The hand

- Typical deformities in rheumatoid arthritis include ulnar drift of the fingers, swan-neck and Boutonnière deformity (imbalance and malalignment of the PIP and DIP joints of the fingers), and shoemaker's thumb. These malalignments, along with pain and decreased mobility, may seriously impair hand function.
- The goal of surgical treatment is to:
  - achieve pain relief
  - counteract deterioration
  - improve function
  - achieve cosmetic improvement.
- Soft tissue surgery, eg, synovectomy in joints and tendon sheaths, for joint pain or mobility problems, tendon transfer for deviated fingers or following tendon rupture, and neurolysis to treat compression of peripheral nerves, can often improve hand function and counteract deterioration.
- If the joints are more or less destroyed by the rheumatic process, arthrodesis may be a suitable treatment in some joints (the MCP joint of the thumb, DIP joints of the fingers), while arthroplasty is the most appropriate surgical approach in other joints (the MCP joints of the fingers).
- The data in this chapter are based mainly on retrospective clinical and radiological studies of rheumatic patients.

Anatomy

The bones and joints of the hand (starting from the wrist) consist of 5 carpometacarpal joints (CMC I–V) between the wrist (carpal bones) and metacarpal bones, 5 metacarpophalangeal joints (MCP I–V) between the metacarpal bones and phalangeal bones, and proximal and distal interphalangeal joints (PIP and DIP joints) between the different phalangeal bones. Mobility in CMC I (saddle joint) is good which, eg, enables the thumb to be positioned in opposition to the fingers. Other CMC joints have little or no mobility; CMC II and III are tight joints. The MCP joints have a mobility of approximately 90° from extended to flexed position, and also have the capacity to deviate to the side so the hand grip can adapt to the shape of an object. The PIP and DIP joints are hinge joints with mobility of approximately 100° (PIP) and 70° (DIP) respectively.

Introduction

The hand is not only for grasping and feeling. It is also a means of communication and is of major importance for body language and social contact. An aching, swollen, and deformed hand, perhaps with impaired mobility and sensitivity, therefore represents an important medical and social disability. Inability to carry out ADL activities due to impaired hand function often determines whether or not a patient will need care. Hand surgery plays an important role here—relatively simple procedures may often substantially improve hand function, and thus increase the patient's opportunities for independence.

Hand surgery procedures in rheumatoid arthritis are targeted at pain relief, improved joint mobility and stability, and correction of deformities—operations which generally lead to improved hand function and improved cosmetics. Furthermore, several procedures are of prophylactic value, aimed mainly at preventing tendon rupture. Major benefits can also be achieved from simple procedures such as arthrosynovectomies, tenosynovectomies, and arthrodeses. Certain types of tendon transfers may be useful for correcting malalignments such as ulnar drift and swan-neck deformity (hyperextension in the PIP joint and flexion contracture in the DIP joint), or Boutonnière deformity (flexion in the PIP joint, hyperextension in the

DIP joint) in the fingers. Arthroplasties with or without an endoprosthesis may come into question when less advanced procedures no longer have the intended effect, ie, in severe destruction of the MCP joints with flexion contractures and subluxation of the base phalanges accompanied by the inability to open the grip of the hand. The goal of a MCP joint arthroplasty is to correct subluxation and ulnar drift of the fingers, to improve mobility, and to shift the range of motion to a more physiological position which allows the gripped hand to open. Another aim is to relieve pain. The outcome is always best when mobility in the proximal interphalangeal (PIP) joints can be maintained.

Several types of deformities may be found in the PIP joints of the rheumatic patient. Long-term synovitis with weakening of the extensor aponeurosis may cause an extension defect, and an inability for active extension. Likewise, imbalance between the extensor and the flexor tendon system may result in a hyperextension position of the PIP joint and swan-neck deformity. Arthroplasty in the PIP joint aims at pain relief in combination with improved balance and mobility.

In the thumb, a typical deformity involves a highly flexed position in the MCP joint and hyperextension in the IP joint (so-called "shoe-maker's thumb"). Furthermore, the MCP joint of the thumb is often unstable and painful. Both problems are indications for operative procedures, usually tenoplasty or arthrodesis.

A common problem is tenosynovitis with swelling and tenderness along the distal tendon sheaths in the hand, and on the inferior side of the fingers, often with impaired mobility and uneven finger movement. Untreated, long-term tenosynovitis may create a risk for tendon rupture. Tenosynovectomy is an important procedure for relieving pain, can improve mobility, and provide good prophylaxis against tendon rupture.

Tenosynovitis and arthrosynovitis may cause pressure on nearby nerve structures, resulting in sensory impairment and decreased motor function. Most common is tenosynovitis within the carpal tunnel, which easily causes carpal tunnel syndrome, but compression neuropathy may also be present at other levels in the arm. In such cases, arthro/tenosynovectomy with decompression of the nerve structures is important to relieve pain and improve sensitivity and mobility in the hand.

MCP joints

Ulnar drift

Malalignment in the knuckle joints which causes the fingers to deviate toward the little finger (ulnar drift) is perhaps the most characteristic malalignment of the hand in rheumatoid arthritis, and the one the patient often experiences as a mark of disease. Apart from the face, the hands are the only part of the body constantly exposed, so deformities of the hand are often quite noticeable. Hence, patients experience ulnar drift as cosmetically disturbing, and most want to have the problem corrected. Ulnar drift may also impair hand function due to the extension loss. The hand cannot be fully opened, and the patient may have difficulties grasping a glass or shaking hands. In some cases, the ulnar drift is so pronounced that it is difficult to touch the other fingers with the thumb. The ability to grip with the fingertips disappears, and the only fine manipulatory grip remaining is the key grip between the thumb and the side of the index finger [84]. Apart from functional impairment, synovitis in the MCP joints may cause local problems with swelling, pain, and stiffness.

Ulnar drift is usually classified into three stages, according to Fearnley [30]. At an early stage (Fearnley 1 = moderate malalignment which is actively correctable by muscular activity in the hand itself), ulnar drift is usually treated non-surgically with a splint or orthosis, while local joint symptoms can be suppressed by intra-articular steroid injections.

In stage 2 (Fearnley 2 = more pronounced malalignment which is correctable through traction from splints, the other hand, or the caregiver), the MCP joints are radiologically intact, and it is possible to treat the malalignment by soft tissue surgery.

In Stage 3 (Fearnley 3 = joint contracture which is non-redressable and usually combined with luxation of the joint and/or radiological destruction), soft tissue surgery is not appropriate.

Centralization

A common, contributing cause to ulnar drift is ulnar luxation of the extensor tendons, ie, the extensor tendons slide down the side of the knuckle since the transverse ligament structures which keep the tendons in place stretch or rupture as a result of synovitis in the MCP joint. Since the tendons almost always slide ulnarly, each extension of the MCP joint creates an uneven force in the fingers which contribute toward permanent malalignment. This progression can be prevented by correcting the position of the extensor tendon over the knuckle at an early stage. The procedure, ie, centralization of the extendor tendon, can be performed at Fearnley stages 1 or 2. It involves releasing the ulnar bands of the extensor tendon, while tightening the radial part of the extensor hood by means of suture rows through a doubled connective tissue layer (raphi) so that the extensor tendon centers over the MCP joint. Postoperative mobility exercises must be initiated early. However, the fingers should be protected from ulnar deviation by using a suitable dynamic orthosis for 4 to 6 weeks. The method yields reliable results with approximately 80% of results reported as "good" or "excellent" when performed on the appropriate indications [84,85].

Straub arthroplasty

Correction of ulnar drift in Fearnely stage 2, in cases where the extensor tendons are not dislocated, can be performed by moving the interosseous tendon insert on the base phalanges of the fingers, ie, intrinsic transfer or Straub arthroplasty [72]. The interosseous muscles affect the abduction and adduction movements of the fingers, and moving the insert of the ulnar band from the fingers II–IV to the radial side of the closest ulnar finger can increase radial traction in the fingers III–V. After this operation, early mobilization is required in a protective dynamic orthosis for 4 to 6 weeks. The literature revealed no postoperative long-term results.

Fingers

Swan-neck deformity and button-hole deformity

Rheumatic attacks on the PIP and DIP joints in combination with inflammatory changes of extensor tendons and flexor tendons often cause deformity of the fingers either as a swan-neck deformity (hyperextension of the PIP joint, flexion contracture in the DIP joint) or a button-hole deformity, also called Boutonnière deformity (flexion contracture of the PIP joint, hyperextension of the DIP joint). While the swan-neck position is caused mainly by imbalance between the muscles and tendons that manage the movement of the finger, the button-hole position is caused mostly by rheumatic synovitis in the PIP joint and the resulting hypofunction of the extension apparatus of the PIP joint. Local disease symptoms from the PIP and DIP joints may indicate synovectomy at an early stage or arthrodesis/arthroplasty in later stages. Synovectomy of the PIP joint should include tightening the insert of the extensor tendon to counteract the tendency for Boutonnière position. Swan-neck and button-hole deformities may also be graded, according to Fearnley, into three stages; soft tissue correction may be performed in early stages, but later stages require joint procedures involving arthrodesis or arthroplasty.

Soft tissue arthroplasty in swan-neck deformity

Swan-neck deformity in early stages, ie, when the joints are dislocated or destroyed, can be corrected by soft tissue procedures including transfer of a tendon or tendon insert to cause a tenodesis effect, ie, stabilization of the joint.

Littler arthroplasty involves transferring one of the lateral bands in the extensor aponeurosis to achieve a flexion position in the PIP joint instead of the hyperextension included in the deformity. Kleinert arthroplasty involves a similar procedure on the volar side of the PIP joint, where one of the bundles included in the superficial flexor tendon is transferred to achieve a tenodesis effect. In early stages of a swan-neck position, tightening the skin on the volar side of the PIP joint, ie, dermodesis, can often correct a minor tendency toward hyperextension. The results after soft tissue arthroplasty are satisfactory when performed on the correct indication for surgery, however, the progressive character of rheumatic disease implies that long-term results after this type of surgery are difficult to evaluate [34].

Soft-tissue arthroplasty in button-hole deformity

Button-hole deformity is usually the result of synovitis in the PIP joint which has caused destruction or elongation of the insert of the extensor tendon in the middle phalanx. Synovectomy of the PIP joint combined with reinsertion or shortening of the central band of the extensor tendon, can, in early stages, provide the needed correction in finger position.

Arthroplasty

In stage 3 finger deformities with joint destruction and/or dislocation, malalignment can be corrected only through joint procedures such as arthrodesis or arthroplasty (see below).

The proximal interphalangeal (PIP) joint

Synovectomy

Synovectomy of the PIP joint is indicated for painful synovitis, especially where there is threatening button-hole malalignment. The procedure is performed from the dorsal side, preserving the integrity of the extensor aponeurosis and usually tightening the extensor tendon insert on the middle phalanx. The result is usually alleviation or relief of joint pain, but in many cases there is also deterioration in mobility (in some series 4% to 22% loss in mobility) and a risk for relapse (relapse rate, 24% to 41%). Synovectomy as a separate procedure is becoming increasingly unusual [17,67,87].

Arthrodesis

Destruction of the PIP joint with malalignment (fixed swan-neck deformity), loss of mobility, and/or instability may impair hand function. The symptoms, combined with local pain, form the indication for surgery. Since arthroplasty of the PIP joint does not yet offer optimal results, the alternative is usually arthrodesis. Since mobility in the PIP joint is essential, the alternative of arthrodesis is less appealing than, eg, when the DIP joints or the MCP joint of the thumb are involved. Therefore, the indications should be strong before arthrodesis is recommended. The surgical procedure involves resection of remaining joint surfaces, and then a pin, screw, or plate is used to fix the joint in a slightly flexed position. There is an advantage in achieving primary stability by arthrodesis, so that immobilization time is as short as possible. The results in terms of pain relief and correction of deformities are usually good, while the loss in mobility may involve permanently impaired hand function [17,60,71]. Attempts to replace bone healing in an arthrodesis with implantation of a stiff silicone plug, to achieve stability, yielded poorer results [78].

Arthroplasty

Mainly, Swanson or Niebauer silicone implants are used in arthroplasty of the PIP joint (Table 1) [25,56,57,63,74,75,77]. The outcome in terms of pain relief is usually good, but outcomes related to correction of malalignment and improvement in mobility are mostly discouraging. The data are summarized in Table 1. In a recent report, the relapse rates concerning corrected swan-neck deformity and button-hole deformity have been reported at 86% and 80%, respectively [2]. The same study noted a deterioration in mobility (on average 8°) in the PIP joint after arthroplasty. In 28 of 40 fingers, the outcome was disappointing (fair or poor). Another recent study found no improvement in mobility after the procedure, but noted relief of pain in 67/69 cases [46]. It is a widely spread opinion that arthrodesis is the best alternative in this joint. If arthroplasty is selected, it is important to first correct the deformities in the MCP joints [2].

Arthroplasties using cemented two-piece joints have shown unsatisfactory results and a high rate of loosening [7,25,46,47].

No prosthesis which has been satisfactory and sufficiently well-documented is currently available for the PIP joint. Arthrodesis is the most suitable method for achieving pain relief and stability, and for correcting deformities.

The MCP joint

Synovectomy

Synovectomy is seldom done as an isolated procedure, but is usually performed in combination with centralization of extensor tendons or other correction of ulnar drift. Synovectomy usually re-

Table 1. Endoprosthetic operations in the PIP joint

Author	Implant (silicone)	No. patients	No. joints	Follow-up (years)	Active mobility postop.	Extension defect postop.	Complications		Comments
							Prosth. fracture	Other	
Swanson 1973	Swanson		222	>1	63° (20-120)°	4°	2%	19 revisions for other reasons	
Dryer et al. 1984	Swanson/ Niebauer		30	4	37°	1°	10%		37% relapse of swan-neck deform.
Swanson 1985	Swanson	182	424	5	32–60°	1–20°	5%		21% relapse of swan-neck deform.
Pellegrini & Burton 1990	Swanson/ Niebauer		26	4	56°	3°	4%		
Adamson et al. 1994	Swanson 37 Niebauer 3	19	40	8	unchanged		13%		12 good 18 fair 10 poor

lieves pain in the cases where articular pain is caused by synovitis, but as with PIP joint synovectomies, the relapse rate is high, and postoperative limitation of movement is common [17,29, 67,87].

Arthrodesis

Good hand function depends on mobility in the MCP joints of the fingers—opening the hand requires good MCP joint extension, making a fist requires good MCP joint flexion. Furthermore, adaptation of the fingers to the various shape of objects depends on the hand's capacity for ulnar-radial deviation, including some finger rotation. Therefore, arthrodesis of the MCP joints of the fingers is not recommended, with the exception of MCP joint II. This joint is subject to greater pressure, and in some cases, when combined with arthroplasty of other MCP joints, it may be fixed in a suitable position relative to the thumb.

Soft-tissue arthroplasty

Several different arthroplastic principles, with and without prostheses, have been described. The goal of these procedures is to relieve pain, increase mobility, enable opening of the hand, and improve cosmetics.

Data on the results of soft tissue arthroplasty procedures are sparse. A followup of 20 patients (73 joints) who received Tupper arthroplasty and were followed for 0.5–4.5 years reported a postoperative passive range of motion in the MCP joint of approximately 63°, approximately two thirds of which was the active range of motion [82].

The main advantage of soft tissue arthroplasty is that no foreign material is inserted into the hand. The disadvantage is that mobility in the operated joints is often limited, and they often stiffen quite rapidly. No comparative studies are available which compare soft tissue arthroplasty to endoprosthetic surgery.

Endoprosthesis

The first operation involving an endoprosthesis in the MCP joint was performed in the 1950s. Since then, several different endoprosthetic models have been presented [10]. Joint mechanics is generally based on one of two main principles: 1) a two-piece, hinged joint mechanism which allows flexion and extension; 2) a solid flexible component of silicone or other polymer which can be deformed to permit mobility in flexion and extension, but also deviation (adduction/abduction). In both cases, two shafts originating from the joint device are inserted into the medullary cavity of adjacent bones. Two-piece joint devices are usually cemented into place while the shafts of the silicone joints are not cemented and can move inside the medullary cavities. Recently, silicone joint devices have been introduced which are attached to titanium screws that are anchored (osseointegrated) into adjacent medullary cavities [48].

Silicone arthroplasty

For more than 20 years, Swanson arthroplasty has been the predominant technique for arthroplasty in the MCP joints of the fingers (Table 2) [8,11, 12,24,32,35,36,45,49,51,73,79]. With the Swanson approach, the implant—a flexible silicone spacer with proximal and distal shafts—replaces the destroyed MCP joint. After the metacarpal head has been resected, the two shafts of the prosthesis are inserted into the medullary cavities of the metacarpal bone and phalanx, respectively. The aim is not to anchor the silicone implant permanently to bone tissue – on the contrary, the implant is viewed as a "dynamic spacer" which can move longitudinally in the medullary cavities so that, during flexion, stress on the material is spread over a greater area. To be successful, the silicone material must be surrounded by a fibrous capsule, which is functionally adapted and oriented during postoperative mobilization. In conjunction with the operation, the collateral ligaments are also reconstructed to the extent possible (mainly the radial collateral ligament of the index finger which has an important stabilizing function in the thumb/index finger grip).

The Swanson method usually provides immediate, satisfactory results in terms of pain relief, cosmetic appearance, and hand mobility. In the long run, however, local tissue reactions may occur in response to the movement of foreign material inside the medullary cavities. Bone resorption, thinner cortical bone, and silicone fracture were described by Hagert in 1975, often in combination with increased stiffness [38]. Local tissue reactions may occur. These are induced by the silicone or silicone particles which have been observed in lymph nodes even some distance from the surgical site [32,61,62].

The results of Swanson arthroplasty, as reported in literature, are summarized in Table 2. Prospective randomized clinical studies are lacking. Followup time varies up to 16 years. Outcomes in terms of range of motion vary from 25° to 66°. The rate of fractured prostheses varies from 1.25% in Swanson's own study, to 39% [1,73]. There appears to be agreement that Swanson arthroplasty generally provides pain relief and good cosmetic correction, but that the joints gradually stiffen in conjunction with bone resorption and subsidence of the prosthesis into adjacent bone structures.

Niebauer silicone/dacron prostheses

Niebauer silicone/dacron prostheses are constructed of silicone, but include an in-woven superficial dacron net intended to increase durability and decrease prosthetic mobility in the medullary cavity [8,35,58]. This model is no longer in general use.

Sutter prosthesis

The Sutter prosthesis has become increasingly popular, not least in Sweden [9]. The Sutter prosthesis is a variation of the Swanson silicone prosthesis, but based on a somewhat different principle for achieving mobility of the central silicone component. The Sutter prosthesis is considered to provide better side stability than the Swanson prosthesis, but no clinical data have been published.

Two-piece joint devices

Experience with cemented prostheses in the metacarpal phalangeal joints is limited (Table 2). Isolated reports describe the use of two-piece joint devices where a metal ball articulates with a plastic socket, and where the attachments are cemented into adjacent bone structures [1,40,70]. Local tissue reactions are reported as severe (extensive periarticular ectopic bone formation) in 32%, "loosening distally" in 17–18% [1,70]. These prostheses are not in general use.

Occasional reports have been published on different models of uncemented two-piece mechanical joints, eg, of alumina-ceramic material or polyester (isoelastic arthroplasty), which are attached to the medullary cavity via an expansion mechanism based on a basal longitudinal screw in the intramedullary parts of the prosthesis [52,80]. None of these prostheses are yet in general use.

Osseointegrated joint implants

The aim in the new generation of joint implants has been to permanently attach an artificial joint to the adjacent bone structures by means of osseointegrated titanium screws [48]. The technique is based on the osseointegration principle, as described by Brånemark and applied, eg, in the fixa-

Table 2. Endoprosthetic operations in the MCP joint

Author	Implant	No. patients	No. joints	Follow-up (years)	Active mobility postop.	Extension defect postop.	Complications		Comments
							Prosth. fracture	Other	
Swanson 1972	Swanson (silicone)		358 2,736[b]	0.5–5 1–4	(62° p.[a]) (58° p.[a])	3° 4°	2% 1%	1% dislocation of implant 1%	
Madden et al. 1977	Swanson (silicone)	43	238	0.5–2	57°	9°	13%		
Gschwend & Zimmerman 1974	Swanson (silicone)		200	1.5	42°	6°		dislocation >1.5%	
Ferlic et al. 1975	Swanson (silicone)	44	162	3			9%		
Mannerfeldt & Andersson 1975	Swanson (silicone)	50	144	2.5 (1.5–3.5)	40°	4–12°	3%		
Beckenbaugh et al. 1976	Swanson (silicone)	44	186	3	38°	10°	26%		
	Niebauer (s.-Dacron)[c]	16	68	3	35°	30°	38%		
Goldner et al. 1977	Niebauer (s.-Dacron)[c]	95	441	4–6	54°		17%/4 year 30%/6 year		
Steffee et al. 1981	Two-comp.[d] cemented	"type I" "type II"	160 577	>1 >1	35° 42°	30° 19°		17% distal loosening 18% distal loosening	
Blair et al. 1984	Swanson (silicone)	28	115	4.5 (2–10)	43°	13°	21%		
Bieber et al. 1986	Swanson (silicone)	46	210	5 (2–8)	51°	10			
Derkash et al. 1986	Niebauer (s.-Dacron)[c]	16	89	12 (8–17)	28°	25°		12% subluxation or fracture	
Jensen et al, 1986	Swanson (silicone)	22	74	2 (1–7)	29°	13°	5%		
Vahvanen & Viljakka 1986	Swanson (silicone)	32	107	4 (1–10)	34°	7°	4% 10%[e]	24% bone resorption	
Zimmen and Geschwend 1988	Swanson (silicone)	50	207	5 (2–10)	33°	13°	8% 14%[e]		no pain 87% light pain 12% moderate pain 1%
Figgie et al. 1990	Swanson (silicone)	38 (thumb)	43	6.5 (3–13)	25°	15	0%		
Maurer et al, 1990	Swanson (silicone)	105	446	9	48°	9°		4% revision required	
El-Gammal et al. 1993	Swanson (silicone)	39 hands		2	42°	14°			data coincides in part with Blair et al. 1984
Kirschenbaum et al. 1993	Swanson (silicone)	27	144	9 (5–16)	56–66°	7–19°	10%		
Wilson et al. 1993	Swanson (silicone)	35	185	10 (5–14)	29	21°	3%		
Olsen et al. 1994	Swanson (silicone)	16	60	7 (5–10)	30°		22%		
Minami et al. 1988	ceram./PE[f] uncemented	21	82	3 (24–62)	36°	18°	0%		
Adams et al. 1990	Ball in socket cemented	8	36	11 (5–12)	10°	58°	39%	22% exten. periarticular ectopic bone formation	

Table 2. Continued

Author	Implant	No. patients	No. joints	Follow-up (years)	Active mobility postop.	Extension defect postop.	Complications Prosth. fracture	Complications Other	Comments
Lundborg et al. 1993	Ti/silicone[g] uncemented	31	69	2.5 (0.5–4.5)	50	10	6%		
Vermeiren et al. 1994	"Isoelastic" (polyester) uncemented	19	68	3	37°	26°	4 meta-carpal-fractures		

[a] passive
[b] field clinic study
[c] silicone-Dacron
[d] two component joint with metal and plastic
[e] suspected
[f] alumina ceramics/ polyethylene
[g] osseointegrated titanium screws with silicone component

tion of tooth implants to the maxillary bone [3,14, 15,16,86]. A flexible silicone component, similar in shape to a Swanson implant, is attached to titanium screws inserted longitudinally into the medullary cavities of adjacent bones. Before the screws are set in place, the medullary cavities are packed with bone transplanted from the iliac crest. Hence, the screws are very stable, even in rheumatic patients. If needed (eg, due to a fracture in the silicone), the silicone component can later be easily replaced since the titanium screws seem to be permanently fixed to the bone.

In the first series of osseointegrated joint implants, complex mechanical joints were used which did not yield satisfactory long-term clinical results [39]. This study included five arthroplasties performed on the indication of osteoarthrosis in the metacarpophalangeal joints. In a new generation of clinical studies, initiated in 1987, a considerably simplified mechanical joint was used with a flexible silicone component attached to the titanium screws as described above [48]. In a 2.5 year followup of 68 joints in 31 patients, good results were reported with a range of motion of approximately 50°, and clinical and radiological osseointegration in all cases. Fracture of the silicone implant was reported in 6%. This method is currently in clinical trials and not yet available for general use. Results thus far show that the titanium implants integrate satisfactory, but that the flexible component in the endoprostheses is not yet fully developed.

MCP joint arthroplasties—a summary

In recent decades, the most common MCP implant has been the Swanson silicone implant. This method provides immediate pain relief and good cosmetic appearance, but in the long run, the joints tend to stiffen due to the bone resorption that occurs from the movement of the silicon against adjacent bone tissue. The method may be appropriate for treating rheumatic patients who are middle aged or older, especially when there is good mobility in the PIP joints. On the other hand, Swanson silicone arthroplasty should not be performed in younger patients. Osseointegrated joint implants appear to be promising, but are not yet ready for routine clinical use. Although the osseointegration principle makes it possible to permanently implant anchor points for a joint implant in the bones of the hand, developmental work still remains to be done before a satisfactory artificial joint is ready for use.

The thumb

The three different joints of the thumb (CMC, MCP, and IP joints), are often involved in rheumatoid arthritis. A typical malalignment of the thumb, with a flexed position of the MCP joint and hyperextension of the IP joint, ie, "shoemaker's thumb" occurs in most rheumatic patients. The opposite malalignment with hyperextension of the MCP joint and flexion of the IP joint, so

called "swan-neck thumb", is less common [55]. Good thumb function requires stability of the joint system of the thumb, and since joint and soft tissue destruction often causes instability in the attacked joints, poor thumb function is often a fundamental reason behind impaired hand function in rheumatoid arthritis. Corrective soft tissue procedures with transfer or stabilization of the tendons and ligaments of the thumb may restore normal thumb function at early stages [55]. Since stability in the joints of the thumb is often preferred over mobility, arthrodesis is the most common and often the best method of helping a dislocated, painful, or unstable thumb. Arthrodesis of the MCP joint of the thumb is generally considered to be one of the safest and best measures to achieve better hand function in rheumatic patients [17]. Arthrodesis in the CMC joint of the thumb is usually not used in patients with rheumatoid arthritis since the disease usually involves several joints at the base of the thumb, and, in most cases, impaired mobility is unacceptable if arthrodesis is used in all joints. Instead, excision of the entire trapezium bone is often performed, usually followed by interposition of a tendon to stabilize the base of the thumb and decrease the tendency for skeletal shortening [4]. The trapezium can also be replaced with an endoprosthesis, although use of the method is declining due to the risk of unfavorable tissue reactions around the implant [17,18,27,37, 68,76].

Tendons and tendon sheaths

The tendons in the hand and wrist which are covered by synovial tendon sheaths may be affected by rheumatoid synovitis, ie, tenosynovitis. This affects both extensor tendons where they pass over the wrist, and flexor tendons at both the wrist and finger levels. Patients with psoriatic arthritis are often affected by tenosynovitis. Tendon sheath inflammation causes local symptoms such as swelling, impaired movement, and sometimes pain. Furthermore, synovitis weakens the strength of the tendon, causing an increased risk for rupture.

Another common reason for tendon rupture is wear or rubbing against adjacent sharp bone edges, "attrition rupture". Typical locations for attrition ruptures are the extensor tendons to the ring and little fingers against the ulnar caput (caput ulnae syndrome), the flexor tendons (mainly the long flexor tendon of the thumb) in the carpal tunnel against dislocated carpal bones, and the flexor tendons against the metacarpophalangeal joints when the base phalanx of the finger shows volar dislocation in the tendon sheath [81].

Surgical excision of inflammatory tissue from the tendon and tendon sheath (tenosynovectomy) eliminates local symptoms, improves mobility, and probably decreases the risk of tendon rupture [22]. Tenosynovectomy can be performed in the tendon sheath region of the fingers (from the middle of the palm to the terminal phalanx). The indication is inflammation of the tendon sheath with pain or limited ability for flexion and/or nodule formations on the tendon, causing the finger to catch during flexion and extension movements. Tenosynovectomy of the fingers requires thorough anatomical knowledge to avoid injury to the nerves, vessels, and other surrounding structures. The transverse tunnel shaped reinforcing ligaments (annular ligaments) of the tendon sheath must be carefully maintained [23]. Tenosynovectomy is often performed in the carpal tunnel when inflammatory changes in the flexor tendons can be confirmed. Again, the indication for surgery is pain and limitation of movement, and often secondary involvement of the median nerve with sensory impairment, which itself is an indication for surgery. Tenosynovectomy can also be performed within the tendon sheath area of the extensor tendons on the back of the wrist. Appropriate post-tenosynovectomy treatment is necessary for good results: early, supervised mobility training should allow for possible weakening of the tendon so that tendon ruptures can be avoided in the course of training. Long-term followups after tenosynovectomy show good results, and the operation is considered to help prevent tendon rupture, although comparative studies with non-operated controls are lacking [13,31,43].

With ruptured tendons, there is loss of mobility in the affected finger. Ruptured extensor tendons on the back of the hand (caput ulnae syndrome) impair extension in the MCP joints of the fingers, and rupture of flexor tendons in the carpal tunnel

or in the finger impairs flexion. If the loss in mobility affects only the outer joints of the fingers or thumb (as in rupture of the deep flexor tendon or the long flexor tendon of the thumb), functional impairment may be compensated by arthrodesis of the affected joint to prevent hyperextension deformity and decreased pinching strength. If multiple flexor tendons or the extensor tendons on the back of the hand have ruptured, usually the tendons must be reconstructed. In most cases, the ruptured tendon cannot be anastomosed; rheumatic weakening of the tendon substance makes joining such a tendon unreliable. The tendon is usually replaced as a whole with a free tendon transplant or transfer of the insert from an adjacent tendon whose function is less important to overall hand function, ie, tendon transfer. Mobility usually improves after such reconstruction, but the normal range of motion is usually not regained [28,53].

Compression neuropathies

Compression neuropathies in RA patients generally reflect the presence of synovitis or tenosynovitis, which may cause pressure on adjacent nerve structures. A report concerning RA patients with severe peripheral involvement and subcutaneous nodules showed that some form of nerve entrapment was diagnosed in 45% of cases at some point during the course of disease [54]. Carpal tunnel syndrome is the most common compression neuropathy in RA patients, with a reported prevalence of 10% to 69% [6,19,20,41,42]. Carpal tunnel syndrome causes numbness and sensory impairment in several fingers of the hand with the exception of the little finger. In advanced cases it also weakens the opposition strength in the thumb. The disease profile is a direct consequence of tenosynovitis around the flexor tendons where they pass through the carpal tunnel. Considerably less common is compression of the median nerve at the elbow. Involvement of the motor trunk innervating the flexor muscles of the thumb and index finger (anterior interosseus nerve) has been reported in occasional cases [54,64]. The result can be a deterioration of the flexion capacity of the thumb and index finger.

Involvement of the ulnar nerve at the elbow has been reported in RA patients as a result of elbow synovitis [5,42,54,59,66]. This may result in numbness and sensory impairment in the ulnar fingers of the hand, and impaired grip strength and fine motor function in the hand, as a consequence of weakening the small muscles of the hand and the long flexor muscles of the little finger and ring finger.

The posterior interosseus nerve, the motor trunk of the radial nerve, may also come under pressure as a result of an elbow synovitis [21,33,44,50,65, 66,83]. This results in an inability to fully extend the fingers, usually most pronounced in the ulnar parts of the hand. The symptoms may easily be confused with extensor tendon ruptures.

Since a compression neuropathy in RA is usually a consequence of tenosynovitis or arthrosynovitis, treatment should be directed mainly at the primary disease. Local steroid treatment may have effects (usually temporary) on moderate symptoms. If sensory impairment and/or motor involvement is constant, tenosynovectomy or arthrosynovectomy should always be performed. Such procedures are usually quite effective in relieving pressure.

Rehabilitation

Rheumatic surgery in the hand requires specific resources for postoperative care. The rheumatic patient is sensitive to immobilization, both in general (bedrest, need for wheelchair, etc) and locally (cast, splints, dressings, etc). Surgery must be oriented toward methods requiring the shortest possible immobilization time. The postoperative inpatient treatment is usually longer than in other hand surgery, and requires care inputs from physical therapists, occupational therapists, and other nursing staff. Hence, more inpatient beds are needed for rheumatic surgery than for other types of hand surgery.

Operating on one or more joints in the hand/arm may often have negative secondary effects on surrounding joint systems. Casts or dressings on the hand may make it difficult to use assistive walking devices, or subject the remaining joints to greater stress. The shoulder joint is often affected by symptoms, resulting in a risk for impaired mobili-

ty and impaired arm function. Adequate physical therapy is essential to retain mobility.

Orthoses

Many hand surgery procedures place specific requirements on immobilization and postoperative exercise. The usual method of immobilization via a plaster cast is often unsuitable in the rheumatic patient due to the weight of the cast itself and the risk for unfavorable secondary effects on surrounding joint systems. Lighter plastic materials, ie, orthoses, are often used instead of plaster. These are usually designed individually in consultation with an occupational therapist familiar with rheumatic surgery. Orthoses are classified into:

Static orthoses

"Stiff" splints immobilize or maintain joints in a predetermined position. Can be used as an alternative to plaster for postoperative immobilization, or for long-term use (usually at night) to prevent malalignment.

Dynamic orthoses

Splints with flexible components to facilitate mobility training of the joint or relieve weight on structures close to the joint, used in association with postoperative exercise. The flexible components usually rely on elastic bands or steel springs to facilitate a range of motion for joint training. Dynamic orthoses using elastic bands are used regularly in arthroplasty, where the bands counteract the tendency for ulnar drift in postoperative mobility training and relieve stress on the extensor tendons, which are often reconstructed by arthroplasty. Dynamic orthoses are often used in association with tendon reconstruction to relieve stress on the tendon during mobility training. Special knowledge is needed by the occupational therapist and rheumatic surgeon to apply and check dynamic orthoses.

Functional training

Often the goal of reconstructive hand surgery is to increase the patient's hand function, and thereby his/her general functional level. A patient's ability to live independently is often related to hand function. Preoperative evaluation of hand function and adequate postoperative functional training are important aspects of care. Special methods for measuring hand function can be used, mainly when evaluating preoperative hand function as a part of establishing the indications for surgery [69].

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