Bone and soft tissue loss of the proximal interphalangeal joint of the long fingers. Emergency treatment with a Swanson implant: prospective study of ten patients with a mean 2.7-year follow-up

Perte de substance ostéo-articulaire de l'IPP des doigts longs : traitement en urgence par implant de Swanson. Étude prospective de 10 cas avec 2,7 ans de recul moyen

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RÉSUMÉ
Les traumatismes de l'articulation inter-phalangienne proximale (IPP) avec perte de substance ostéo-articulaire, plus ou moins associée à une perte de substance tendineuse et cutanée font discuter l'arthrodèse, parfois l'amputation même sur un doigt vascularisé.
Treize patients ont bénéficié d'une reconstruction en un temps de l'IPP. Dix patients, 16 implants, ont pu être revus avec un recul moyen de 2,7 ans (1-6). Aucune infection n'a été observée. Aucune arthrodèse ou amputation n'a été demandée en secondaire. Après 1 an, l'amplitude de flexion maximale était atteinte. En moyenne, la flexion active atteignait 41,8° (20-80). Deux implants étaient fracturés sans perte fonctionnelle au recul de 6 ans. Dans ces lésions tangentielles de la face dorsale de l'IPP, le travail du bois en loisir est responsable de la majorité des accidents. La mise en place en urgence d'implant type Swanson a permis si la reconstruction tégumentaire et tendineuse est effectuée, d'éviter l'amputation et d'obtenir une flexion utile, supérieure à 50° chez 5 patients (7 articulations inter-phalangiennes).

Mots clés : Articulation inter-phalangienne proximale, fracture, implant de Swanson, arthrodèse.

ABSTRACT

Purpose of the study
Injury of the proximal interphalangeal joint (PIP) with loss of bone and soft tissue (joint surface, tendon, skin cover) can compromise finger vascularization. Fusion or amputation is often proposed. We report our experience with another solution, emergency implantation of the Swanson implant.

Material and methods
Thirteen patients, with a mean age of 47.4 years (range, 18-76 years), underwent emergency surgery between 1997 and 2003. In 12 patients, the finger injury occurred when working with wood. For ten of the 13 patients, the injury occurred during recreational activity. The index was involved when only one ray was injured. The thumb was spared in all patients. Joint tissue was lost in all patients. The head of the distal phalanx was injured in all cases, creating a situation incompatible with fusion without loss of finger length. All patients underwent emergency surgery for complete reconstruction of the PIP joint with a Swanson implant, tendon reconstruction or suture, and skin cover performed during the same procedure.

Results
Ten patients, 16 implants, were reviewed at a mean of 2.7 years (range, 1-6 years). Mean flexion reached 41.8° (range, 20°-80°). Maximal amplitude of flexion was achieved at 1 year and remained unchanged thereafter. There were no cases of infection or secondary amputation. Two implant fractures were noted with no functional impact at 6 years. There were four cases of instability.
**INTRODUCTION**

Complex injuries to the proximal interphalangeal joint (PIP) of the long fingers presents specific therapeutic problems. For example, a vascularized finger with no palmar structure involvement can present associated lesions of the extensor apparatus and the soft tissue and bones or the ligaments of the PIP joint. These can be partial lesions or true substance loss in these structures. In the few published studies in the literature, complex injuries seem to stem from firearm lesions. These complex PIP injuries regularly result in functional problems of the distal interphalangeal joint (DIP) with stiffness and therefore an overall loss of finger function. We encountered lesions resulting from wood-working activity: tangential lesions of the dorsal aspect in several PIPs, resulting from the recreational or professional use of a circular saw. The need to treat these often multi-tissue lesions in an emergency context encouraged us to propose a Swanson implant. Indeed, in more than two-thirds of the cases, the loss of bone and soft tissue involved the entire head of the proximal phalanx. In view of this substance loss, the alternative of arthrodesis would have resulted in a grotesque shortening of the finger. The objective of this study was to evaluate the results that can be expected from this strategy.

**MATERIAL AND METHODS (table I)**

Between 1997 and 2002, 13 patients were admitted for a complex injury of the proximal interphalangeal joint (PIP) of the long fingers (16 interphalangeal joints). The patients were males with a mean age of 47.4 years (range, 18-76 years) who had had a work accident in three of 13 cases, with bone and soft tissue destruction. In all cases, the finger was vascularized. The lesions involved the dominant hand in most cases; the thumb was spared in all. In seven cases out of ten, the accident occurred during recreational activity.

The lesions are described in table I. Loss of bone and soft tissue involved the head of the phalanx and at least one condyle. The extent of this substance loss made us reject a substantial shortening of the finger. Eight fingers presented tendon lesions, two of which with interruption of the continuity of the median band. Six cases presented substance loss but only two cases required reconstruction because of median band involvement. In the other cases, this substance loss did not interrupt the continuity and/or involved the lateral bands; this was repaired by suture. In cases of skin loss, a skin cover with a local flap was constructed. All patients underwent emergency surgery and were followed up at 6 months, every year, and at the longest follow-up by an independent operator so as to evaluate the active function of the injured joints and the progression of the implants (synovitis on a silicone particle, destruction, luxation), using frontal and lateral x-rays centered on the repaired joint. The duration of sick leave and whether the patient returned to the same work station were both noted. Ten of 13 patients were followed up with a mean follow-up time of 2.7 years (range, 1-6 years). Three patients could not be evaluated at the last follow-up and were excluded from the analysis, which therefore is based on ten patients and 16 fingers.

**RESULTS (tables II and III)**

No infection occurred. No fingers were arthrodesed or amputated secondarily. Necrosis of one intermetacarpal band (technical error during removal) was treated with a Bunnel-Colson flap (rotation flap of the laterodorsal aspect of the finger). One regional type-1 pain syndrome was observed, which required a 1-year sick leave. Pinch strength was not evaluated but in all cases of index injury, this was included and used in pinches and grips. Crush strength was not evaluated. The mean range of movement amplitude was 41.8° (range, 20°-80°), whatever the finger injured. Only seven fingers out of 16 presented an active range of movement amplitude greater than 50° (figs. 1-3). Six out of 16 presented an active range of movement amplitude less than or equal to 30°. Attenuating circumstances explained these poor results: one patient presented algodystrophy (patient no. 1), another patient was 76 years old (patient no. 5), and a third patient had been injured by a grinder with a crushing component (patient no. 10). The maximum flexion angle was reached during the 1st year. At
<table>
<thead>
<tr>
<th>Patients: age, WA or recreational Tool</th>
<th>Fingers injured</th>
<th>PIP bone and soft tissue injuries</th>
<th>Associated skin lesions $\rightarrow$ treatment</th>
<th>Associated tendon and ligament lesions $\rightarrow$ treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient no. 1, 42 years Recreational: circular saw</td>
<td>F2 Dominant</td>
<td>Distal phalanx: SL lateral condyle and trochlear groove Middle phalanx: 40% SL head, distal dislocation</td>
<td></td>
<td>ILL $\rightarrow$ reinsertion Extensor $\rightarrow$ suture</td>
</tr>
<tr>
<td>Patient no. 2, 68 years Recreational: circular saw</td>
<td>F4</td>
<td>Total SL distal phalanx head F4</td>
<td></td>
<td>SL extensors $\rightarrow$ suture</td>
</tr>
<tr>
<td>Patient no. 3, 54 years Recreational: circular saw</td>
<td>F2 F3 Dominant</td>
<td>F2: total SL medial distal phalanx condyle F3: Total SL distal phalanx head</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient no. 4, 18 years Recreational: spindle molding machine</td>
<td>F3 F4 Nondominant</td>
<td>F3: total SL distal phalanx head F4: total SL distal phalanx head</td>
<td>PIP skin SL $\rightarrow$ F3: fascio-fat flap F4: Bunnel-Colson flap</td>
<td>Extensor SL F3 $\rightarrow$ Oberlin</td>
</tr>
<tr>
<td>Patient no. 5, 76 years Recreational: circular saw</td>
<td>F3 F4 Dominant</td>
<td>F3: total SL distal phalanx lateral condyle with metaphyso-epiphyseal fracture F4: total SL distal phalanx head, dislocation</td>
<td></td>
<td>Extensor SL F4 $\rightarrow$ suture DF F4 $\rightarrow$ suture</td>
</tr>
<tr>
<td>Patient no. 6, 70 years Recreational: circular saw</td>
<td>F4 Nondominant</td>
<td>Complete comminuted joint fracture distal phalanx</td>
<td></td>
<td>80% resection DF $\rightarrow$ suture</td>
</tr>
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<td>Patient no. 7, 26 years WA: press</td>
<td>F2 Dominant</td>
<td>Total SL distal phalanx head, with metaphyso-epiphyseal fracture</td>
<td>Palmar plate $\rightarrow$ suture</td>
<td>Extensor $\rightarrow$ suture</td>
</tr>
<tr>
<td>Patient no. 8, 59 years WA: circular saw</td>
<td>F2 F3 Nondominant</td>
<td>Complete comminuted joint fracture distal phalanx with SL of lateral condyle</td>
<td></td>
<td>50% SL extensor $\rightarrow$ suture</td>
</tr>
<tr>
<td>Patient no. 9, 37 years Recreational: spindle molding machine</td>
<td>F2 F3 Dominant</td>
<td>Total SL distal phalanx head F2, F3</td>
<td></td>
<td>$&gt;60%$ SL extensor F2, F3 $\rightarrow$ Snow plastic surgery ELL F4 $\rightarrow$ reinsertion</td>
</tr>
<tr>
<td>Patient no. 10, 24 years WA: grinder</td>
<td>F4 F5 Dominant</td>
<td>Total SL distal phalanx head, F4, F5</td>
<td>SL extensor F4, F5 $\rightarrow$ suture</td>
<td></td>
</tr>
</tbody>
</table>

DF, deep flexor; F, finger; I/ELL, internal/external lateral ligament; PIP, proximal interphalangeal joint; SL, substance loss; WA, work accident.
follow-up, there were two cases of clinodactyly and two cases of objective instability. In these four cases of instability, three were related to implant fracture (patient no. 2), bone loss (patient no. 7), or a ligament lesion (patient no. 9). At 6 years of follow-up, two of 16 implants (in the same patient) were fractured. This patient nevertheless had obtained an active range of movement amplitude of 70° (figs. 4 and 5). None of the fingers were excluded. The six patients who were working at the time of the accident were able to return to work, four of them at the same station, with a mean delay of 6.7 months (range, 4-12 months). Patient no. 8, a farmer, reduced his professional activity but did not stop working.

**DISCUSSION**

**Methodological limitations**

The series studied is small but reflects the frequency of this type of injury and the management problems involved with these patients. The very short follow-up time underestimates the fractures and the unavoidable destruction of implants, although they are unparalleled in terms of possible loss of function. This assessment did not evaluate all the phalanges (DIP not taken into account, overall finger
how they were associated, and the fingers injured, crush strength was not measured because it was difficult to relate a given performance with a particular lesion or even stiffness in a segment.

**Joint reconstruction procedures**

In cases of nonreconstructible PIP injury, several solutions can be proposed.

**Arthrodesis**

Arthrodesis is a definitive solution that can simplify the problems of integument or tendon reconstruction. It can be proposed for the ulnar fingers (F4 and F5) as well as for F2 and F3, thereby guaranteeing stability. The position usually recommended is 40° for the index PIP and an additional 5° per finger from radial to ulnar. These arthrodesis positions continue to be debated. Fixation of the arthrodesis can be done with pins, miniscrews, or metal cerclage. Although this is a seemingly simple solution, bone loss can make arthrodesis difficult. In addition, we always preferred the most mobilizing solution for both ulnar fingers (pinch-grip strength) and radial fingers specialized in finer grips. In our experience, a stiff index finger in extension is more quickly excluded than an unstable index finger.

**Arthroplasty using the palmar plate**

As for old lesions, in an acute situation, it is possible to use the palmar plate to resurface the base of the middle phalanx and hope for PIP range of movement [Eaton [1], Tupper [2], Saffar [3]]. The arthroplasty techniques used by Eaton [1] and Tupper [2] are the best known. They are seldom used for injuries involving the distal phalanx.

**Cartilage grafts**

Song et al. [4] and Hasegawa and Yamano [5], and Seradge et al. [6], respectively, reported their experience using conchal cartilage or costal graft. Song [4] used a thin layer of cartilage conchal and in four cases of firearm injury obtained both active and passive PIP flexion varying from 40° to 90°. Gaul [7] reported his experience with the use of repair with partial toe joint osteochondral autografts with less convincing 5-year results. Recently, Williams et al. [8] showed the advantage of hamate-cartilaginous autografts.

**Toe PIP joint transfers**

Reported as secondary reconstruction by Foucher et al. [9], Tsai and Singer [10], and Imamura et al. [11], free joint transfers of the second toe or the DIP of the injured finger, have been shown to be advantageous in children or young adults. Undertaking this surgery in emergency situations is debatable and has never been published. However, in a relatively young patient, it could be possible to provide temporary emergency stabilization using pins, with joint transfer at a later time.
EMERGENCY TREATMENT WITH A SWANSON IMPLANT: PROSPECTIVE STUDY OF TEN PATIENTS WITH A MEAN 2.7-YEAR FOLLOW-UP

Swanson implants

Like Nagle et al. [12], we chose the option of Swanson implants to reconstruct in a single procedure the destroyed PIPs. The remaining volume of the bone stock is less determining, in our experience, than for arthrodesis. The long-term outcome remains unknown in that patients have a high level of need. Gérard et al. [13] reported our experience, but only seven patients out of 24 had an emergency implant. In this study, the Swanson prosthesis implanted secondarily were regularly followed by poor results. From the evaluation of the patients in this series followed up over the long term, we were able to designate three principles from the use of these implants in emergency situations.

- Even though these implants imply restrictions, the instability of the fingertips should be anticipated by the emergency ligament reconstruction (stabilization of bone plate containing the ligament insertion using a pin). We only had two cases of ligament repair.
- The implants must be aligned as closely as possible, despite any bone destruction, which is never regular or rectilinear on the head of the distal phalanx. As in rheumatoid arthritis, a misaligned implant will wear and be destroyed. However, as in PR, this destruction will not mean a poor functional result.
- Finally, short- and medium-term revision showed that it was preferable to oversize the implants to obtain implant stability. The necessary time must be taken to prepare the phalanx shaft with a reamer, but caution is required because the middle phalanx shaft is flattened and erroneous trajectories or fractures, in case of splitting, are possible. New designs and better-quality silicone support our idea of reconstruction in a single operation because of the Swanson-type implants. In addition, the use of anatomic implants should come into play with the possibility the operator has of implanting only one side of the implant (often the distal phalanx head), when the ligaments are preserved.

Associated skin and tendon loss repairs

The cross-finger flap, long considered the only therapeutic option, cannot be used when neighboring fingers are injured, the most frequent situation. Dap et al. [14] summarized the different therapeutic possibilities. Briefly, when skin loss is minimal, the homodigital flaps are the choice solutions (Smith flap, VY flap, advance-
ment rotation flap). These homodigital solutions should in principle not be used if the energy and mechanism of the injury risk compromising the viability of the blood-carrying flap. A simple and effective flap is the Bunnel-Colson flap, which is a flap based on the quality of vascularization of the dorsal aspect of the finger (fig. 6). As soon as the substance loss involves the entirety of the functional unit, the solutions are found on the back of the hand: an intermetacarpal flap based on the dorsal phalangeal vascularization. The trick, described by Bakhach et al. [15], to reach the PIP and further, allows covering extensive tissue loss.

When extensor ligament material is lost, the median band is always injured. If palmaris longus or retinaculum muscle dorsal grafts are possible, the Snow procedure is also usable (fig. 7): a rotation flap, which should be taken relatively far above the tissue loss with stopping points placed at the junction of the rotation zone. The extension obtained with this type of plastic surgery is acceptable but unpredictable in our experience. The arthroplasty practiced by Aiche et al. [16] consists in taking two lateral half-bands to reconstruct the median band. In our experience, this solution is not very relevant because it is exceptional that the lateral bands are spared to the point that they can be harvested. In view of substantial tissue loss, one can consider the extensor tendon reconstruction solutions that are classically used in cases of boutonnière deformation. As such, by-pass extensor tendon transfer, published by Oberlin et al. [17], is very attractive. It uses an autonomous motor and the graft (long palmar) is used to stretch the transplant between the back of the hand and the base of the second phalanx. The extensor apparatus of the injured finger has only the active extension of the DIP to control. Extension of the injured PIP is possible with the band grafted on the neighboring extensor apparatus.

CONCLUSION

Too few cases of nonreconstructible injuries to the PIP have been published. These injuries, even if they are rare, can be dismembered to facilitate injury analysis and management; the objective, in our opinion, is to preserve the greatest range of movement possible. The therapeutic project in these complex lesions is to prevent exclusion of a ray, which, if it is stiff, such as the fourth or fifth finger, is the first step toward amputation. The simplicity of the act makes it possible to “make time” for the more delicate reconstruction of the integuments and the extensor apparatus, the basis of the final prognosis. Instability is the particular consequence of metaphyseal bone loss or of implant fracture. However, even if relatively easy, implanting a Swanson-type prosthesis requires respecting certain rules: repair the ligament apparatus, align and oversize the implant. The vast majority of cases reported result from recreational accidents, underscoring the absence of relevant prevention.
References