DIP dorsal splinting before proceeding with the surgery. Even though our study includes only patients older than 50 years, we believe that DIP joint arthrodesis with the X-Fuse[®] implant could be used in younger patients (chronic mallet finger, post-traumatic osteoarthritis). Still, due to the risks of infection, we strongly discourage using this implant in cases of acute open fractures.

In a single case, we used the large X-Fuse[®] implant for the thumb, achieving fusion within 2 months. We did not include this thumb in our series because of its singularity.

Finally, the implant's intramedullary character means it does not need to be systematically removed and provides more comfort to the patient, without the need for extensive nursing care once the skin has fully healed, and also facilitates the immediate self-teaching of proximal interphalangeal joint mobility, in view of an optimal functional result.

The procedure cost with the X-Fuse[®] implant is approximately twice that with K-wires and 1.5 times more than with compression screws but is better tolerated than K-wires [9]. DIP joint arthrodesis is primarily performed with the X-Fuse[®] implant in our surgical unit. K-wires are only used for small DIP joints.

Some limitations of our study are its retrospective design and the small number of cases in the non-union group, which did not allow for comparison with the successful group fusion.

5. Conclusion

In view of our study's results, the X-Fuse[®] implant appears to be a valid alternative to the other means of internal fixation for DIP joint arthrodesis. It provides satisfactory clinical and radiological results, with a high fusion rate and few complications, while providing improved comfort for the patient during the bone healing period. In the future, a large prospective study directly comparing compression screws and X-Fuse[®] implants would be beneficial.

Disclosure of interest

The authors declare that they have no competing interest.

Informed consent

The participants gave their informed consent for the study.

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