
CLINICAL ARTICLE

The MIRA prosthesis

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Abstract

Osteoarthritis of digital joints, e.g. proximal interphalangeal joints and metacarpo-phalangeal joints, may need surgical intervention if conservative management has failed to control function loss and/or pain.

The ideal arthroplasty prosthesis should cause minimal loss of bony tissue, should have a high level of congruency, a low degree of constraint and not be technically demanding.

The MIRA prosthesis replaces only the damaged osteoarthritic tissue, is biomechanically sound and respects the all important investing and stabilising capsule-ligamentous and musculo-tendinous structures.

Introduction

Alfred Swanson^{1,2,3} is credited for addressing the painful and distorted arthritic digital joint with a replacement prosthesis. His aim was to improve on the simple resection arthroplasty which Vainio^{4,5} popularised. Swanson stated that: "Simple resection arthroplasty could be enhanced by improved distribution of forces across the bone ends with a spacer of a low modulus of elasticity". Today we know that the modulus of elasticity of silicone is much too low, and over the years this material has also shown to be prone to wear and tear causing silicone particulate synovitis which destroys the surrounding bone and soft tissues. Its main mode of function was the fibrous tissue response which acted as the stabilising mechanism. The silastic prosthesis is also subject to cold flow deformation, which when all is taken into consideration, indicates a basic flaw in biomechanical understanding.

Further development aimed to increase the modulus of elasticity by using materials such as stainless steel, titanium, carbon fibre, etc.

However, the biomechanical aspect includes much more than the modulus of elasticity. Initially it was not realised that the digital joints are **not** simple hinge joints and therefore the forces to be transmitted demanded a much more sophisticated mechanism than just a hinge. The prosthesis was also constrained, needed a fair amount of bone resection and relied on intramedullary bony fixation of some sort.

As time went by, it was realised that digital joint articulation was a combination of movements which consisted of hinging and gliding. Because the axis of rotation was not constant, this multidirectional movement put 'abnormal' stresses on the constrained prosthesis which led to a high incidence of failure such as fractures of the prosthesis, dislocations, deformation, etc.

The ideal arthroplasty prosthesis should cause minimal loss of bony tissue, should have a high level of congruency, a low degree of constraint and not be technically demanding

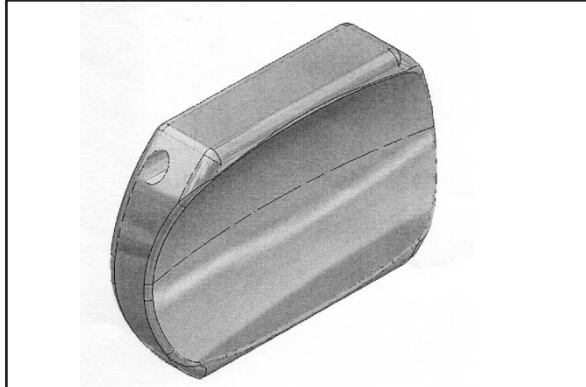


Figure 1: The MIRA prosthesis: concave proximally and slightly convex distally. Note the hole for the retaining suture

It therefore becomes clear that a prosthesis needs to comply with all the biomechanical demands of a particular joint. These should include having a high modulus of elasticity, i.e. not be deformable; should be able to stay congruent during all the positions of movement, i.e. adapt to the moving axis of rotation; and should have a low degree of constraint, i.e. allow easy movement.

Having said this, it is also a recognised fact that the contribution to the success of an arthroplasty depends largely on the quality of the surrounding soft tissue and the quality of rebalancing these structures. The contribution of the prosthesis plays only a relatively minor role.

The MIRA prosthesis has been designed to be as tissue-sparing as possible and to accommodate the normal biomechanical demands. It has the following unique features:

- It is an intercalated replacement arthroplasty. Only the damaged joint tissue is removed and the joint surfaces remodelled to simulate the anatomy.



Figure 3: The MCPJ skin incision when all four joints are to be replaced

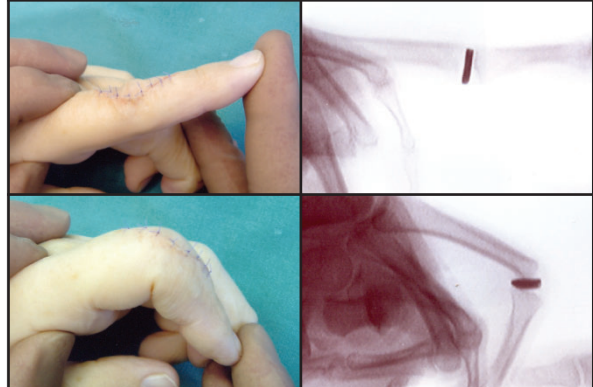


Figure 2: The MIRA prosthesis: full extension and 80°-90° of flexion. The X-rays confirm excellent position of the MIRA prosthesis

The gap (lost articular tissue) is replaced by a specially designed ‘spacer’, made from titanium which is coated by a highly smooth surface consisting of titanium nitrous oxide. The medullary canals, and therefore the endosteal blood supply, are left untouched.

- The MIRA prosthesis is designed to accommodate the proximal phalangeal or metacarpal head, i.e. concave proximal surface. It has a flat distal surface to fit the base of the adjoining phalanx and a transverse hole for a retaining suture (*Figure 1*).

The success of an arthroplasty depends largely on the quality of the surrounding soft tissue and the quality of rebalancing these structures

- The MIRA prosthesis is unconstrained and allows gliding on the metacarpal of phalangeal head, gliding on the base of the phalanx and gliding by translation. These three movements, when added up give more than adequate flexion of the joint (*Figure 2*).

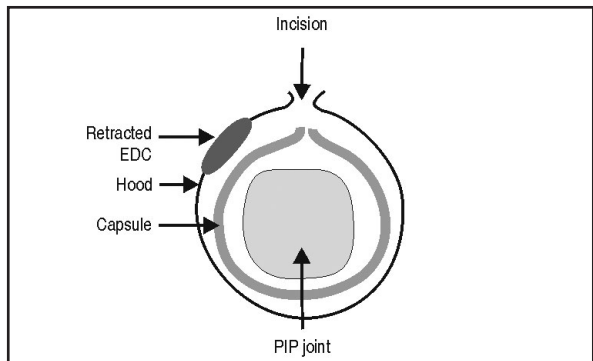


Figure 4: Skin incision over the MCPJ is followed by an incision on the ulnar side of the EDC tendon which is displaced radially

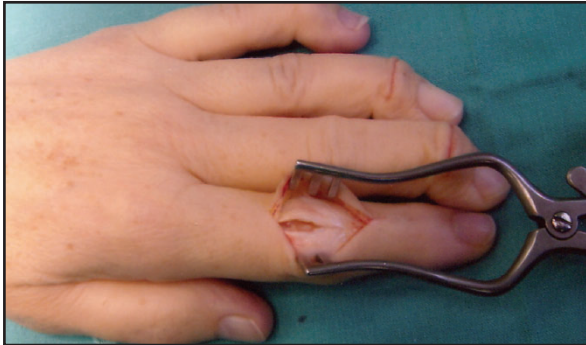


Figure 5: Midline incision of the middle slip of the EDC over the PIPJ



Figure 6: The joint is cleared of all synovitis, osteophytes and destroyed cartilage. The joint is reshaped to mimic the original anatomical configuration. Take care not to damage the collateral ligaments

- Since the minimum amount of bone and cartilage is removed, a revision procedure or an arthrodesis can easily be done, if required.

Operative technique

A curved skin incision is made over the metacarpophalangeal joint (MCPJ) or proximal interphalangeal joint (PIPJ) to expose the extensor tendon. If multiple MCPJ replacements are done, a transverse incision is indicated (Figure 3).

A longitudinal incision on the ulnar side of the tendon is made to allow radial displacement of the extensor tendon (Figure 4) at the MCPJ, and a midline extensor tendon split incision over the PIPJ (Figure 5).

The capsule is opened lengthwise, followed by a debridement of the joint cartilage and osteophytes. A synovectomy should remove all inflamed and chronic synovitis.

The joint surfaces are reshaped to mimic normal anatomy taking great care not to damage the collateral ligaments and capsule (Figure 6).

A prosthesis of correct thickness and size is selected from the trial set, inserted into the gap, held in place by a finger, while flexion and extension of the joint is checked. One aims to get full extension and 90° of flexion. Do not overstuff the joint (Figure 7).

The most important part of this procedure is meticulous attention to the soft-tissue reconstruction

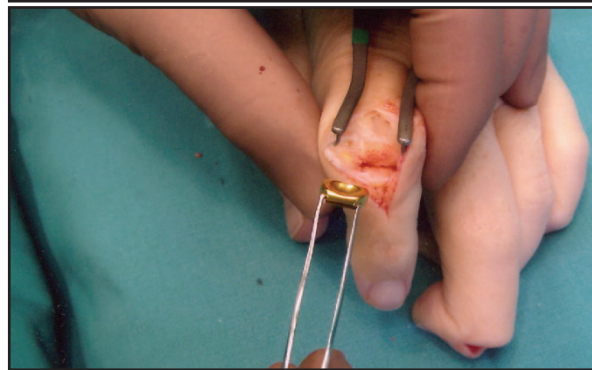


Figure 7: The MIRA prosthesis is placed and checked for correct size and thickness

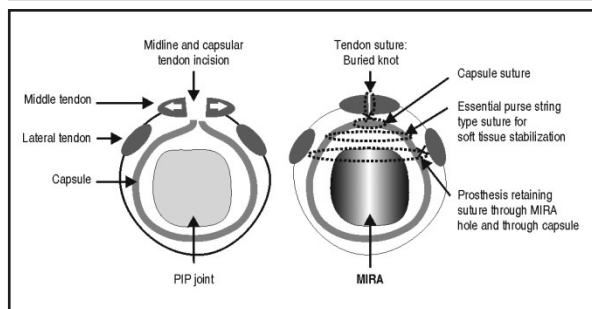


Figure 8: Midline incision of the middle slip of the EDC over the PIPJ

The non-absorbable retaining suture is put through the capsule and collateral ligaments to anchor the prosthesis in the correct position. At least one (or better two) purse-type sutures (non-absorbable) are inserted over the dorsal aspect of the prosthesis to prevent dorsal subluxation of the prosthesis (Figures 8, 9, 10).

The extensor tendon is sutured into position, after which the skin is closed.

If the lateral stability is unsatisfactory, a collateral tightening suture should be added. This suture also helps in realigning any deviation that may exist.

It should be emphasised again that the most important part of this procedure is meticulous attention to the soft-tissue reconstruction.

Postoperatively the joint(s) is splinted in full extension for 3 weeks, after which gentle rehabilitation by a qualified hand therapist is started.

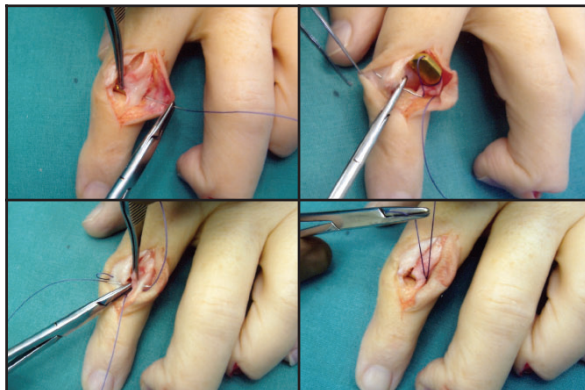


Figure 9: Closure is by the retaining suture through the prosthesis, one or two purse string sutures and fine, interrupted inverted sutures for the tendon. The retaining suture involves the collateral ligaments and capsule. See also Figure 8.

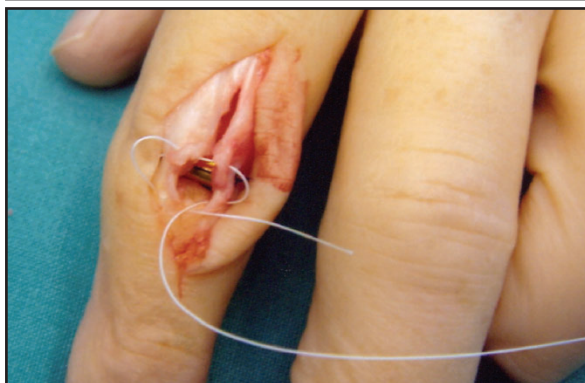


Figure 10: The all-important purse string suture. It may be prudent to add a second closing purse string suture, especially in fingers with poor soft tissue

Patients and results

In 66 patients (osteoarthritis 48, rheumatoid arthritis 14, trauma 1, gout 2, scleroderma 1), aged 25–75 years (female 54, male 12), 130 arthroplasties were performed (MCPJ 61, PIPJ 69).

The follow-up period ranged between 18–36 months.

The results are captured in Table I.

Complications

The complications included:

- 8 dislocations (due to incorrect suture placing)
- 1 skin breakdown (in a rheumatoid arthritis patient)
- 6 stiffness
- 5 swelling (6 months)

The high incidence of dislocation was because the purse suture was only introduced halfway through the study. No further dislocations were seen.

Discussion

The MIRA prosthesis is a novel design, with unique characteristics (Figure 11) as follows:

- It is an intercalated, replacement arthroplasty.
- It replaces only damaged or lost articular tissue.
- It does not violate the integrity of the constituent bones, e.g. phalanges and metacarpals.
- It allows hinging of the joint.
- It allows gliding of the joint on two surfaces.
- It allows easy revision surgery if need be, e.g. arthrodesis or placement of any other prosthesis.
- It is a new concept: the transarticular forces are still transferred to the cortical bone by the capsule-ligamentous complex (rather than to soft, intramedullary cancellous bone).
- It respects the all-important investing and stabilising capsule-ligamentous and musculo-tendinous structures.
- It is easy to use, not technically demanding and cost effective.
- It succeeds in achieving the ideal arthroplasty: high congruency and low constraint.

Table I: Study results

Movements:	average pre-op ext – flex: 18°–57° (39°) post-op ext – flex: 6°–68° (62°)
Pain (0–4):	improved by 2
Deformity:	correction
Stability:	achieved
Patient satisfaction:	83%



Figure 11: Follow-up X-ray: MIRA prosthesis in a good, functional position.

The indications for the MIRA prosthesis are to replace damaged metacarpo-phalangeal joints (MCPJ) and proximal interphalangeal joints (PIPJ) due to primary or secondary osteoarthritis. In high demand hands, the PIPJ of the index finger should preferably be fused. In hands with poor quality and unbalanced soft tissue such as in rheumatoid arthritis, digital arthroplasty has a high morbidity rate and may be a contraindication.

Conclusion

The MIRA prosthesis offers the surgeon a simple, but biomechanically sound concept to deal surgically with destroyed digital joints.

If the surgical technique is carefully and meticulously performed, the success rate is higher than with conventional procedures and if complications are encountered, revision surgery is easily achieved.

This article was submitted to an ethical committee for approval. The content of this article is the sole work of the authors.

No benefits of any form have been derived from any commercial party related directly or indirectly to the subject of this article.

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