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The proximal interphalangeal joint: arthritis and deformity

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- Finger joints are of the most common site of osteoarthritis and include the DIP, PIP and the thumb saddle joint.

- Joint arthroplasty provides the best functional outcome for painful destroyed PIP joints, including the index finger.

- Adequate bone stock and functional tendons are required for a successful PIP joint replacement

- Fixed swan-neck and boutonnière deformity are better served with PIP arthrodesis rather than arthroplasty.

- Silicone implants are the gold standard in terms of implant choice. Newer two-component joints may have potential to correct lateral deformities and improve lateral stability.

- Different surgical approaches are used for PIP joint implant arthroplasty according to the needs and the experience of the surgeon.

- Post-operative rehabilitation is as critical as the surgical procedure. Early protected motion is a treatment goal.

- Revision and exchange PIP arthroplasty may successfully be used to treat chronic pain, but will not correct deformity.

Introduction

Destruction of a proximal interphalangeal (PIP) joint is either a result of an inflammatory/degenerative process or is post-traumatic. It is a clinical diagnosis and is confirmed with conventional radiographic examination (Fig. 1). Patients classically present with swollen, tender PIP joints, with a more diffuse, swollen appearance and a fusiform joint contour. Joint stiffness is almost always present and often correlates with the degree of swelling. In specific post-traumatic instances at the PIP joint level, a computerized tomography (CT) scan may be useful to determine whether a joint-preserving procedure is warranted, such as an intra-articular osteotomy or joint reconstruction.

Most authors, especially in the rheumatology and arthritis literature, use a modification of the Kellgren and Lawrence scale,[1] initially described for patellofemoral arthritis, for radiographic classification:

Grade 1: doubtful narrowing of joint space and possible osteophytic lipping

Grade 2: definite osteophytes, definite narrowing of joint space

Grade 3: moderate multiple osteophytes, definite narrowing of joint space, some sclerosis and possible deformation of bone contour

Grade 4: large osteophytes, marked narrowing of joint space, severe sclerosis and definite deformation of bone contour

Treatment

Non-operative treatment

Non-operative treatment for advanced destruction of finger joints may be considered both for inflammatory disease or ongoing joint degeneration in osteoarthritis (OA), depending on the severity of symptoms and functional impairment. Treating affected joints with OA does not appear, to date, to alter the appearance of OA in unaffected joints, or delay the progression of OA elsewhere. In the pathophysiology of the disease, catabolic cytokines and anabolic growth factors play key roles in the destruction of the cartilage.

Conventional treatment includes analgesics and non-steroidal anti-inflammatory drugs. Intra-articular visco-supplementation with hyaluronic acid has been shown to be effective in terms of pain relief and improved functionality. In comparison with intra-articular corticosteroids, it seems to have longer-term benefits,[2] especially in the knee joint. However, this has not been reproduced in the hand literature and is not supported by personal experience.

Glucosamine and chondroitin are important components of the normal articular cartilage. Like viscosupplementation, the efficiency of glucosamine and chondroitin

Fig. 1 Classical X-ray presentation of severe osteoarthritic changes in the DIP and PIP joints including the IP and MP joints of the thumb.

in the treatment of OA has been documented best in the knee joint.[3] They seem to reduce the need for anti-inflammatory drugs and to improve functionality.[4] Few side effects have been reported. Most authors recommend a combination of the two, at a dosage of 1500 mg glucosamine and 1200 mg chondroitin daily. Since the onset of the effects is slow and takes at least four weeks, most authors recommend either three months' therapy twice a year or continuous treatment.[4] TNF-alpha-blocking agents, used mainly in patients suffering from rheumatoid arthritis, are good candidates for suppressing the destructive inflammatory process in OA as well. Beside the classic systemic application of this drug, an intra-articular treatment with injection showed in a pilot study a possible disease-modifying action of intra-articular infliximab in erosive osteoarthritis of the hands.[5]

In the fingers, the PIP joint reacts well to intra-articular corticosteroid injections. The most common side effect is atrophy of the skin and subcutaneous tissue, which is more of an aesthetic than a functional problem. No known correlation exists between the radiographic appearance of the joint and the effectiveness of intra-articular steroid administration, and is typically self-limiting. There are different techniques for PIP infiltration: the author finds injecting into the dorsal recess of the joint, similar to a knee joint, is the easiest to perform.

Splints for painful inflamed joints might be effective, but their regular use limits hand function and lowers patient satisfaction.[6] Modification of activity may be beneficial in limiting articular inflammation. Joint protection devices may relieve the joints and help to prevent further irritation of the joints affected. The effects of ultrasound, laser and electrotherapy in the treatment of OA in the fingers are not well documented. Experience has shown

limited and short-term effects with an, often inappropriate, cost-efficiency ratio.

Operative/surgical techniques

Surgical treatment options for destroyed finger joints include joint replacement and joint arthrodesis. The ideal goal for reconstruction of end-stage PIP joint arthritis is a pain-free restoration of sufficient mobility and stability. The index and middle fingers are the pinching partners of the thumb, while the ulnar fingers need mobility in order to grasp larger objects. When considering the correct PIP joint procedure, the degree of instability and deformity must be taken in account. Experience shows that pre-existing deformity and instability in the PIP joint is difficult to correct with implant arthroplasty, even with formal collateral ligament reconstruction and prolonged splinting during rehabilitation (Fig. 2). Arthrodesis should therefore be considered carefully, especially in the radial digits, if the lateral deformation of the PIP joint exceeds 30°. PIP joint arthrodesis in a functionally good position provides adequate function, although fine motor skills, in particular, may be affected. Woodworth et al[7] evaluated the impact of simulated PIP joint fusion on all four fingers with the PIP joint fixed in 40° of flexion. Low-demand activities of daily living suffered significantly when compared with unrestricted motion in all finger joints, with precision handling perceived to be more difficult and requiring more compensation by the metacarpal-phalangeal joints.

Simultaneous fusions of the PIP and distal interphalangeal (DIP) joints in the same finger ray are possible, although precision handling will suffer. The combination of PIP arthroplasty and DIP fusion is better tolerated functionally even if the range of motion in the PIP joint is limited.

PIP joint fusion

Arthrodesis of the joint may be indicated in cases of severe instability and deformity of the PIP joint, difficult bone situations or as a revision after failed arthroplasty. Several techniques have been described for this procedure. Tension band wiring (Fig. 3), plate fixation, and screw arthrodesis (Fig. 4) are the most common techniques. Tension band wiring has the advantage that compression of the arthrodesis site occurs during active motion. This technique is also cost-effective, using inexpensive hardware. The disadvantages are possible pin protrusion and painful hardware requiring subsequent metal removal.[8] Plate fixation, usually 2.0 to 2.4 mm in size, allows rigid fixation at the desired angle. It has the disadvantage of causing extensor tendon adhesions along the plate, thus limiting DIP motion. The newer-generation plates are thin and hardware removal is not necessary in most patients. The screw fixation technique, preferably with a headless screw, is another option. Theoretically, a single screw has no rotational stability but in practical use this is rarely a problem.[9] The main challenge
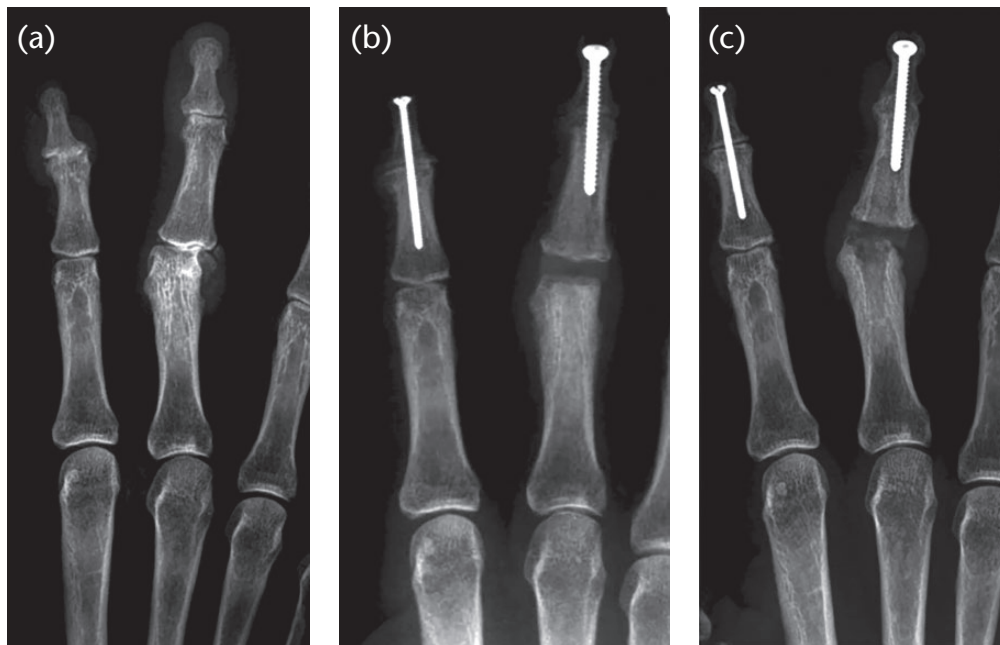
Fig. 2 Recurrence of deformity after silicone PIP arthroplasty. (a) Pre-operative status with the ulnar deviation. (b) Post-operative appearance after six weeks with good alignment. (c) Recurrence of the deformity at the PIP joint 12 months after the intervention.
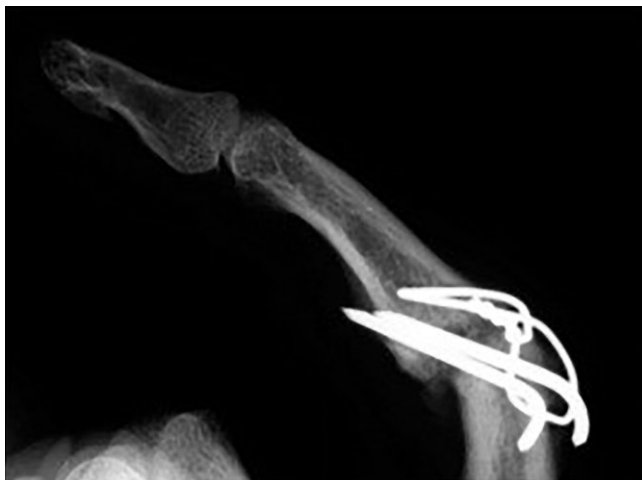

Fig. 3 PIP fusion with tension band wiring.

with the screw technique is to achieve the desired fusion angle. This is difficult to accomplish, especially for angles less than 30°. The straighter the fusion position, the more difficult it becomes to obtain adequate purchase on the distal volar fragment. The screw also has more potential for protrusion on the proximal dorsal cortex.

Surgical technique: PIP joint arthrodesis
The joint is approached from the dorsal aspect. The central slip of the extensor tendon is split and the joint opened. After removing the osteophytes and releasing both collateral ligaments, there is a good view of the joint. The

Fig. 4 Single screw fixation of PIP fusion. The more flexion angle needed the shorter the screw must be chosen.

osteotomy should be performed in such a way that the desired fusion angle is set on the proximal phalanx and a perpendicular bone cut is made on the distal phalanx. Suitable fusion positions are usually 15–20° of flexion angle in the radial digits and 25–40° in the ulnar joints. Trial reposition is performed and can be held in place with a
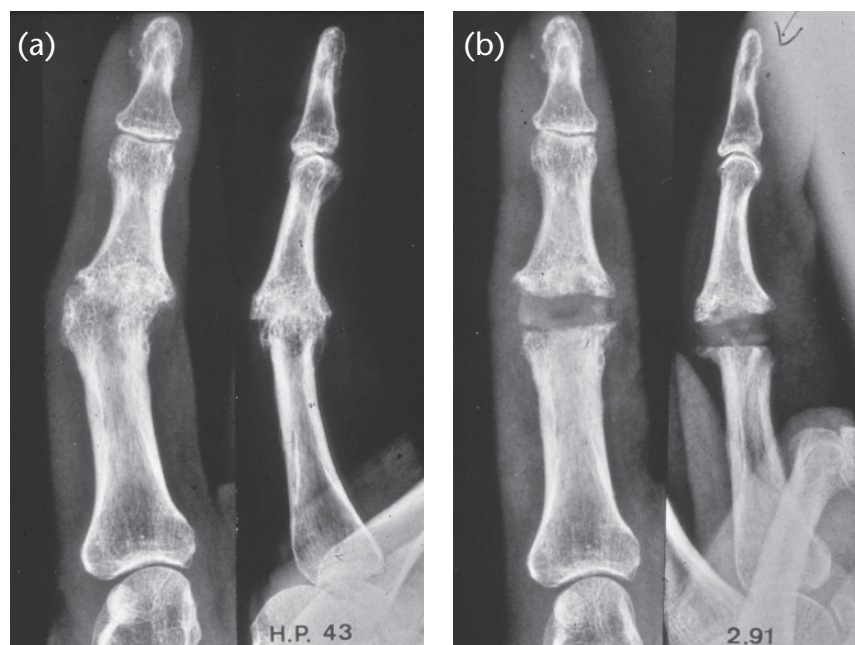
Fig. 5 (a) PIP joint osteoarthritis with completely missing cartilage. (b) Subsequent PIP arthroplasty with a silicone implant.

temporary K-wire. Fluoroscopic control should confirm good bone contact over the whole area of the osteotomy. Once this preliminary fixation has been carried out, the hand is removed from the operating table to check the three-dimensional appearance of the finger. Rotational malpositioning, in particular, has to be avoided. Definitive fixation is then performed.

Post-operatively, the PIP joint should be protected in a finger splint for six weeks. Early mobilization of the DIP joint out of the protective splint is started after a few days. Bone healing should be confirmed with radiographs six weeks after surgery.

PIP joint replacement
PIP joint arthroplasty is a widely accepted procedure in joints with either OA destruction or in post-traumatic conditions. Pre-requisites are intact tendons and at least some residual joint stability. Although no exact degree of instability can be defined, corrections of a lateral deviation beyond 30° are difficult and likely to fail.

PIP arthroplasty has a shorter history than MCP joint replacement. For decades, joint arthrodesis was the standard procedure for painful PIP joint destruction and the functional results of this procedure were generally reported to be good.[8] Pellegrini and Burton[10] reviewed a number of patients who had undergone different procedures for PIP joint destruction. They observed that arthrodesis in the radial digits brought an improvement in the lateral pinch, while arthroplasty in the ulnar digits gave reasonable functional mobility with good pain relief. Based on this analysis, the authors were not able to make

a definitive recommendation on the optimal procedure for destroyed PIP joints. Since that publication, however, several authors have advocated the concept of reserving PIP arthroplasty for ulnar digits and treating the index finger, which is the main partner for pinching with the thumb, with PIP joint fusion. The author has adapted this concept in that PIP arthroplasty is offered for all digits depending on functional demands and pre-operative deformity, but the rehabilitation programme in the index finger is slightly modified. Functional exercises with the index finger are begun later and functional splinting is prolonged in order to protect the radial collateral ligament, which is most important for the lateral stability of this joint. The goal of index-finger rehabilitation after PIP arthroplasty is not maximum mobility but an optimal balance between mobility and stability. Contraindications to PIP joint replacement include the classic criteria of insufficient bone stock, missing or dysfunctional tendons, and severe tendon imbalance, especially contracted boutonnière and swan-neck deformities. In severely contracted joints with a long-standing history of immobility, PIP joint fusion in a functional position may be a better choice than implant arthroplasty. Severe joint instability and deformity of more than 30° is extremely difficult to correct with an implant and is usually a contraindication to arthroplasty.

The choice of implant and the approach used are the two most frequently discussed issues for PIP arthroplasty. A variety of implants is available, but only a few series with adequate long-term follow-up have been published. Silicone implants (Fig. 5), introduced by Swanson in the late 1960s, are still the gold standard for newer generations of

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Fig. 6 (a) PIP joint osteoarthritis with completely missing cartilage. (b) Subsequent PIP arthroplasty with a surface replacement implant (CapFlex KLS Martin Tuttlingen).

implants with respect to functional performance, revision rate, and long-term outcomes. Silicone joint spacers carry a risk of implant breakage and associated silicone synovitis. Overall, the silicone spacer produces fairly consistent results with good pain relief and reasonable function, with a range of motion of between 40° and 60° active flexion/extension. Silicone synovitis is not a hallmark of PIP joint arthroplasty as it has been historically with wrist implants. Only a few cases with relevant silicone synovitis have been reported and, although implant failure is seen, it does not necessarily lead to revision.[11–14] No randomized controlled trials with series of different silicone implants in the PIP joint are available, and analysis of the different case series suggests similar results for most of the silicone implant designs.

The newest generation of PIP joint implants follows the principles of surface replacement with a two-component concept.[15–17] The proximal component replaces the bicondylar head of the proximal phalanx and the distal component has a sort of cup, which articulates with the head. Most of these implants do not represent a real resurfacing concept, since a significant amount of bone must be resected and long stems for both components are needed to provide adequate fixation. The newest generation of implants provides a real surface replacement with a very short-stem subchondral bone fixation (CapFlex KLS Martin Tuttlingen) (Fig. 6).

Several material combinations are available, from the classic chrome cobalt/polyethylene to ceramic/ceramic and pyrocarbon/pyrocarbon. Although pyrocarbon has excellent biocompatibility and ideal gliding characteristics, problems have been reported, with difficulty demonstrating osteo-integration and reports of joint squeaking. Most of these implants may be used without cement, although some of them require cementing for primary fixation in the bone. The majority of surgeons prefer non-cemented implants, since revision is easier, and removal of the implant causes less damage and bone loss. Overall, the newer generation of PIP implants based on the resurfacing concept seemed a logical development in PIP arthroplasty, but most of them have not yet stood the test of time and real-life long-term follow-up series are still lacking for most implant designs.

The concept of resection-interposition arthroplasty, with a volar plate for example, is reported only for traumatic or post-traumatic conditions. Depending on the existing condition and the soft tissue configuration, this technique has an inherent danger of producing an unstable joint situation, especially in the radial digits.

The choice of implant depends on several factors, including the surgeon's experience, the local anatomical situation, especially the bone stock, and the surgical approach. Silicone devices, which act as joint spacers, are by far the most forgiving implants. They provide reproducible results even in cases with difficult bone stock and with limited surgical experience. They can be implanted easily using different surgical approaches. More complex, two-component joints need an adequate bone stock and no large cystic bone defects can be allowed to exist with implants, as they must be inserted without cementing. Correct placement, with the goal of restoring the biomechanical centre of rotation, needs some experience. Some of these implants are supplied with resection guides, which can be used only with a dorsal approach. In addition, some prostheses need more space for implantation, which also means that a dorsal or lateral approach is required.

Surgical technique: PIP joint replacement
Different surgical approaches have been described to implant a PIP joint replacement. All of them have theoretical advantages and disadvantages. So far, no one approach has proved to be superior to the others, although the theoretical advantages of the volar approach are now being discussed. The *dorsal approach* (Fig. 7) is the most widely used and technically least demanding in comparison with the volar and lateral approaches. It is also required when certain soft tissue conditions, such as mild swan-neck or boutonnière deformity, are to be corrected at the same time. A straight or slightly curved longitudinal incision is performed. The dorsal veins should be preserved if possible and care taken with the dorsal nerve branch to the PIP joint. Several techniques have been described to access
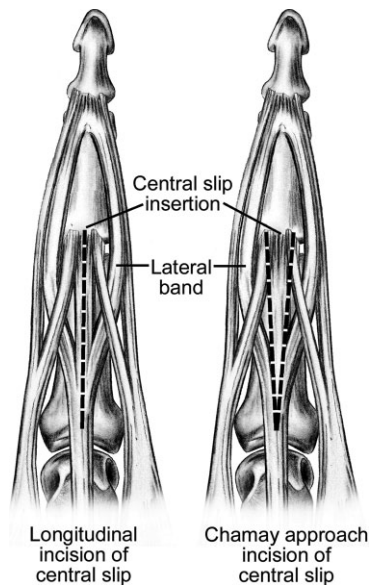
Fig. 7 Dorsal approach to the PIP joint, either by central slip incision or through a V-shaped Chamay tendon flap.

the joint. Swanson and de Groot Swanson[14] advocated a midline split of the central slip of the extensor tendon. An alternative is the approach described by Chamay.[18] He uses a V-shaped extensor flap, which offers a good view of the joint and allows a long stable suture line for tendon closure. However, according to our experience this approach showed some problems including calcification of the extensor tendon and hyperextension deformity in the course of rehabilitation, probably due to excessive scarring of the tendon with subsequent contracture. We therefore prefer the tendon split. The joint can be exposed easily through the release of the insertion of the central slip. For closing a strong but simple suture can be used to close this spilt around the insertion, without a transosseous fixation.

The bone is prepared according to the needs of the selected implant. For silicone implants, the resection line is planned according to the implant size (most often size 1 in the original Swanson design) and care should be taken to preserve as much of the collateral ligaments as possible, although overstuffing of the joint must be avoided. The tension should be chosen so that full flexion and, in particular, extension is possible. Either a smaller implant or more bone resection is needed if there is an extension lag. When there is significant joint deformity or deficient collateral ligaments, reinforcement suture of the ligaments and/or a staged release is needed on the contracted side. The joint should now be well balanced but with a full passive range of motion still being possible. It is virtually impossible to correct any deformity remaining on the operating table, even with a well-applied rehabilitation programme.

Rehabilitation must be individualized according to the intra-operative stability, the collateral ligament status, the surgical approach and the finger ray. It might be advisable to plan a more conservative rehabilitation programme for the index finger and for any joints that are severely deformed and consequently require collateral ligament re-balancing. Theoretically, the long suture line in the extensor tendon allows early active mobilization. Resting splints in the intrinsic plus position are worn for up to six weeks. Buddy splinting to the neighbouring radial finger is a good way of protecting the collateral ligaments and yet still allowing an active and passive range of motion. Individual adaptations need to be made during the rehabilitation programme. If the joints become stiff early, more vigorous mobilization is needed. In general, dynamic splinting is rarely needed and not tolerated by the soft tissues until four to six weeks after surgery. The average range of motion which can be expected after PIP joint arthroplasty is 50–60° active flexion/extension. Flexion provides more function and extension a better aesthetics to the finger. Night splints in extension and dynamic extensor splints may help. In cases of a mild, passively correctable swan-neck or boutonnière deformity in combination with destruction of the PIP joint, a dorsal approach is essential for joint replacement. Careful attention should be paid to the cause of the swan-neck deformity, as this is very often found at a different level from the PIP joint. These cases require release of the lateral bands, often in combination with lengthening of the central slip. A central slip reconstruction or reinforcement is needed with boutonnière deformity. Several techniques have been described for this difficult procedure.

Overall, PIP arthroplasty has limited results in the presence of these deformities and there is an inherent danger that the joint will become stiff or that the deformity will recur. Figure 8 shows some types of dynamic splints which allow immediate movement exercises but prevent lateral deviation (Fig. 8).

The *volar approach* (Fig. 9) has, at least theoretically, several advantages over the other approaches. The tendons are not violated directly with this technique and, in particular, the delicate extensor mechanism remains untouched. However, the volar approach is technically more demanding and offers less space for the implantation of an artificial joint. In addition, pre-existing tendon imbalances are more difficult to correct. The technique described by Herren and Simmen[11] offers good access to the joint. A Bruner incision forms a radially based skin flap. The flexor tendon sheath is exposed and opened transversely in the area of the A3-pulley on both the volar and the dorsal side. On the ulnar and the radial sides, the incision is continued to form a sleeve, which includes the release of the accessory collateral ligaments. Access to the joint is now achieved with hyperextension. Some release
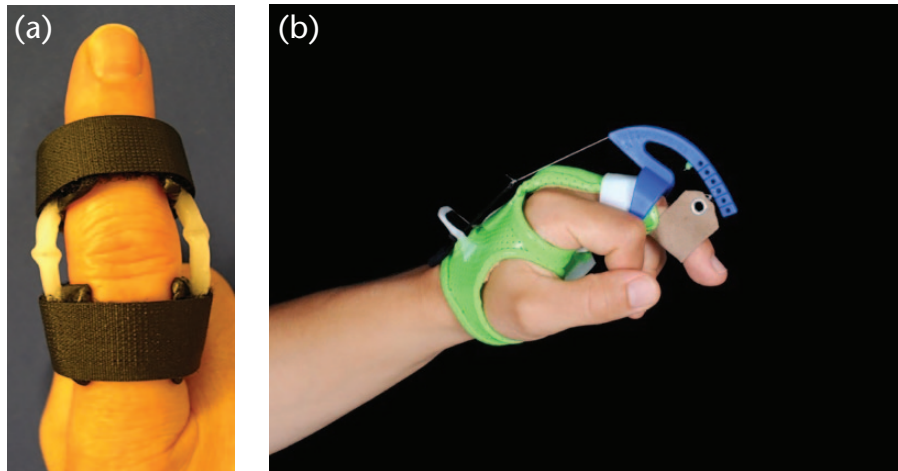
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Fig. 8 (a) Short dynamic hinge splint to protect the collateral ligaments. (b) Long dynamic splint with an isometric outrigger allowing optimal distribution of the forces to the PIP joint in flexion/extension.
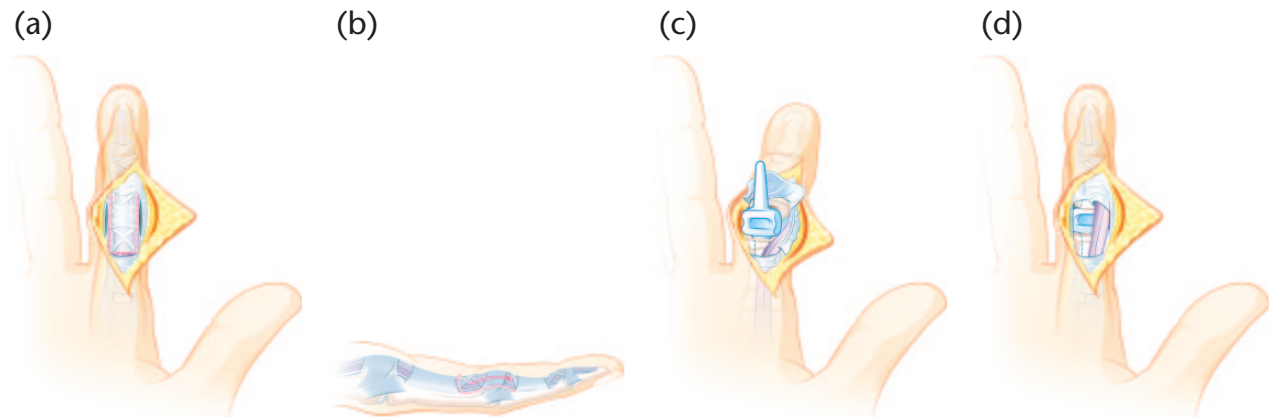

Fig. 9 Volar approach to the PIP joint for arthroplasty. (a) A sleeve of the flexor pulley system is formed starting at A3 pulley, including the release of the accessory collateral ligaments. (b) Sleeve from the side. It contains the volar plate. (c) Retraction of the flexor tendons and after the preparation of the bone the implant can be inserted. (d) Final appearance after joint reposition. The flexor pulley sleeve can be re-fixed and immediate active and passive rehabilitation is possible.

of the ulnar collateral ligament may be needed if the joint is not supple enough to get a good exposure. The osteophytes, especially those on the volar side, can now be removed. This is important since it may be a potential site of impingement with the implant in flexion. The head of the proximal phalanx can now be resected but care must be taken to identify the ulnar neurovascular bundle and protect it with retractors. Preparation of the bone and implantation of the prosthesis follow the same principles as for the dorsal approach. For closure, the pulley sleeve is retracted and re-attached in its anatomical position. In cases with pre-existing deviation of the flexor tendon due to lateral deformity, the tendon can be re-centred. It is important to test the passive range of motion again before final closure. The rehabilitation programme follows the principles outlined for the dorsal approach, but no special protection of the extensor tendons is needed, and even passive motion is allowed.

The *lateral approach* (Fig. 10) is the least common approach used for PIP implants. The incision goes along the midline on the ulnar side of the finger and curves dorsally on the middle phalanx. After releasing the oblique and transverse fibres of the retinacular ligaments, the extensor apparatus is elevated and can be mobilized laterally, with the insertion of the central slip remaining intact. The ulnar neurovascular bundle remains on the volar side of the joint. In the classic lateral approach the ulnar collateral ligament must be detached completely in such a way that the joint can be opened on the radial side. This is best done with a triangular proximally based flap that can be reflected proximally. The implant can be inserted as described previously. For closure, it is essential
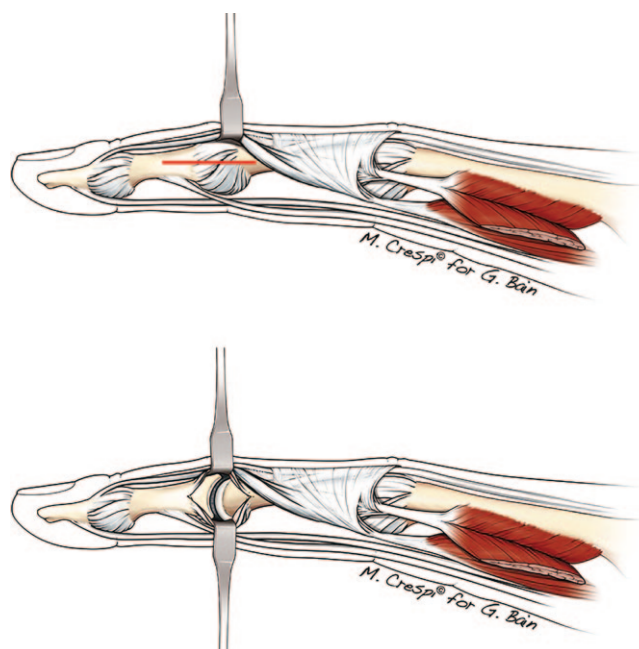
Fig. 10 Classic lateral approach with complete detachment of the collateral ligament and simplified lateral hinge approach according to Bain with split of the proper collateral ligament. Copyright Dr Gregory Bain and Max Crespi.

to re-attach the ulnar collateral ligament in such a way that active rehabilitation is possible. The ulnar side must be protected with buddy splinting for up to six weeks. Bain et al[19] described a modified lateral approach, which splits the collateral ligament for implant insertion and repairs it side to side. At least theoretically there is less danger of instability and early unrestricted active mobilization is possible.

Complications

In PIP fusion the most common complications are non-union and malunion.[20,21] Non-union might be due to biological factors, mainly in difficult bone conditions or as a result of technical problems with the bone fixation. Bone conditions for joint fusion might be compromised after infection, in the course of an inflammatory disease or in post-traumatic joints with severe bone defects with or without previous bone grafting. Since bone defects overall are relatively low in volume and some shorting is functionally acceptable, conventional grafting with a rigid fixation often solves the problem. Prolonged immobilization might be needed in some cases, until bone healing is confirmed radiographically. Malunion can be functionally disabling, especially in terms of co-ordination with the other fingers of the hand. This includes malrotation and lateral deviation. It is therefore mandatory to check during the procedure these parameters as described, carefully.

The complication rate in PIP arthroplasty is significant. While the main problems of silicone devices are implant failure and cystic bone formation with time,[12] more complex joints might show implant loosening and joint dislocation. In the long-term follow-up, it is to be expected that 10–30% of the silicone implants at PIP level show a fracture. This is clearly less than in the MCP joints and does not always mean revision surgery. In comparison with the MCP joints, the rate of silicone synovitis is less and, in our experience, only a few cases need revision for this problem. A review investigating complications after different types of PIP arthroplasties found that silicone implants showed more post-operative finger deviations (3%) and instabilities (2%) compared with surface-replacing implants.[22] Implant-related complications, such as implant fractures, migrations and luxations were associated with 14%, 10% and 11% of pyrocarbon, metal-polyethylene and silicone implants, respectively. By contrast, re-operations (subsequent surgeries without implant modifications) were fewer for silicone arthroplasties (1%) compared with pyrocarbon (7%) and metal-polyethylene implants (10%). However, revision rates were 4% for all types of implants.[22] As already mentioned, recurrence of pre-existing deformity is high. The overall revision rate in the literature varies from 2% up to 13%.[12] The main reasons for revision were pain, limited range of motion and joint deformity, mainly ulnar deviation. Most patients showed a combination of these problems. Revision surgery gave good to moderate pain relief, no change in the range of motion, and a high recurrence of joint deformity.[23]

The newer generation of prostheses, including pyrocarbon, ceramic and other resurfacing implants, shows a relatively high complication rate with implant dislocation and problems in bone fixation in non-cemented devices.[24–27] A permanent squeaking, unrelated to pain, was observed with some of the implants.

Outcomes

Almost all publications on replacement of the proximal interphalangeal joint report variable indications and thus preclude comparable outcome analysis. Most series have shown that patients with rheumatoid arthritis had a poorer outcome, due to pre-existing deformity that could not be corrected with the implant.[12] Overall, the results of this procedure in PIP joint destruction are quite uniform regardless of the implant. Pain relief is good to excellent, the average range of motion for almost all implants, including the newer designs, is 40–60°, and there is a high recurrence of pre-existing deformities in silicone arthroplasty. The pre-operative range of motion could rarely be improved, and no clear correlation between pre-operative mobility and post-operative range of motion is to be

expected.[11] The newer designs do not improve the active range of motion, moreover they have a greater potential for complications compared with silicone implants.[27,28]

PIP joint arthrodesis gives reproducible results regardless of the technique used.

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