The wrist

- Rheumatoid arthritis often causes symptoms in the wrist; pain and deformity affect the function of the entire hand and predispose deformity of the fingers.
- Preventive surgery, ie, synovectomy, joint stabilization, and resection of the ulnar head may decrease pain, correct deformity, and avoid tendon ruptures in the hand.
- If rheumatic disease has destroyed the wrist, total or partial arthrodesis (fusion) is an appropriate way to achieve stabilization and pain relief.
- Currently, there is no wrist endoprosthesis available which offers practical and reliable long-term results.
- The data in this chapter are based mainly on retrospective clinical and radiological studies in rheumatic patients.

Anatomy

The wrist is a complex, anatomic structure including multiple joints among the long bones of the forearm (radius and ulna) and the eight bones of the wrist (carpal bones). The wrist can be divided into three different joint systems:

Distal radioulnar joint (DRU joint). Together, the DRU joint and the proximal radioulnar joint of the elbow enable rotation of the forearm, ie, pronation (downward rotation) and supination (upward rotation) of the arm.

The radiocarpal joint. The actual wrist between the joint surface of the radius and the first row of carpal bones. Approximately half of the upward and downward mobility of the wrist takes place in this joint.

The intercarpal joints. The wrist (carpus) consists of eight carpal bones that articulate with each other, involving complex biomechanics. Approximately half of the upward and downward mobility of the wrist takes place in the joints between the first and second rows of carpal bones. The ability of the wrist to move sideways (radial-ulnar deviation) depends on the mobility in the intercarpal joints.

Introduction

Rheumatoid arthritis often affects the wrist, and it is not uncommon for the disease to manifest itself in this joint. Changes and disease symptoms are usually symmetric, ie, the right and left wrists are equally involved. An attack of rheumatoid arthritis includes early synovitis, which causes inflammatory symptoms involving swelling, pain, and stiffness. The connective tissue of the joints is affected, causing increased deformity. In the rheumatically altered wrist, the joints often slip out of place (subluxation) with palmar and ulnar displacement of the carpal bones in relation to the radius. The joint surfaces deteriorate with time, causing either ankylosis or instability [19,52]. Surgery in the rheumatic wrist focuses mainly on pain relief and stability, and prophylaxis of extensor tendon ruptures. Synovectomy, possibly in combination with resection of the ulnar caput, may be sufficient in many cases. Complete or partial arthrodesis of the wrist provides stability, but mobility is impaired or lost. A wrist prosthesis may appear to be the ideal solution, but a prosthetic device that meets all the necessary requirements has yet to be developed.

DRU joint

At the distal end of ulna is a cylindrical joint surface (ulnar head) which articulates with a lateral joint surface of the radius in rotation of the forearm. Several ligaments originate from ulnar head which are important to wrist stability. Rheumatic problems in the DRU joint cause pain on rotation and often impair rotation ability. For example, it

may be difficult to turn the palm of the hand upward so that objects can be placed in the hand. Eventually, the ligaments around the ulnar head are usually destroyed, with subluxation (dislocation of the joint) as a consequence. Subluxation makes forearm rotation even more difficult. Furthermore, dislocation of the ulnar head may negatively influence the adjacent extensor tendons of the fingers. In many cases, the ulnar head is totally destroyed, causing greater functional impairment, and a major risk for rupture of the finger extensor tendons, when sharp bone segments rub against the tendons. With time, the combination of cartilage destruction, ligament laxity, and synovitis may lead to caput ulnae syndrome, with rupture of the extensor tendons to the ring finger and little finger [5]. The syndrome is also characterized by weakness in the hand and wrist, painful and limited rotation of the forearm, an ulnar head with dorsal prominence, tenderness on palpation with painful crepitation during articulation against the radius, synovitis in association with the ulnocarpal extensor tendon and the ulnar extensors of the wrist, and rupture of one or more of the dorsal extensors of the wrist. Up to 30% of patients with rheumatoid arthritis are affected by caput ulnae syndrome [40].

Indications for surgery

The indication for surgical treatment of rheumatic problems in the DRU joint is local pain with limitation of rotation and/or threatening tendon rupture.

Caput ulnae resection

Surgical interventions directed at the ulnar caput mainly include partial or total resection of the caput, the so-called Darrach operation [42]. The procedure may be combined with different types of connective tissue reconstruction for stabilization. A method to cover the ulnar end with a silicone cup was attempted but has been abandoned or reserved for older patients [34]. Apart from basic arthroplastic adjustment of existing fascial and periostal structures, stabilizing procedures that have been suggested include tendon transfers or tenodeses based on ulnocarpal extensor or ulnocarpal flexor tendons [35].

Ulnar caput resection is a rewarding procedure which usually leads to significant reduction in pain and increased rotational ability in the forearm. Since the ulna can be seen as a stabilizing column structure for the mobility of the forearm and wrist, an ulnar caput resection is a procedure which could, however, have a negative impact on the strength and mobility of the forearm. Hence, ulnar caput resection is not an appropriate procedure for post-traumatic problems in the distal radioulnar joint, eg, radial fractures [2]. In rheumatoid arthritis, however, requirements on strength are limited, and the positive effects of the procedure generally exceed the negative. In cases with incipient lateral slippage of the carpus (ulnar translation), ulnar caput resection may accelerate this malalignment and should therefore be avoided or combined with stabilizing arthrodesis between the lunate bone and radius (see below).

Kapandji-Sauvé procedure

Following an ulnar head resection, there may be a risk for increasing ulnar translation of the carpus. One method of preventing such translation is the so-called Kapandji-Sauvé procedure. A cuff resection of the ulna is performed just proximal to the caput, after which arthrodesis is performed between the radius and ulna corresponding to the distal radioulnar joint. For this procedure to be meaningful, however, remaining joints should be free of radiocarpal and intercarpal changes, which is rare in rheumatoid arthritis. Some authors therefore believe that the procedure is of limited value in rheumatoid arthritis [39,49]. The method is mainly suited to post-traumatic arthrosis in the DRU joint or in primary osteoarthrosis in this joint. However, Taleisnik has shown promising results with Kapandji-Sauvé procedures in rheumatoid arthritis: 13 patients, with 16 operated wrists, followed for 69 (12–113) months reported total freedom from radioulnar pain in all cases [57].

Radiocarpal joint

Indications for surgery

The main indications for surgery in the wrist are pain, threatening tendon rupture, and a tendency for subluxation. At early stages, arthro/tenosynovectomy may be sufficient for achieving pain re-

lief, while partial or total arthrodesis is usually required in late stages when the problems are mainly due to joint destruction and/or malalignment of the wrist. At this stage, different types of endoprosthesis have also been tried, however, without any great success.

Arthro/synovectomy

At early stages (Stages 1-2), synovectomy of the wrist may be considered as a means to reduce disease symptoms, eg, swelling and pain. Usually the DRU joint, radiocarpal joint, and intercarpal joints are operated on concurrently, resulting in an extensive operation involving major intervention and a lengthy healing period. The technique for wrist synovectomy and tenosynovectomy has been well described in several textbooks [40]. Adolfsson and Nylander have described a method for wrist synovectomy via arthroscopy [1]. Arthroscopic synovectomy has been introduced as a means to decrease surgical trauma and shorten rehabilitation time [1,21,64]. Surgical results following synovectomy vary, usually the flexion-extension mobility of the wrist becomes worse, while the rotational ability usually improves, particularly if ulnar head resection or another intervention in the DRU joint is performed concurrently [3,4,35,58,59]. Long-term studies have shown rather good pain relief, even 8 to 12 years after the operation, while progressive rheumatic destruction of the joint does not seem to be affected by synovectomy [9,60]. Use of potent long-acting steroids in injection treatment of rheumatic synovitis has reduced the need for surgical synovectomy.

No comparative prospective studies could be found addressing the effects of wrist synovectomy. However, observations have been published which compared (in the same patient) the progression of bone destruction in a wrist where synovectomy was performed and the other wrist where it was not [28]. Progression was parallel on both sides. The study included 43 patients who had synovectomy on one side and also had ulnar head resection. Followup time was 11 (4–22) years. Total freedom from pain was achieved in 88% of cases, and "occasional mild pain and discomfort" in 12%. Wrist mobility remained unchanged after the procedure. Relapse of synovitis was noted in 9%. Brumfield et al followed up 78 RA patients with 102 synovectomies and ulnar head resections after 11 (3-20) years [12]. Pain decreased in 83% of the cases. On a VAS scale, the postoperative outcome concerning pain was 2, compared to 6 preoperatively. Wrist mobility remained unchanged or decreased somewhat after the procedure. In total, the results were graded as "excellent" in 50%, "good" in 42%, "fair" in 15%, and "poor" in 28% of the cases. Revision was required after an average 6 years in 27% of the cases due to recurring synovitis, tendon rupture, instability, or progressive radiological destruction of the wrist.

The prophylactic value of a tenosynovectomy is likely to be significant since inflammation of rheumatoid tissue in the extensor tendons may cause rupture. For the procedure to have a truly prophylactic effect, this should take place at an early stage, before ingrowth of rheumatoid tissue in the tendons becomes extensive. Brown and Brown performed a retrospective study on the effects of synovectomy in 173 wrists after 70 months (2-12 years), including both flexor tenosynovectomies and extensor tenosynovectomies, reporting 7/129 cases of relapse and 5 cases of tendon rupture, all on the extensor side [11].

An intercarpal joint which is usually not involved in routine dissection of the wrist is the pisiform-triquetral joint. This joint is often the site of rheumatic inflammation and/or destruction with local pain as a consequence. Selective synovectomy of this joint or excision of the pisiform bone is indicated in these cases [43].

Proximal carpectomy

In late stages (Stages 2–3), pain relief with some retained mobility may be achieved by removing destroyed joint components, eg the first carpal bone row so that a new joint function between the radius and the distal carpal bone row develops (proximal carpectomy). Interposition of soft tissue (interposition arthroplasty) which replaces the resected articular segments may, in some cases, improve stability and function after such a procedure [16,23].

Arthrodesis

Arthrodesis of the wrist is a safe, reliable, and efficient method which usually reduces pain and cor-

rects malalignment and instability of the wrist [15,26,30,31,33,38,47,63]. Stability and freedom from pain improves hand function and strengthens the grip. Bilateral wrist arthrodeses may also be compatible with good hand function. However, the general opinion is that some mobility in one of the wrists should be aimed for in bilateral wrist procedures [47].

Several surgical methods have been described. The method often used in Sweden is the one described by Mannerfelt and Malmsten, based on fixation of the wrist using a Rush pin inserted from the third metacarpal bone up into the radius [33]. A similar technique, based on insertion of a Steinmann pin, was described by Millender and Nalebuff in 1973. Using these methods, the wrist can be fused in a neutral position with slight ulnar deviation—a functionally beneficial position. Fixation using an AO plate offers greater freedom of choice concerning the alignment of the wrist, but the rheumatic patient's fragile bones and skin in combination with the rough osteosynthesis material, makes this method less suitable. In some cases, bone grafts from the iliac crest or "sliding grafts" from the radius have been combined in different types of osteosynthesis. In total arthrodesis of the wrist, the intercarpal joints should always be included [45,63].

Arthrodesis generally has good effects in terms of pain relief and improved hand function. In a study of 87 wrist arthrodeses examined after 6 years, "excellent" or "good" results were reported in 97% of the cases [30]. Pain was eliminated or nearly eliminated in all patients and 95% of the patients reported improved hand function. Complications may occur, particularly carpal tunnel syndrome, and especially in patients who preoperatively had a volar subluxation of the carpus. The frequency of carpal tunnel syndrome was reported as 5/87 in the Kobus and Turner data. Vicar and Burton conducted a retrospective followup of 33 wrist arthrodeses, on average followed for 82 months [61]. All patients reported reduced pain and most reported improved grip. The complication rate was 18%: three patients with carpal tunnel syndrome, two problems with the osteosynthesis material, and one case of hematoma and delayed healing.

Partial wrist arthrodesis

Arthrodesis between the radius and os lunatum is an established technique which has been in clinical use for more than a decade. The method may be indicated at an intermediary stage and is a way to prevent translocation of the wrist after a caput ulnae resection [17]. However, this operation has no effect on the progression of destructive changes in the wrist and often a total wrist arthrodesis is later required. The method may have good effects in terms of pain relief and improved hand function without concurrently necessitating total arthrodesis or arthroplasty. The operation does not always decrease mobility in the wrist—several series reported no differences in preoperative and postoperative mobility [53].

Arthrodesis between the radius and proximal carpal bone row, with maintenance of the joints between the proximal and distal carpal bone row, has been described as a useful method for instability, palmar subluxation, and wrist pain. After such procedures, wrist extension and flexion have been preserved at 70% and 54% of preoperative mobility, respectively, [27]. On followup after 3 (2-6) years, total freedom from pain was reported in 84% of the cases. Strength in the hand grip also improved considerably. In some cases of rheumatic destruction of the wrist, the intercarpal joints are affected more than the radiocarpal joint, and in such cases an isolated intercarpal joint arthrodesis may be indicated.

Endoprosthesis

Endoprosthetic surgery in the wrist is a controversial subject. This method, which was described as early as 1890, has enjoyed increased popularity during the past three decades [48]. The advantage of some degree of preserved mobility must be weighed against the possible disadvantages, eg, bone destruction, foreign body reaction, bone resorption, fracture of the implant. It is reasonable to prioritize freedom from pain and stability before mobility in rheumatoid arthritis, where demands on wrist mobility are limited. Although arthrodesis may be a beneficial procedure in rheumatic patients, bilateral arthrodeses are far from ideal. Therefore, when wrist involvement requires bilateral surgery, the need for a functioning wrist prosthesis must be recognized. Demands on mo-

bility in the wrist are, however, limited. A clinical biomechanical study has shown that most ADL activities can be carried out with a wrist capable of 30° extension, 5° flexion, 10° radial deviation, and 15° ulnar deviation [44].

Problems associated with wrist arthroplasties are usually attributed to three main factors: centering of the prosthesis on insertion, fixation of the prosthesis to the bone, and imbalance in surrounding soft tissue with a tendency for malalignment in the system [14].

Essentially, four different models for wrist prostheses have been presented: the Swanson silicone implant, the Volz prosthesis, the Meuli prosthesis, and the Tri-axial prosthesis.

Silicone implants

The Swanson silicone implants have been the dominate alternative for more than 20 years as concerns prosthetic surgery of the wrist [10,13, 20,24,29,32,41,50,54,56,61]. Initially, this prosthesis was received enthusiastically: the operation was relatively easy to perform; usually, the patients were free from pain quite rapidly; and some mobility seemed to remain. With time, however, several complications appeared, and seemed to increase with duration of observation time (Table 1). The maximum followup times shown in literature are around 6-8 years. Radiological changes such as bone resorption and subsidence were found in 70% to 100% of cases. This process is usually parallel to increasing stiffness. Fracture of the silicone material was found in up to 20% to 65% of cases. In some reports, mobility increased postoperatively, but several studies reported the same preoperative and postoperative mobility. After 5 to 6 years, maximum extension and flexion wrist mobility was reported to be 20° to 30°.

In 1974, more durable high performance silicone elastomer material was introduced, and in 1982, titanium grommets were introduced to protect the midsection of the implant from shear forces and sharp bone edges [48]. There are, however, no comparative long-term studies showing whether this modified technique improved results. Horlbeck and Thabe have shown bone resorption even around the grommets in two of eight cases followed for 18 months [25].

A serious complication is reactive synovitis, which has been observed after silicone arthroplasty of the wrist [46,51]. Problems may include extensive cyst formation within the carpus, involving bone destruction and infiltration of silicone particles.

In most cases, significant pain relief is reported. The current consensus, however, seems to be that a Swanson arthroplasty of the wrist should be avoided as far as possible: "our indications for this procedure have drastically narrowed", "we have narrowed our indications for silicone rubber wrist arthroplasty" [20]. Nevertheless, Lundkvist and Barfred are positive toward this type of procedure despite the reported complications [32].

Two-piece joint devices

The Swanson prosthesis should be viewed more as a "spacer" than as a true joint mechanism. However, approximately 20 years ago, different types of two-piece joint devices, based on a ball and socket joint, were introduced. Two such types, the Meuli and Volz prostheses, are put in place with two shafts in both the second and third metacarpal bones and one shaft in the radius.

The Volz prosthesis has been in use for over a decade, and Volz reports very good results including, eg, substantial pain relief (Table 1). In a comparative 3-year followup, no cases of loosening or infection were reported [62]. Other followups, however, reported bone resorption in the radius in 80% of the cases, but good results were nevertheless reported concerning freedom from pain [18]. Mobility is reported to be 30° to 40° regarding both extension and flexion [18,62].

The Volz prosthesis is cemented into place, but in some cases the metacarpal component may be attached without cement. The prosthesis is of "semi-constrained" type and is based on a convex metal ball in a polyethylene socket. In the first design, the distal component (inserted into the third metacarpal bone) was placed in a direct longitudinal line with the proximal component inserted into the radius. This resulted in an imbalance with a tendency toward ulnar deviation of the wrist. The reason is that the rotational center in lateral movement of the wrist is in the capitatum pole, ie, somewhat ulnar to the longitudinal axis of the radius. In later designs, this has been taken into account, and the results are better. Pain relief, gen-

erally, seems to be good, but the complication rates are high in most reports. Menon reports complications in 44% of cases [36]. In 33%, reoperation was required due to loosening, dislocation, or muscular imbalance.

The most recent design of the Meuli prosthesis is based on a completely spherical metal component articulating in a polyethylene cup. The prosthesis is intended to be attached to the bone, with or without cement. A recently published 4.5 year followup of the Meuli prosthesis reports very good results concerning pain relief and mobility. However, there are problems with occasional loosening of prosthetic components, which may require surgical revision (Table 1) [37]. Prosthetic loosening was noted in 11 of 49 cases. Summers and Hubbard compared the outcome of 6 Swanson prostheses and 6 Meuli prostheses [55]. The Meuli prostheses allowed somewhat better mobility, but the authors were still inclined to continue using the Swanson prostheses to avoid the need for cement fixation.

Beckenbaugh has presented an endoprosthesis with an ellipsoid ball designed to imitate normal joint function [6,7]. The prosthetic shafts have a porous surface so that cement is not required for healing of the prosthesis into the bone. Due to distal loosening problems, however, cement was usually used with the distal prosthetic components. Outcomes are not reported.

Another type of two-piece prosthesis, a so-called trispheric model, was introduced by Figgie et al [22]. This prosthesis, which is not cemented in place, is also based on a "ball and socket" construction involving a metal ball which articulates with a high-density polyethylene plastic surface. The articular head is fixed into position with a transverse axis. In a 9-year followup, very good results were shown concerning pain relief and hand function, but radiological zones around the shafts of the prostheses were noted in approximately 20% of the cases.

In summary, silicone implants are on their way out—the complications are all too obvious and the risks are too large. The future will show whether other types of wrist prostheses, cemented or uncemented, will become durable alternatives. Presently, the frequency of loosening is too high for such prostheses to be recommended in clinical use.

Arthrodesis or endoprosthesis?

Both arthrodesis and arthroplasty of the wrist have advantages and disadvantages. The advantages of arthrodesis include efficient pain relief and that it is relatively easy to perform. Most patients are willing to accept a loss in mobility in exchange for achieving freedom from pain. However, postoperative surveys have shown that the patients would have preferred to maintain some mobility in the wrist. Such mobility, usually within the range of 30° in both extension and flexion, can be achieved through arthroplasty. This surgical approach is, however, substantially more complicated, and the complication rates are very high regardless of what method is used. In the long run, the Swanson prosthesis has a high rate of complications including risk of silicone synovitis and increasing stiffness. The rate of loosening in cemented or uncemented multicomponent prostheses is high (Table 1).

In conclusion, the wrist prosthesis should be viewed as the most appropriate method in most cases where there is no specific requirement for wrist mobility. In cases where both wrists require intervention, and where synovectomy is insufficient, a prosthetic operation on one wrist may be considered.

A retrospective study by Vicar and Burton compared 33 wrist arthrodeses with 37 silicone arthroplasties [61]. Both groups were comparable in clinical outcome ("excellent" and "good"). The arthrodesis data showed no "failures", while in the arthroplasty data showed five "failures", four of which required surgical revision.

Biyani and Simison reported a method for fibrous stabilization of the rheumatoid wrist [8]. This method involves an ordinary resection of the cartilage in the radiocarpal and intercarpal joints, after which a fixation is achieved using crossed K-wires after slight traction has been applied to widen the radiocarpal joint space. Immobilization is maintained for 6 weeks, after which mobilization is initiated. Of 17 patients, followed for approximately 2 years (13 to 40 months), 4 were "excellent", 11 were "good", and 2 were "poor". The method is interesting, but has yet to be clinically tested.

Table 1. Prosthetic surgery of the wrist

Author	Implant	No. pts	No. joints	Follow-up (years)	Active mobility postop	Fracture/ dislocation of implant	Bone resorption	Other complications	Pain relief	Comments
Nylén et al 1984	Swanson	51	60	3 (1–5)	48°	7/60	14		pain ffree 3 pain free 19	
Summers & Hubbard 1984	Swanson (silicone)	6	6	2.5 (1.5–4)	ext 18° flex 11°	0		One case of ankylosis	"No pain: 5 slight pain:1"	
Brace et al 1986	Swanson (silicone)	61	71	6		20%	"subsidence of the prosthesis and collapse of the wrist in 100%"			"revision required in 16 cases" "we have narrowed our indications for wrist arthroplasty"
Vicar and Burton 1986	Swanson (silicone)	28	37	4.5	ext 29° flex 32°		"bone resorption in 14%" "settling in 11%"	"78% good or excellent results"		"Complication rate 25%" "Revision required in 4 cases"
Comstock et al 1988	Swanson (silicone)	19	20	6	ext 21° flex 24°	65%	"subsidence of the implant occurred 100% of the time"		"65% pain reduction"	"Revision surgery necessary in 30%."
Haloua et al 1989	Swanson (silicone)	52	62	5 (2–9)	43°	23%	"bone lysis around the implant, cortical erosion multiple cystic areas" in 13/62 cases	foreign body synovitis in 29%	"Pain, mobility and grip proved satisfying in 66% of the cases"	
Horlbeck & Thabe 1989	Swanson (silicone + grommets)	8	8	1.5 (1–2)		0	around proximal grommets in 2/8 cases	"Subsidence in one case"		
Fatti et al 1991	Swanson (silicone)	30	39	6	Postop = preop		100%		51%	"With increasing follow-up progressive deterioration of clinical results was noted" "Siliconesynovitis with cystic changes in 25%" "our indications for this procedure has drastically narrowed"
Jolly et al 1992	Swanson [silicone)	23	23	6 (0.5–13)	ext 6° flex 39°	52%	boneresorption >75%	"proximal settling of the prosthesis in 86%, distal settling in 82%	48% free of pain 17% mild 9% moderate 26% severe pain	revision frequency 30% silicone synovitis 30% "progressive clinical and radiological deterioration"

Stanley and Tolat 1993	Swanson (silicone)	38	50	8 (6–12)	ext 25° flex 31°	22%		"Carpal collapse in all cases"	"excellent sustained pain relief" mean score 1.7 (1–10; 1 = no pain)"	"98% entirely satisfied" "gross erosion, cysts and lysis rare, no case of true small particle synovitis found"
Lundkvist and Barfred 1992	Swanson (silicone)	18	19	5	39° (0–70°)	26%	"Severe subsidence in all patients followed up for more than 2 years"		"All but two were relieved of pain"	
Volz 1984	Volz	22	25	3 (0,5–6)	ext 36° flex 40°		"No cases of dislocation or clinical loosening have occurred"		Postop pain 1.2 (scale 1–5; 1 = no pain)	
Dennis et al 1986	Volz	23	30	6 (3–9)	ext 33° flex 34°		Loosening of the radial component in 79%, loosening of metacarpal-component in 24%		Pain relief in 86%	"60% good or excellent." "Complications occurred in 12 cases but affected the final outcome in only 3 cases"
Menon 1987	Volz modified (cemented)	16	18	3 (2–6)	8 exc. 1 good 2 fair 1 poor	Dislocation in 2	Loosening of the prosthesis in 2 cases		"all but one patient reported complete relief of pain"	Complication rate 44% (loosening, dislocation, muscular imbalance). Reoperation 33%
Summers & Hubbard 1984	Meuli (cemented)	5	6	4 (2–5)	ext 30° flex 27°		Radiological loosening in 1 case	Skin ulceration and removal of prosthesis in 1	"No pain: 4 slight pain:1 severe pain:1"	
Goth and Königsberger 1993	Meuli (uncemented)	11	13	3	≈100°	Dislocation in 2			50% completely pain free, 33% persistent mild pain	
Meuli and Fernandez 1995	Meuli ball-and-socket (uncem.)	44	49	5 (2–6)	ext 40° flex 30°		Loosening in 11/49 cases		Pain free in 38/49 cases	ADL-activities: 39/49 better 2/49 no change, 8/49 worse
Figgie et al 1990	trispherical, ball-and-socket, transverse axis	34	35	9 (5–11)	50°	–	Loosening in 7/35 cases	–	Pain free in 30/35 cases	"excellent" 20/35 "good" 8/35 "fair" 3/35 "poor" 2/35 "requiring revision (fusion) 2/35"

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