

# ONE-YEAR RESULTS OF USE OF POLY-L/D-LACTIC ACID JOINT SCAFFOLDS AND BONE PACKING IN REVISION METACARPOPHALANGEAL ARTHROPLASTY

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**Revision metacarpophalangeal arthroplasty after silicone implant arthroplasty is frequently complicated by severe bone loss, osteolysis and diaphyseal perforations. Impacted, morselised allografts are frequently used to treat bone loss in revision surgery. A new method of treatment using bioconstructive poly-L/D-lactic acid (PLDLA) joint scaffold and allograft bone packing, after complete removal of the original silicone implants, allows recovery of bony deficiencies, correction of malalignment and improves function of the hand. This article presents the one-year results of a prospective, non-randomised clinical and radiographic follow-up study of 21 patients with 52 revision metacarpophalangeal arthroplasties using the PLDLA implants and allograft bone packing.**

*Journal of Hand Surgery (European Volume, 2007) 32E: 4: 427–433*

**Keywords:** rheumatoid arthritis, metacarpophalangeal arthroplasty, revision arthroplasty, osteolysis

Silicone implant arthroplasty was introduced in the 1960s (Swanson, 1972) and has gained wide acceptance in the management of rheumatoid metacarpophalangeal joint destruction. However, the good initial results of this operation deteriorate with time and late correction of volar subluxation and ulnar deviation at the metacarpophalangeal joints are suboptimal. In a large recent study, the ten-year survival of the implant was 83%, deteriorating to 63% by 17 years (Trail et al., 2004).

Revision metacarpophalangeal arthroplasties may be complicated by cortical bone defects and perforations. The pumping movement of the implant may have rounded off the intramedullary canal leaving the quadrangularly designed implant stem without rotational support. The survival of the silicone implant after revision metacarpophalangeal arthroplasty may also be compromised by the cut edges of the cortical bones becoming thin and sharp due to osteolysis (Bass et al., 1996; Parkkila et al., 2005; Wanivenhaus et al., 1991).

Based on interposition arthroplasty—the so-called ‘Vainio method’ (Vainio, 1989)—and bone grafting, the concept of bioconstructive joint scaffold was developed in order to overcome these problems. Initial operations were carried out using commercially available bioabsorbable Vicryl and Ethisorb fleeces folded into small, rectangular scaffolds (Honkanen et al., 2003). Although the early results were promising, the resorption time of these materials proved too short and the joint space collapsed. An alternative scaffold consisting of a porous, bioabsorbable poly-L/D-lactic acid (PLDLA) was developed (Kellomäki et al., 2002). The implant (Fig 1) was designed to retain its shape and resist compression long enough to allow the ingrowth of host tissue and then, gradually, be absorbed. Initial results from both primary and revision metacarpophalangeal arthroplasties using PLDLA implants produced

promising results (Chung et al., 2000; Honkanen et al., 2003). Since 2001, we have used this method prospectively in selected patients with severe osteolysis after failed Swanson, or Sutter, silicone arthroplasty. We postulated that the progression of host bone loss and subsequent loss of function could be prevented by bioabsorbable interposition arthroplasty and bone grafting. In other words, severe osteolysis, such as is shown in Fig 2A, could be prevented from advancing into an inoperable and non-functioning state (Fig 3).

In this article we present the one-year results of a prospective, non-randomised clinical and radiographic follow-up study of 21 patients with 52 revision metacarpophalangeal arthroplasties using the PLDLA implants and allograft bone packing.

## PATIENTS AND METHODS

### Patients

Twenty-one patients (all women) with rheumatoid arthritis, previous silicone implant metacarpophalangeal arthroplasty and severe osteolysis at one, or several, metacarpophalangeal joints were recruited to this prospective non-randomised study. All patients signed a written informed consent and were operated on using morselised allograft, or autograft, bone packing and PLDLA joint scaffolds between the years 2001 and 2003 at the Rheumatism Foundation Hospital. Päijät-Häme Central Hospital District Ethics Committee granted permission for the study.

One-year follow up of all these patients was available. In this prospective study the following pre-operative data was recorded: the diagnosis and duration of disease, sex, hand dominance, type of previous implant (Sutter or Swanson), indication for revision and



Fig 1 A bioabsorbable poly-L/D-lactic acid (PLDLA) implant and a Swanson silastic implant, size 5. The size of the PLDLA implant is 4 mm × 12 mm.

significant radiographic cortical bone thinning (over 50%) of the metacarpus or phalanx.

### Operative technique

In all 21 patients, the procedure (Fig 3) was performed under tourniquet control through a transverse incision and with a single intravenous dose antibiotic prophylaxis of cefuroxime 3000 mg. The joints were approached through longitudinal incisions radial to the extensor tendon. Old prostheses were removed. Scar and granulation tissue was also removed from inside the metacarpal and phalangeal bones. The volar plates were released when necessary. Significant cortical bone perforations and periarticular cortical defects were recorded and the status of the previous implant was assessed. Allograft bone (fresh frozen femoral heads or tibial/femoral cuts from non-rheumatoid patients) was morcelised to 2 to 3 mm chips

which were packed inside the metacarpal and phalangeal bones, leaving the juxta-articular portion empty at this stage. In two patients, the resected autograft bone from ipsilateral primary metacarpophalangeal arthroplasties was used instead of allograft. Two to three microburr holes were drilled in the distal dorsal aspect of the metacarpal bones for later reattachment of the collateral ligaments. A PLDLA scaffold (Bionx Implants Inc., Tampere, Finland) of thickness 4 mm and diameter 12 or 14 mm, was inserted into the joint space and fixed in place with absorbable mono-filament 3.5 metric sutures of PDS (Ethicon Inc., Somerville, NJ, USA) passed through the distal metacarpal burr holes and picking up the volar plate adjacent to the base of the phalanx. At this stage, the bone packing was completed up to the level of the ends of the bones. After bone packing, the implant fixation suture was tightened and, then, the collateral ligaments were tightened by suturing their proximal ends to the metacarpal burr holes with absorbable, multi-filament 3 or 2 metric sutures



Fig 2 Anteroposterior X-rays of a 66 year-old female patient with rheumatoid arthritis and previous metacarpophalangeal arthroplasty with a Swanson implant: (A) the pre-operative image shows the broken Swanson implant, severe osteolysis and cortical bone defects; (B) the immediate postoperative X-ray displays the packed allograft bone in both medullary canals with the PLDLA implant in interposition; and (C) at one-year follow-up, X-ray of the same patient shows incorporation of the allograft bone in the diaphyseal area and a concave resorption in the periarticular area.

of Vicryl (Ethicon Inc., Somerville, NJ, USA), while balancing the finger alignment. Suction drains were inserted in those cases in which revisions of all of the metacarpophalangeal joints had been carried out, but not in cases in which only one or two revisions had been done. Capsule closure was performed with absorbable multifilament 2 metric sutures of Vicryl. Extensor tendons were centralised by ulnar release and radial tightening with absorbable multifilament 2 metric Vicryl. Subcuticular closure was carried out with absorbable multifilament 1.5 metric sutures of Vicryl Rapide and skin closure with non-absorbable 1.5 metric Ethilon (Ethicon Inc., Somerville, NJ, USA) sutures. A padded dressing supporting the fingers in a radial direction was applied. On the second, or third day, after operation, the hand dressing was changed and the fingers were supported in a thermoplastic splint in a radial direction. Patients were then discharged. They returned to the ward 10 to 14 days postoperatively to begin range of motion exercises in outrigger splints. Splints were used for 3 months with the exercises being supervised by an occupational therapist in the ward and, thereafter, by a physiotherapist in the outpatient department.

#### Clinical and radiographic examinations

Outpatient visits were programmed at 6 weeks, 3 and 12 months postoperatively, with X-rays taken before and after the operation and at 3 and 12 month. Additional

visits are planned at 24 and 60 months. Patient follow-up visits included clinical measurements of range of motion and ulnar deviation. Radiographs were assessed to determine the incorporation of the allograft bone and the amount of volar subluxation.

Most descriptive data are presented as means and ranges.

#### RESULTS

The mean age of the 21 patients was 54 (range 24–66) years. All patients were right handed. Fourteen patients had rheumatoid factor positive rheumatoid arthritis, four had juvenile rheumatoid arthritis, one had psoriatic arthropathy and one had rheumatoid factor negative chronic polyarthritis. The mean duration of the disease prior to this study was 27 (range 12–42) years. Five left hands and 15 right hands underwent surgery and the total number of revised joints was 52. In two patients, two metacarpophalangeal joints underwent surgery and eight patients had only one metacarpophalangeal joint revised. Additional ipsilateral metacarpophalangeal joint synovectomies, soft tissue balancing operations or primary silicone implant arthroplasty were performed during the same session in some of the patients who only underwent one or two joint revisions as part of this study. In ten patients, all metacarpophalangeal joints underwent surgery.



Fig 3 A 47 year-old female patient with juvenile rheumatoid arthritis with broken and dislocated Swanson silastic implants 13 years after primary arthroplasty. The metacarpal bones show severe shortening and loss of bone stock due to osteolysis. At such an advanced state of hand destruction, there are no treatment options available.

The indication for all of the metacarpophalangeal joint revision arthroplasties was a combination of pain, dysfunction and bone loss. The pre-operative X-rays of the 52 metacarpophalangeal joints showed cortical bone thinning to less than 50% of the original thickness of either the metacarpal, or the proximal phalangeal bone, or both, in all but one joint. The perioperative findings included severe defects in the periarticular bone stock in 18 of 52 metacarpal bones and 26 of 52 phalangeal bones. Diaphyseal cortical perforations were detected in 11 of 52 metacarpal bones and 8 of 52 phalangeal bones. One patient with a single metacarpophalangeal joint

silicone implant arthroplasty had developed an aggressive foreign body reaction to silicone microparticles. In this case, the PLDLA implant and bone packing was chosen to avoid recurrence of this reaction, although there was not severe bone loss. The previous implants used in the metacarpophalangeal joints which were the subject of this study included Swanson silicone implants in 41 joints and Sutter silicone implant in 11 joints. The majority of the implants removed were broken.

One-year follow-up X-rays showed complete incorporation of the grafted bone to the diaphyseal portion of the host metacarpal and phalangeal bones in 48 of the

52 joints. However, a concave resorption of 3.0 (range 0–7) mm in depth occurred in the ends of all the bones in contact with the PLDLA implant (Fig 4C, Table 1).

Recurrent volar displacement of the proximal phalanges occurred in 33 of the 52 joints (Table 2). In all cases with one or two revised joints, the volar alignment was satisfactory. The average ulnar deviations of all four joints of each hand which underwent surgery are shown in Table 3. The ranges of motion at one-year follow-up of the metacarpophalangeal joints which underwent surgery are shown in Table 4.

No wound healing problems were encountered. Some patients suffered transitional loss of tactile sensation. This loss of sensory perception was unevenly distributed among the fingers and it was, probably, due to the dissection of the fibrous and scarred tissue around the metacarpophalangeal joints. It was not related to the

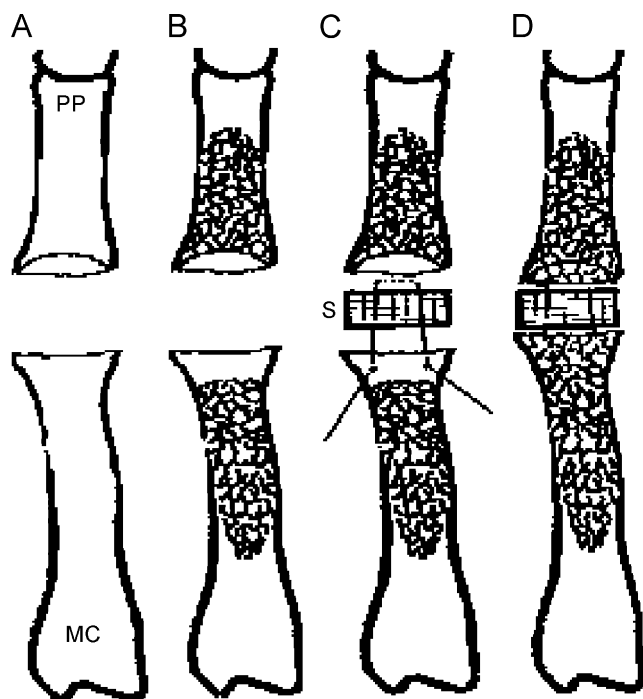


Fig 4 Operative technique for revision metacarpophalangeal arthroplasty using poly-L/D-lactic acid (PLDLA) scaffold and allograft bone packing: (a) after removal of the previous silicone implant, the osteolytic thinning and perforations in the metacarpal (MC) and proximal phalanx (PP) can be assessed; (b) the medullary canals are packed with allograft bone chips leaving the ends of the bones unfilled at this stage; (c) the fixing suture for the PLDLA scaffold (S) is passed through the scaffold, the distal part of the volar plate and the microburr holes in the metacarpal. The scaffold is inserted into the joint space; and (d) the suture is not tightened at this stage. The holding sutures (not shown) for reattachment of the collateral ligaments are also passed through the bone holes at this stage, but not yet tightened. Bone packing is completed and the scaffold fixing and collateral ligament reattachment sutures are tightened.

Table 1—Average amount of periarticular resorption of allograft bone at one year after revision arthroplasty using poly-L/D-lactic acid (PLDLA) scaffold and allograft bone packing

Metacarpal	Mean resorption mm (range)	Proximal phalanx	Mean resorption mm (range)
Index	3.3 (1–5)	Index	4.1 (0–6)
Middle	3.2 (0–6)	Middle	3.9 (0–7)
Ring	2.5 (0–5)	Ring	2.8 (0–5)
Little	2.1 (0–5)	Little	2.5 (0–5)

Table 2—Volar subluxation of the proximal phalanx at one year after metacarpophalangeal joint revision arthroplasty using poly-L/D-lactic acid (PLDLA) scaffold and allograft bone packing

Joint	Degree of volar subluxation <sup>1</sup> (n)			
	0	1	2	3
Index finger MCPs (n = 15)	4	6	3	2
Middle finger MCPs (n = 14)	4	6	3	1
Ring finger MCPs (n = 11)	4	5	2	0
Little finger MCPs (n = 12)	7	3	2	0

<sup>1</sup>0 = no subluxation, 1 = subluxation less than 50% of the metacarpal thickness, 2 = subluxation more than 50% of the metacarpal thickness, 3 = complete dislocation.

Table 3—Average metacarpophalangeal (MCP) joint ulnar deviation one year after MCP revision arthroplasty using poly-L/D-lactic acid (PLDLA) scaffold and allograft bone packing

Joint	Ulnar deviation degrees (range)	
	Before surgery	After surgery
Index finger MCPs (n = 15)	10 (0–40)	5 (0–15)
Middle finger MCPs (n = 14)	12 (0–45)	6 (0–25)
Ring finger MCPs (n = 11)	16 (0–45)	10 (0–25)
Little finger MCPs (n = 12)	16 (0–50)	13 (0–25)

Table 4—Average metacarpophalangeal (MCP) joint range of motion (ROM) one year after MCP revision arthroplasty using poly-L/D-lactic acid (PLDLA) scaffold and allograft bone packing

Joint	Active ROM degrees (range)	
	Extension lag	Flexion
Index finger MCPs (n = 15)	9 (0–45)	70 (40–90)
Middle finger MCPs (n = 14)	13 (0–30)	69 (55–90)
Ring finger MCPs (n = 11)	11 (0–40)	73 (40–100)
Little finger MCPs (n = 12)	4 (0–15)	74 (45–90)

tourniquet time. Three patients required manipulation under regional anaesthesia at 5, 6 and 7 weeks after surgery, respectively, because of limited flexion movement in at least one of the fingers which had undergone

surgery. In all three patients, the ranges of motion improved notably and for the whole follow-up time. One patient with severe dorsal defects in the second metacarpal bone underwent additional surgery to excise sharp residual volar osteophytes that were interfering with flexor tendon function in the tenosynovial sheath.

## DISCUSSION

Over 50% of patients with long-term rheumatoid arthritis develop symptomatic or radiographically detectable metacarpophalangeal joint involvement and deformities (Belt et al., 1998). Progressive destructive changes (Larsen et al., 1977) and joint malfunction may demand surgical intervention. Early results of silicone implant arthroplasty have been encouraging when measuring range of motion and correction of angular deformities. However, silicone implant arthroplasty of the metacarpophalangeal joints has commonly recognised problems, including volar subluxation, implant breakage and gradually deteriorating function. Several approaches to solving these problems have been tried (Beckenbaugh, 1999; Chung et al., 2000).

Metacarpophalangeal arthroplasty using the PLDLA scaffold and allograft bone packing is basically an innovative interposition arthroplasty based on the classical 'Vainio arthroplasty' (Vainio, 1989). As in resection arthroplasties, the aim of this procedure is to promote the formation of a fibrous tissue pseudo-joint. The PLDLA scaffold has been shown to retain its shape and resist compression for at least one year in animal tests and initial clinical experiments have also been promising (Honkanen et al., 2003). In their work, Honkanen and colleagues found similar early results in both primary and revision metacarpophalangeal arthroplasty in terms of ranges of motion and correction of ulnar deviation as earlier studies using silicone implant arthroplasty (Chung et al., 2000; Honkanen et al., 2003).

Patient selection to the present prospective study was based on such severe destruction and osteolysis that revision arthroplasty using silicone implants was not an option. All of our patients had severe soft tissue deficiencies with missing, or only rudimentary, collateral ligaments. Also, the joint capsules and extensor mechanisms were stretched and elongated.

The active range of motion of the individual revised metacarpophalangeal joints at one-year follow-up was better in our series than that reported by Honkanen and co-workers (2003) after primary metacarpophalangeal arthroplasty with the PLDLA implant. Some of our patients achieved active ranges of motion of 0° to 90° with vigorous training. It remains to be seen whether this remains on longer follow-up, or whether the ranges of motion deteriorate, as with silicone implants.

Despite the meticulous ligament balancing and reconstruction, we encountered recurrent volar subluxation of more than 50% in 33 of the 52 joints at one-year

follow-up. In the study by Honkanen and co-workers (2003), this occurred in only 6% of cases at one-year follow-up. However, they had mixed material, including mostly primary metacarpophalangeal arthroplasties with better soft tissue quality. At one year follow-up, the volar subluxations in our series did not appear to impair function, except in four joints in two patients in which the proximal phalanges were fully dislocated. In these cases, we encountered instability and impaired function. Partial adaptation to these dislocations had occurred earlier in the history of the disease (and before this study) and these patients were coping with basic daily functions at one-year follow-up, as they had done before the recent surgery. Nevertheless, this frequency of volar subluxation at a relatively early stage of follow-up is concerning.

The amount of ulnar deviation was also larger in our patients than in the mostly primary cases in the study by Honkanen et al. (2003), who recorded an average ulnar deviation of six degrees at one year. The ulnar deviation in this study was 5° to 13°, with this tendency being greater in the ulnar fingers. Frequently, the patients also described their fingers as being "less controlled" at three months after this surgery than in their earlier experience with silicone implant arthroplasty. At one year, however, this feeling had disappeared.

In this study, allograft and autograft bone incorporation was complete in the diaphyseal areas of the metacarpal and phalangeal bones. The follow-up X-rays frequently showed the periarticular parts of the bone grafts were regularly absorbed and, possibly, replaced by scar tissue. This may have occurred as a result of insufficient blood supply to the thinned and deficient cortical bone ends. On the other hand, foreign body reaction and enhanced leukocyte activity caused by the PLDLA implant may lead to graft resorption. Measurement of the depth of the convex absorption was made difficult because of the asymmetrical nature of the periarticular defects, especially on the phalangeal side, but the finding was routinely present in our patients. Our early results do not suggest that this affects the outcome adversely.

This study examined the use of the PLDLA implant and allograft bone packing in very difficult revision metacarpophalangeal arthroplasties in selected patients with failed Swanson or Sutter silicone implant metacarpophalangeal arthroplasty and severe osteolysis. Our results not only support the earlier findings of tissue compatibility of the implant but also, most definitely, successful operative technique and postoperative management. Bone packing appears to be successful in restoring host bone stock and the PLDLA implant provides a bioconstructive scaffold for fibrous tissue ingrowth to promote adequate stability and function. The effect of the method must ultimately be judged on the basis of longer-term radiographic and clinical findings. The promising early results have, however, encouraged us to commence a randomised multi-centre

trial comparing primary silicone implant metacarpophalangeal arthroplasty with PLDLA implant metacarpophalangeal arthroplasty. Another large multi-centre study is investigating the possible use of this method, compared to more traditional methods, in other clinical situations including osteoarthritic trapeziometacarpal and finger proximal interphalangeal joint destruction, hallux valgus and in lesser degrees of rheumatoid metatarsophalangeal joint destruction.

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Received: 11 May 2006

Accepted after revision: 19 March 2007

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doi:10.1016/j.jhse.2007.03.006 available online at <http://www.sciencedirect.com>