The foot

- Adapted shoes and orthoses can eliminate the need for surgery.
- Hindfoot arthrodeses give a high frequency of freedom from pain and may work preventively against development of the final stage of the destructed planovalgus rheumatic foot.
- Forefoot surgery involving resection of the MTP joints is the most common foot procedure, but the effects concerning the weight-bearing condition of the foot are insufficiently researched.
- Achieving satisfactory results in foot surgery requires subspecialization and special interest by the rheuma-orthopedic surgeon, corresponding to the specialization in the rheumatic hand by the hand surgeon.

The foot can be divided into the forefoot, midfoot, and hindfoot. The forefoot consists of toes and metatarsal bones and the hindfoot of the talus and the calcaneus. The medial edge of the foot is arched with the anterior base at the great toe (hallux) and the arch consisting of the first metatarsal bone, the internal, middle, and external cuneiform bones, the navicular bone, the talus, and with the posterior base at the calcaneus. This arch is stabilized, eg, by joint capsules, the lifting force of the posterior tibial tendon, and of the lateral edge of the foot consisting of the calcaneus, the cuboid bone, and the fifth metatarsal bone. The plantar fascia further stabilizes the arch. This complex of joints is affected in its entirety in rheumatoid arthritis, and hence the pathophysiological process cannot be described for isolated joints separately.

Problems in the forefoot are common in rheumatoid arthritis [20]. Initially, there is tender synovitis without malalignment. Later, the joints are affected by destruction and stretched capsules with subsequent instability. Changed balance between extensors, flexors, and intrinsic musculature, due to tenosynovitis, causes deformities. The great toe is drawn into valgus (hallux valgus), and the first metatarsal bone into varus with widening of the foot. The toes are pulled into valgus and dislocate dorsally. The proximal toe joints are pulled into flexion and contract into a hammer or claw toe position. The metatarsal heads are pressed down through the anterior pad, causing tender bursa formations and callosities in the skin. Forefoot pain may also cause functional hallux rigidus with hyperextension of the interphalangeal joint when the patient tries to unload the pad with the great toe [6].

The destructive process in the forefoot is affected by concurrent changes in the hindfoot and midfoot. Synovitis of the posterior tibial tendon may affect its lifting capacity. Concurrently, synovitis and destruction of the joints around the talus cause the heel to turn outward into a valgus position, and the anterior part of talus with the rest of the foot arch sinks down resulting in flat-foot deformity (pes planovalgus). The forefoot then twists outward, and the valgus pull of the toe tendons is strengthened, while further pressure is put on the great toe. The last phase of the step becomes more difficult and the affected individual is forced to walk in short steps. Comparative gait analysis indicates that the planovalgus malalignment is an effect of changed gait pattern due to forefoot and hindfoot pain and muscular weakness, but with an overactive posterior tibial muscle [28]. The end-stage is a dislocated heel with the malleoli pressed directly against the underlying surface or the heel bone. Other types of malalignment may also appear in the hindfoot and midfoot.

Scope of the problem

The prevalence of the onset of RA symptoms are the same for the hand and foot [20]. In a cross-sectional study of 99 non-hospitalized patients, 94% reported foot pain [38]. 42% considered the ankle joint the most painful, while 28% had most

pain in the forefoot. Few stated most pain from the hindfoot and midfoot, although 20% had limited movement and pain when testing the subtalar joints. 35% had significant hallux valgus and 43% had hammer toes, of which more than half had fixed and dislocated MTP joints. Flat-footedness was observed in 64% of the cases. The percentage with foot pain increased with duration of the disease. A similar study including 100 patients noted equal distribution between forefoot and hindfoot pain (60% each), hallux valgus in 65%, malalignment of the toe in 60%, hammer toes in 55% (of which more than half were fixated), and prominent tender articular heads in 26%. 15% were using orthopedic shoes [30].

Indications and surgical methods

Many rheumatic foot problems can be solved with adapted shoes with or without different kinds of insoles. Some patients with ankle joint and hindfoot pain manage well with a stiff ankle joint cap. Local steroid injections may also provide relief, especially of tenosynovitis.

The most important indication for surgery is pain on weight bearing, which threatens walking ability. However, there is also a preventive indication, partly to avoid progressive malalignment and partly to avoid wound formation. Pressure from shoes can cause troublesome wounds, and the importance of careful foot hygiene in rheumatic patients cannot be emphasized enough. Infections in such pressure sores may be a cause underlying late, hematogenously-spread prosthetic infections, mainly to the knee joint. Hence, it is always wise to try to provide rheumatic patients with a foot free from infection and weight-bearing pain, prior to proceeding to prosthetic surgery in the knee or hip. It is also recommended that forefoot problems are managed prior to or concurrently with the ankle joint.

Surgical treatment of forefoot problems includes everything from bursectomy, chiseling of exostoses, hallux valgus procedures, arthrodeses, joint resections, and osteotomies, to forefoot amputation.

If the patient does not experience relief of foot problems by orthoses or specially manufactured shoes, or if the malalignment progresses, surgical treatment can be considered. Since valgus malalignment of the hindfoot creates secondary weight-bearing problems in the forefoot, as a rule, the hindfoot should be treated before performing forefoot surgery [50]. Since arthritis in the talonavicular joint is a common and early finding in RA, isolated arthrodesis in this joint can be used to prevent development of pes planovalgus [7,32]. An isolated talonavicular arthrodesis is shown to limit mobility even in the remaining two hindfoot joints [4]. Pain from the hindfoot joints may cause symptoms which are perceived as originating from the ankle joint. Joint destruction, with a reduction in joint space, is easy to detect radiographically in the talonavicular and calcaneocuboid joints, but much more difficult in the talocalcanear joint. If the heel is already in a valgus position or if pain originates mainly in the talocalcanear joint, a complete triple arthrodesis should be considered, involving the joints between talus and the heel bone, between the talus and the navicular bone, and between the heel bone and the cuboid bone. In patients having major malalignment, corrective talocalcaneal arthrodesis must be performed by removing a wedge of bone during the procedure. Arthrodesis of the hindfoot and midfoot are often performed with transplantation of iliac crest bone. Hence, hindfoot and midfoot arthrodeses are both therapeutic and prophylactic.

There are a number of forefoot operations described for use when conservative treatment fails. The operations aim at alleviating pain and improving walking capacity, but there are often competing symptoms from other joints, which makes assessing the effects of the procedure difficult. No classification of forefoot changes is available, making it difficult to compare different surgical methods. Two main types of surgical methods exist, joint preserving metatarsal osteotomies according to Helal and Wolf [22,52], and joint resections, eg, according to Hoffman, Fowler, Clayton, and Kates et al [5,15,24,27], possibly in combination with arthrodesis of the great toe [11]. Toe amputation has been described by Flint & Sweetman [14].

Joint resections can be performed completely or partially involving one of the metatarsal articular heads or the toe base, and the joints can be reached via dorsal or plantar incisions. These procedures

Table 1. Outcome of arthrodesis in the midfoot and hindfoot

Author	n	Outcome (%)	Healed (%)	Complications (%)	Progress (%)
Talonavicular joint arthrodesis					
Elboar et al. 1976	26	85 improved	?	19 (reoperated)	0 subtalar, 4 ankle joints (arhrod.)
Ruff & Turner 1984	10	70 good	70	0	?
Ljung et al. 1992 [a]	19	89 good	63	0	32 slight subtalar
Thorén et al. 1993 [b]	4	75 improved	0	25 (wound probl.)	
Talocalcanear arthrodesis					
Russoti et al. 1988	45 (2 RA)	90 satisfied	98	2 (infection)	0
Calcaneocuboidal arthrodesis					
Ruff & Turner 1984	2	100 good	100	0	?
Triplearthrodesis					
Ruff & Turner 1984)	8	88 good	88	0	?
Figgie et al. 1989	49	86 good	96	12 (wound probl.)	8 ankle joints (arthrod./prosthesis)
Cracchiolo et al. 1990 [a]	24	88 satisfied	100	21 (wound probl.)	12 ankle joint (arthrodesis) 4 valgus heel

[a] Dowel technique
[b] Dowel technique with defatted allograft with bone marrow injection

have been modified by several authors and completed with volar plate arthroplasty, flexor tendon centralization, and medial capsuloraphy. Several corrective hallux valgus procedures are described, but the methods mainly used in RA include debasing according to Keller (with or without capsuloplasty) [29], metatarsal head resection, arthrodesis, metatarsal osteotomy, or implantation of silicone prostheses [22].

Forefoot surgery belongs to the most common rheumatic surgical procedures. Although the results are reported to be rather satisfactory, the foot becomes shorter, and the toes are functionally detached which in turn affects walking ability [44,49]. There is also a risk of relapse of hallux valgus due to poor lateral support from the other toes, which may be an argument for arthrodesis in the metatarsophalangeal joint of the great toe [3].

Rehabilitation

Midfoot and hindfoot arthrodeses often require long-term cast fixation and no weight bearing, which makes rapid gait rehabilitation impossible. The risk of wound infection is not negligible, neither the risk for new pressure sores under the cast. This often results in long episodes of care, and extended healing times cause long-term functional impairments. Upper extremities that permit the patient to carry weight without excessive pain are also necessary for the patient to keep weight off of the foot postoperatively.

Adapted shoes are often required after corrective surgery, and good collaboration with an orthopedic shoemaker is important for achieving optimal results from foot surgery.

The postoperative course after forefoot surgery is usually uncomplicated, apart from the risk of disturbed wound healing. Postoperatively, patients can put weight on the foot as soon as the pain allows. In osteotomy of the metatarsal bones, a successful surgical outcome requires that patients put weight on the foot for the metatarsal heads to slide dorsally.

Surgical treatment results

Arthrodesis of the hind- and midfoot

The effect of arthrodesis on hindfoot pain is good, regardless whether or not radiographs show the arthrodesis to be healed, ie, fibrous healing appears to be sufficient for relieving pain [32]. Painful, unhealed arthrodesis requiring reoperation is unusual (Table 1). Bone transplantation can be performed by simply using the dowel technique, which works well if autologous bone is used. The fixation method per se (staple, screw, or pin) is of less importance. Progression of ankle joint pain does occur, and seems to be correlated to persistent val-

Table 2. Outcomes in forefoot surgery

Author	n	Age	FU	Good (%)	Pain free (%)	Bone healed (%)	Complications (%)	Reop. (%)
Metatarsal osteotomy (Helal)								
Helal 1975 (47% RA)	47	48	>2	?	?	98	Infection 2, pseudoarthrosis 2, stiffness 8	13
Helal & Greiss 1984 (22% RA)	508	55	4	88	88	84	Wound problems 16, callosities 0	12
Åström & Cedell 1987 [a]	38	58	4	95	–	100	Wound problems 21	–
Metatarsal head resection 1–5								
Beauchamp et al. 1984	30	52	4	–	53	–	Infection 10, callosities 23	13
Gainor et al. 1988	35	58	2	80	71	–	Relapse of malalignment 23, wound problems 10	0
Stockley et al. 1989	60	57	3	91	70	–	Infection 5, valgus 73, callosities 10	–
Hughes et al. 1991	34	60	5	71	85	–	Infection 6, callosities 9	9
vd Heijden et al. 1992	74	61	5	93	–	–	Weak great toe68,	22
Loon et al. 1992	61	–	8	94	92	–	Wound problems 1,	10
Nakamura et al. 1993 [b]	19	–	5	100	–	–	–	–
Patsalis et al. 1996	23	60	11	44	–	–	Callosities 61, toe malalignment 72	26
Metatarsal joint resection 2–5 with debasing of first metatarsal joint								
Goldie et al. 1983)	59	54	5	66	66	–	Wound problems 8, callosities 36	–
McGarvey & Johnson 1988	49	55	5	82	–	–	Valgusrecidiv 51, metatarsalgia 20	4
Loon et al. 1992 [c]	47	–	7	88	88	–	Wound problems 12,	2
Metatarsal head resection 2–5 with arthrodesis of first metatarsal joint (Dwyer)								
Beauchamp et al. 1984 [d]	34	54	2	–	53	85	Infection 21, callosities 32	3
Hughes et al. 1991	34	56	4	71	94	66	Wound problems 18, arthrodesis probl. 26	32
Mann & Schakel 1995 [e]	28	51	4	95	90	96	Callosities 25	0
Debasing 2–5								
Newman&Fitton 1983 [f]	130	53	4	91	88	86	Infection 2	4
Saltzman et al. 1993 [g]	12	57	8	63	63	–	Wound problems 0, late metatarsalgia 82	9
Forefoot amputation								
Flint&Sweetnam (1960)	22	51	8	83	–	–	–	–
Andersen & Klåborg (1987)	8	54	7	75	83	–	Wound problems 25	0
Arthrodesis of metatarsal joint 1								
Mann & Oates 1980	41	–	3	85	–	95	–	–
Mann&Thompson 1984 [h]	18	59	4	89	–	94	Pain-free IP-jiont degeneration 61	–
Prosthesis in metatarsal joint 1								
Cracchiolo et al. 1981	133	–	>1.5	100	100	–	Infection 2	2
Kampner 1984 [i]	29	52	8	51	62	–	Prosthetic fracture (old type) 21	7
Cracchiolo et al. 1992	49	50	6	84	76	–	Prosthetic fracture 10, other 8	8
Moeckel et al. 1992	67	56	6	87	–	–	Wound problems 4, infection 3, prosthetic fracture 3	10

[a] proximal MT I osteotomy with, eg, in 28 cases metatarsal head resection and debasing in 18 according to Keller
[b] complete metatarsal joint resection
[c] no debasing without metatarsal head reduction
[d] great toe arthrodesis using screw
[e] great toe arthrodesis using rod. In 12 toe joint resection with bandage, in 16 metatarsal head resection and rod, same result
[f] with great toe arthrodesis
[g] with various procedures to the first MTP joint
[h] in 12 cases with debasing of toes 2-5
[i] 16 cases combined with Clayton toe arthroplasty with especially poor outcome and prosthetic fracture due to poor support for the great toe by the small toes

gus malalignment of the hindfoot and midfoot [13].

Forefoot

Clinical results after forefoot surgery are presented in Table 2. When the MTP joints of the toes are relatively well preserved, osteotomy of the meta-

tarsal bones may be a good alternative [21,22]. Most surgical methods, however, involve resection of the MTP joints. These procedures yield clinical improvement in approximately 80% to 90% of the cases. Walking distance improves and it is easier to fit shoes [2,17,35,49]. The early gains in function and pain relief, however, seem to decline with longer observation times [19,44]. Callosities occur under unevenly and insufficiently shortened metatarsal bones, and also osteophytes may be formed causing the same result. Several authors have noted that resection of individual metatarsal joints, without exception, result in failure and require reoperation. Attempts at toe debasing alone, do not prevent development of metatarsalgia [48]. Isolated resection of the MTP joints of the small toes creates a risk for later problems in the first MTP joint, due to poor lateral support, even if the great toe appears to be unaffected at the time of surgery [18].

A comparative study shows a high frequency of relapse of metatarsalgia after forefoot arthroplasty, and similar results by conservative treatment with orthopedic technical devices, eg, shoe insoles [10]. This retrospective study is, however, also lacking a clear classification of the treated forefoot. What is needed in the future is both randomized prospective studies to compare different surgical methods and longer followup times after forefoot surgery [19,44].

The literature offers no clear answers regarding the optimum method for treating rheumatic hallux valgus. A retrospective study shows similar results with and without arthrodesis of the great toe [25]. However, results after great toe arthrodesis vary more and are poorest in fibrous healing of the arthrodesis.

Resection of the first MTP joint offers pain relief, but poor function of the great toe, decreased ability to bear weight on the medial forefoot, poorer balance, and a significant risk of hallux valgus relapse with the risk for lateralization of the small toes [2,3,37,44]. In this respect, arthrodesis seems preferable [19,36]. A disadvantage of arthrodesis is the increased risk for interphalangeal joint destruction, either by peroperative trauma of axial pins or later by increased pressure as the foot concludes the stepping motion [2,34].

Several methods have been described for achieving great toe arthrodesis. Screws or crossed pins yield healing in more than 90% of cases. Resorbable pins do not offer any advantages [43].

Comparing the methods is difficult since it has not been possible to compare the data directly, and assessment is subjective. Recently, however, studies have been presented where clinical results are supported by measurements of footsole pressure and gait analyses [49]. Philipson et al unexpectedly found in measuring the pressure under the forefoot, that forefoot arthroplasty increased the maximum pressure but redistributed it from the middle to the side of the great toe and little toe [45]. Dynamic pressure measurements are, however, difficult to evaluate since patients adapt their gait to avoid pain [49]. When patients stand, there is much better correspondence between pain and local increases in pressure [39].

Prosthetic surgery of the first MTP joint remains rather poorly researched, but American studies have shown good results with silicone prostheses [8,9,40]. However, another study shows that some silicone implants fracture, and that prosthetic surgery of the great toe did not work well in conjunction with concurrent small toe resection due to a loss of lateral support for the great toe [26]. Experience with silicone implants is substantially greater in arthrosis and non-rheumatic hallux valgus. Here, it has been found that especially hemiarthroplasty, where the implant articulates with bone, causes wear which in turn causes synovitis and bone resorption [31].

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