Rheumatoid Arthritis of the Foot and Ankle

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Abstract

Rheumatoid arthritis of the foot and ankle can be a debilitating problem, particularly for patients who have undergone successful hip or knee arthroplasty. Optimal medical management, use of orthotic devices, and surgical intervention are essential components of patient care. Forefoot involvement with hallux valgus and lesser metatarsophalangeal joint subluxation and dislocation are the most common findings. Reconstruction usually requires lesser metatarsophalangeal joint excisional arthroplasty and first metatarsophalangeal joint arthrodesis. Midfoot tarsometatarsal and intertarsal involvement is treated with orthotic devices and intertarsal fusion for advanced arthropathy. Hindfoot involvement frequently leads to pes planovalgus deformity, which may require isolated talonavicular arthrodesis if treated early or triple arthrodesis for advanced destruction. Ankle involvement is less frequent; when it is unresponsive to conservative measures, ankle symptoms may be improved by arthrodesis. Although great advances have been made in medical and surgical management of rheumatoid arthritis, the disease remains a serious problem. Through prudent use of medical management, orthotic devices, and other conservative measures as well as surgical intervention, long-term function can be enhanced greatly.

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Rheumatoid arthritis is a chronic, unrelenting progressive condition that affects the musculoskeletal system and also has generalized systemic manifestations. The articular changes include synovitis, ligamentous and capsular laxity, cartilage destruction, and osseous erosion. The extra-articular abnormalities are primarily the result of vasculitis and include rheumatoid nodules, digital ischemia, skin ulceration, pleuritis, pericarditis, neuropathy, lymphadenopathy, and splenomegaly.

The pathogenesis of rheumatoid arthritis is believed to be mediated through the immune system and is related to genetic predispositions, an inflammatory cascade, the formation of antigen-antibody complexes, and the release of proteolytic enzymes, which leads to vasculitis, synovitis, and cartilage destruction.[1] The foot and ankle are a common site of involvement.

This article reviews current concepts in the management of foot and ankle disorders in patients with rheumatoid arthritis, focusing on foot and ankle biomechanics, conservative treatment modalities, surgical options, and the management problems introduced by vasculitis and disordered soft-tissue healing.

General Considerations

Vasculitis

The vasculitis of rheumatoid arthritis is frequently associated with skin ulceration, digital ischemia, rheumatoid nodules, and mononeuritis multiplex.[1] Rheumatoid nodules occur on extensor surfaces and the Achilles tendon below the dermis. Mononeuritis multiplex affects the peripheral nerves and results in motor, sensory, or mixed neuropathies.

Conservative treatment of the complications of vasculitis in the foot and ankle depends on the severity of involvement. The skin must be monitored closely for potential areas of breakdown. Ulceration and neurologic deficits are best treated by the use of protective footwear and orthotics and by appropriate wound care. Education of the patient with rheumatoid arthritis includes practices frequently taught to patients with diabetes. Excessive heat or cold should be avoided when prescribing physical therapy modalities. Digital ischemia and dry gangrene from rheumatoid vasculitis usually result in clear demarcation of tissue viability and autoamputation (Fig. 1).

Soft Tissues

Wound healing is a major concern in the surgical treatment of the patient with rheumatoid arthritis. Soft-tissue handling and skin retrac-

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Fig. 1 Digital gangrene due to rheumatoid vasculitis is seen at the distal tip of the second toe and in the entire distal portion of the third toe.

tion should not be excessive or prolonged. Skin flaps should be kept as thick as possible, with care taken to avoid tension during closure of the wound. One must be cognizant that the vasculitis associated with rheumatoid arthritis negatively affects tissue oxygenation, resulting in the potential for poor wound healing and infection. Dressings and casts need to be monitored carefully to avoid constriction or pressure.

The anti-inflammatory and chemotherapeutic agents used to control rheumatoid arthritis may also adversely affect wound healing. No consensus exists as to whether to discontinue these agents in the perioperative period. Some authors[2] suggest that methotrexate, in particular, be avoided for 2 weeks before and for a variable period after a surgical procedure.

Foot and Ankle Biomechanics

It has been reported[3] that 89% of patients with rheumatoid arthritis have problems with their feet. Synovitis predominates in the early stage of the disease, whereas bone deformities increase in frequency and magnitude as the disease becomes chronic. The forefoot tends to be the area most frequently involved.

Flattening of the longitudinal arch occurs in about 50% of patients and is associated with valgus deformity of the hindfoot and alterations in gait.[1] This deformity is probably caused by attenuation and destruction of soft tissues, particularly the subtalar joint capsule and interosseous ligament. Collapse of the arch is compensated for during gait by increased external rotation.[4] The combination of hindfoot valgus and external rotation leads to contracture of the Achilles tendon. The windlass mechanism of the plantar fascia and metatarsophalangeal joints is lost, potentiating the inability to stabilize the arch during toe rise. This leads to delay in heel rise, shortened step length, and decreased velocity while walking. Electromyographic studies have shown increased activity of the posterior tibial tendon, which is interpreted as an effort to stabilize the arch.[4] This may explain the predilection for involvement of the posterior tibial tendon in rheumatoid arthritis.

Conservative Treatment

The principles of conservative treatment of pathologic conditions of the foot and ankle in rheumatoid arthritis are patient education, relief of pain, accommodation or prevention of deformity, and improvement of function. Like patients with diabetes, patients with rheumatoid arthritis need to be instructed regarding the importance of visually inspecting the feet to monitor skin conditions as well as to identify any sign of progressive deformity. Optimal medical management by the rheumatologist will help minimize synovitis and pain.

Shoes with extra depth in the toe box in conjunction with a soft, accommodative orthotic device provide support of the arch and protection of skin over bone prominences. Excessive hindfoot valgus accompanied by shoe breakdown in the

medial arch and heel counter can be managed with a rigid medial heel counter constructed by a pedorthist. Occasionally, a severe deformity may require a polypropylene ankle-foot orthosis for control. Canes and crutches are useful ambulatory aids, but platforms may be necessary to protect the hand or wrist involved with rheumatoid arthritis from increased weight-bearing.

Exercises should be performed regularly to stretch the Achilles tendon and to maintain range of motion of the hindfoot and metatarsophalangeal joints. Toe-curl exercises are performed by placing a towel flat on the floor and attempting to wrinkle the towel by the repeated action of curling the toes. This maintains intrinsic muscle function. A book or other weighted object placed on one end of the towel adds resistance to this exercise.

Local injection of a corticosteroid agent into a joint or tendon sheath can resolve an acute inflammation. However, it must be remembered that an isolated, inflamed painful joint out of proportion to other joints may reflect infection rather than a flare-up of rheumatoid arthritis. Potential complications of a steroid injection into a tendon sheath are weakening and possible rupture of the tendon.

Forefoot

The forefoot is the area of the foot that is the most frequently involved with rheumatoid foot disease and the most readily apparent to clinical examination. Rheumatoid arthritis initiates a synovitis involving the metatarsophalangeal joints that, in the earliest stage, may be treated by rest, taping, shoe modifications, use of an orthotic device, or injections of a corticosteroid agent. Chronic synovitis leads to capsular distention, attrition of the collateral ligaments, and volar-plate laxity. These changes permit dorsal subluxation and dislo-

cation of the metatarsophalangeal joints. Contracture of the intrinsic musculature exacerbates the clawtoe deformity. The plantar fat pad follows the toes and migrates distally and becomes progressively atrophic. The metatarsal heads are functionally forced plantarward, leading to intractable plantar keratoses that may ulcerate if the deformity is severe, particularly in patients with significant vasculitis (Fig. 2).

The great toe most commonly demonstrates progressive valgus deformity as the metatarsophalangeal capsular restraints are damaged and the lesser toes cease to function as lateral stabilizers. Hallux varus occurs less frequently. Deformity of the hallux shifts weight-bearing laterally to the lesser metatarsals, exacerbating metatarsalgia. A hyperextension deformity may develop in the hallux interphalangeal joint.

Surgical management of the painful forefoot in rheumatoid arthritis may be treated by synovectomy in the early inflammatory stage, while forefoot reconstruction is indicated for progressive joint destruction and deformity. Forefoot reconstruction involves a resectional arthroplasty of the lesser metatarsophalangeal joints and either implant arthroplasty or arthrodesis of the hallux metatarsophalangeal

joint. Historically, resectional arthroplasty of the hallux metatarsophalangeal joint was recommended. This procedure has largely been abandoned because of long-term poor results.[5,6] This includes the potential complications of a cock-up deformity of the great toe and lesser metatarsalgia.

Whether to approach the lesser metatarsophalangeal joints through a transverse plantar incision,[7] two longitudinal dorsal incisions in the second and fourth interspaces,[8] or a combination thereof[9] is controversial. The advantages of the plantar approach include the proximity of the metatarsal heads to the incision and the ability to excise an ellipse of skin, effectively repositioning the toes and the plantar fat pad. Proponents of the dorsal approach argue that there is less risk of damage to the plantar neurovascular bundles and the development of a painful plantar scar. Whichever approach is taken, an effort should be made to preserve the base of the proximal phalanx to improve stability of the lesser metatarsophalangeal joints. However, dislocation and advanced joint destruction often necessitate resection of both sides of the lesser metatarsophalangeal joints.

Silicone implant arthroplasty of the rheumatoid hallux metatar-

sophalangeal joint has the advantage of preserving motion.[10,11] However, complications of silicone implants, such as residual pain, recurrent deformity, plantar-flexion weakness of the great toe, lateral metatarsalgia, silicone synovitis, and progressive osteolysis, have led to the current trend of performing first metatarsophalangeal joint arthrodesis.[5,6,12] This procedure provides a stable first ray for push-off, decreases stress at the lesser metatarsophalangeal joints, and does not carry the potential of deterioration with time.

Synovectomy

Early synovectomy of the metatarsophalangeal joints in the patient with recalcitrant synovial proliferation may lessen or prevent destructive changes in the soft tissues and joints. This operation is performed through three dorsal longitudinal incisions over the first metatarsophalangeal joint, second interspace, and fourth interspace. Dissection just medial or lateral to the extensor tendons, longitudinally dividing the hood mechanism, permits entry to the joint capsule, collateral ligaments, and synovial tissue. The synovial tissue is excised sharply with a rongeur, ensuring complete debridement beneath the collateral ligaments and in the plantar portion of the joint. Postoperatively, a light compressive dressing is applied, and a stiff-soled, Velcro-strap postoperative shoe is worn for 2 weeks.

Reconstruction

The procedure preferred by the authors entails arthrodesis of the first metatarsophalangeal joint, resection of the second through fifth metatarsal heads, and often closed osteoclasis of proximal interphalangeal joint contractures. Three dorsal longitudinal incisions are used, as described for synovectomy.

Fig. 2 One year after forefoot reconstruction of the right foot, plantar keratoses have healed. The left foot has not been operated on and displays the characteristic hallux valgus, clawtoes, and plantar keratoses beneath the second and third metatarsal heads.

The second and fourth interspace incisions often require a Y-type extension distally along the sides of the proximal phalanges for adequate exposure without excessive skin tension in the web space (Fig. 3). The metatarsophalangeal joints are exposed by longitudinally dividing the extensor hood mechanism.

Adequate decompression of the lesser metatarsophalangeal joints with advanced deformity often requires extensor brevis tenotomy (the fifth toe has no extensor brevis tendon), extensor longus tendon Z-lengthening, and resection of the base of the proximal phalanx. The metatarsal head is resected to include the plantar condyles. It is critical that the line of resection of the metatarsal heads form a gentle slope from medial to lateral.

The hallux metatarsophalangeal joint is prepared for a cone-in-cup arthrodesis using hand-held or powered conical reamers. The hallux is

Fig. 3 Recommended dorsal incisions over the first metatarsophalangeal joint and second and fourth interspaces. When the deformities of the toes are severe, exposure of the second through fourth metatarsophalangeal joints may be facilitated by distal extension of the incisions along the sides of the proximal phalanges (dotted lines).

positioned with neutral rotation, approximately 15 degrees valgus, and 20 to 25 degrees of dorsiflexion in relation to the first metatarsal. The lesser toes are aligned and stabilized with 0.045-inch or 0.054-inch wires before fixation of the first metatarsophalangeal joint. The pins are driven from proximal to distal, starting at the base of the proximal phalanx. To accomplish this, the toe must be excessively plantar-flexed, and the interphalangeal joints must be maintained in neutral position. We prefer fixation of the hallux arthrodesis site with a dorsal six-hole Luhr mandibular plate (Howmedica, Rutherford, NJ). Threaded Steinmann pins violate the hallux interphalangeal joint, and crossed screws often achieve less than ideal fixation in osteopenic rheumatoid bone.

Postoperatively, a stiff-soled, Velcro-strap postoperative shoe is worn for about 3 months, with partial weight-bearing the first 6 weeks and full weight-bearing thereafter. The pins are removed 4 to 6 weeks after surgery.

Midfoot

The tarsometatarsal and intertarsal joints are less frequently involved with rheumatoid arthritis (Fig. 4). The first metatarsocuneiform joint is the most likely of these joints to be affected by instability. Orthotic devices may provide support and relieve symptoms. These devices are usually custom-molded, soft, and accommodative to rheumatoid arthritic deformities. However, arthrodesis of the involved joints may be necessary if clinical symptoms and radiographic changes warrant surgical intervention.

Arthrodesis is accomplished through a dorsal longitudinal incision. Preparation of the joint can be by standard planar resection or a cylindrical dowel technique.[13] Bone

graft should be considered if erosion or cyst formation is present. We prefer fixation of an isolated first metatarsocuneiform arthrodesis with a dorsal four-hole Luhr mandibular plate (Howmedica). Most intertarsal arthrodeses are more suitable for fixation with 3.5-mm or 4.5-mm cannulated screws.

Hindfoot

The talonavicular, calcaneocuboid, and talocalcaneal joints are intimately related in the functional anatomy of the hindfoot. Any motion or deformity of the subtalar joint requires accommodating changes of the talonavicular and calcaneocuboid joints, and vice versa. Because the rheumatoid process causes destruction of soft-tissue support structures, the subtalar joint deviates into valgus angulation. The talar head drops into plantar flexion without the support of the calcaneus, and the navicular subluxates laterally. The result is a pes planovalgus deformity with forefoot abduction. It is important to include an anteroposterior weight-bearing view of the ankle in the radiographic evaluation to confirm that the ankle is not contributing to the valgus deformity.

Initially, this deformity may be supple and correctable by a custom orthotic device or an ankle-foot orthotic brace. Eventually, however, the hindfoot may become fixed, and triple arthrodesis will be necessary to reposition and stabilize the joints (Fig. 5). Triple arthrodesis in the patient with rheumatoid arthritis has been successful in terms of functional improvement, relief of pain, and fusion rates.[14]

Occasionally, isolated involvement of the talonavicular joint will occur without deformity. Formation of cysts and joint destruction can sometimes be extensive. In these circumstances, isolated talonavicular

A

B

Fig. 4 Radiographs of a patient with rheumatoid arthritis of the midfoot. **A,** Anteroposterior projection shows rheumatoid arthritis of multiple tarsometatarsal and intertarsal joints. **B,** Oblique projection shows significant articular changes in the cuneiform joints.

joint arthrodesis has been recommended.[15] However, progression of arthritic destruction in adjacent joints is possible. We have found single photon emission computed tomographic (SPECT) bone scanning useful before proceeding with talonavicular joint arthrodesis.[16]

The three-dimensional images provided by SPECT scanning allow improved definition and localization of an inflammatory process. The absence of uptake at the calcaneocuboid and subtalar joints indicates that these joints are not significantly involved with rheu-

matoid arthritis. Some authors[6] advocate double arthrodesis of the talonavicular and calcaneocuboid joints in the younger, more active patient with rheumatoid arthritis.

Talonavicular Arthrodesis

The talonavicular joint is exposed through a dorsomedial incision, retracting the saphenous vein and nerve. A spoon-shaped instrument helps to open the joint. The articular surfaces are removed with an osteotome, a curette, and a burr. The joint is reduced with the hindfoot aligned in 5 degrees of valgus angulation. We prefer fixation with two 4.5-mm cannulated screws placed from the navicular into the talus. Removal of a 1.0×1.0-cm piece of bone from the medial aspect of the medial cuneiform at the naviculo-cuneiform joint permits more lateral placement of the screws at the entry point of the navicular. This is performed with a ¼-inch curved osteotome. This maneuver achieves more perpendicular orientation of fixation with the talonavicular fusion surfaces. When necessary, a bone graft is obtained from the iliac crest or the medial distal tibia.[17] Postoperatively, the patient is kept non-weight-bearing in a short leg cast for 6 weeks. This regimen is followed by 6 weeks of partial weight-bearing in a removable cast boot and range-of-motion exercises.

Triple Arthrodesis

Talonavicular joint arthrodesis is performed as previously described. The calcaneocuboid and subtalar joints are exposed through a lateral incision with elevation of the origin of the belly of the extensor digitorum brevis muscle. The sinus tarsi is cleared of soft tissue. A laminar spreader is used to open the subtalar joint, and the articular surfaces of the posterior and middle facets, as well as the calcaneocuboid joint, are removed

A

B

Fig. 5 Radiographs of a patient with rheumatoid arthritis of the hindfoot. **A,** Anteroposterior weight-bearing projection. **B,** Lateral weight-bearing projection shows that the talonavicular joint is involved more than the subtalar or calcaneocuboid joints.

with osteotomes, curettes, and a burr. It is critical for proper hindfoot alignment to lift the talar head out of plantar flexion before fixation.

The talonavicular joint is fixed as previously described. Calcaneocuboid joint fixation is achieved with two 4.5-mm cannulated screws, one from the calcaneal anterior process into the cuboid and the other usually placed percutaneously in a retrograde fashion from the cuboid into the calcaneus. The subtalar joint is fixed with a 7.0-mm cannulated screw from the plantar calcaneal tuberosity into the neck of the talus (Fig. 6). Postoperative care is similar to that for patients undergoing isolated talonavicular joint arthrodesis.

Posterior Tibial Tendon Dysfunction

The posterior tibial tendinitis that frequently occurs in the patient with rheumatoid arthritis is thought to be the result of overactivity of the posterior tibial tendon in an effort to stabilize the arch.[4] Posterior tibial tendon dysfunction has been classified into three stages.[18]

Stage 1 is localized tenosynovitis with a flexible hindfoot without deformity. Treatment of this stage of the condition consists of rest, anti-inflammatory medication, physical therapy, orthotic devices, and occasionally an injection of a corticosteroid agent into the tendon sheath. When the condition is unresponsive, tenosynovectomy may be required.

In stage 2, the tenosynovitis has progressed to a valgus deformity that remains mobile. Surgical intervention is usually recommended to stabilize the arch. In the absence of systemic inflammatory disease, a soft-tissue reconstruction by transfer of the flexor digitorum longus tendon to the navicular or posterior tibial tendon would most often be recommended. However, with rheumatoid arthritis, an arthrodesis is usually done to eliminate the potential of a progressive inflammatory process with the tendon-transfer procedure. The types of arthrodeses suggested include triple arthrodesis, double arthrodesis (talonavicular and calcaneocuboid joints), and isolated talonavicular arthrodesis.

Stage 3 is a fixed hindfoot valgus deformity, with both medial and lateral pain. This condition requires triple arthrodesis for adequate realignment and stabilization.

Retrocalcaneal Bursitis

Inflammation of the retrocalcaneal bursa and the Achilles tendon insertion is common in patients with systemic inflammatory arthropathy, particularly rheumatoid arthritis. This condition usually responds to rest, anti-inflammatory medication, application of ice, and use of a heel lift. Occasionally, injection of a corticosteroid agent into the retrocalcaneal bursa is necessary. Care must be taken to avoid intratendinous deposition of steroid. When the bursitis is refractory to treatment, debridement of the retrocalcaneal bursa and resection of a posterosuperior calcaneal prominence may be necessary. When the Achilles tendon is involved, a longitudinal incision is made within the tendon to debride intratendinous degeneration or calcification.

Ankle

Rheumatoid arthritic involvement of the ankle joint is seen in about 9% of patients with polyarticular disease.[3] The ankle joint is less commonly involved than other joints of the foot, although chronic subtalar joint malalignment may place increased stress on the ankle and lead to deformity. In the clinical examination, ankle-joint synovitis may be confused with the more common talonavicular joint arthritis. Conservative treatment consists of rest, use of an ankle air splint or ankle-foot orthotic device, medical management, and injection of a corticosteroid agent.
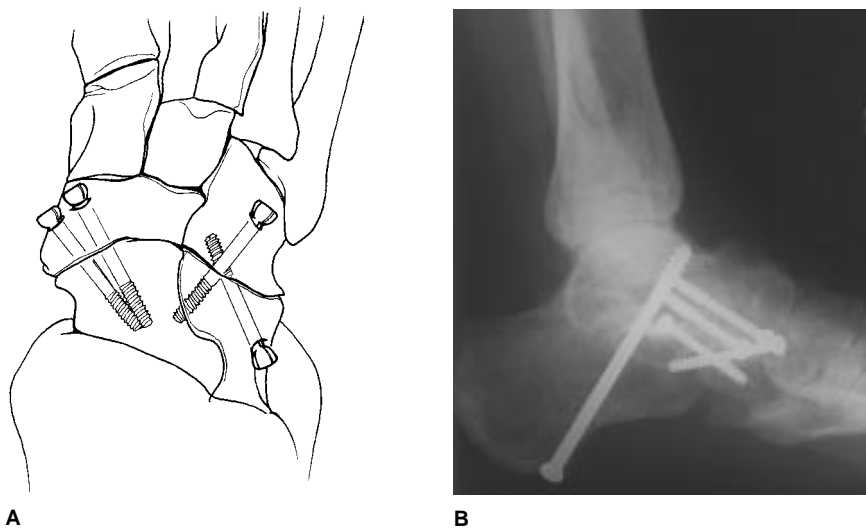

A   **B**

Fig. 6 Images of the foot and ankle of a patient with rheumatoid arthritis of the hindfoot 6 weeks after triple arthrodesis (same patient as in Fig. 5). **A,** Drawing of the radiographic appearance in anteroposterior weight-bearing projection. **B,** Lateral weight-bearing projection. Note the oval osteoperiosteal window in the distal tibia, through which the cancellous bone graft was obtained.

Ankle arthrodesis is indicated in patients with advanced arthritis or deformity. In one study in which compression arthrodesis with external fixation was compared with internal fixation with 6.5-mm cancellous screws, there were no significant differences regarding rate of fusion, time to fusion, or complications.[2] However, the current trend is toward the use of internal fixation.[19] Arthroscopic techniques may offer results similar to those associated with open techniques, with less soft-tissue trauma and postoperative pain.[20]

Summary

The medical and surgical treatment of the patient with rheumatoid arthritis presents a series of challenging problems for the rheumatologist and the orthopaedic surgeon. Despite technologic advances, rheumatoid arthritis continues to be a serious and debilitating disease. Involvement of the foot and ankle creates as much disability as does involvement of any other area of the body. The forefoot and talonavicular joint are particularly prone to the destructive processes of rheumatoid arthritis. However, numerous treatment options are available to provide relief of pain and to improve function. Patient education is necessary to maximize compliance with treatment recommendations. Pedorthic management is important to accommodate deformed toes, relieve metatarsalgia, and support the arch. Reconstruction of the forefoot for hallux valgus and arthritis of a lesser metatarsophalangeal joint offers satisfactory long-term functional results. Surgical stabilization of the deformed rheumatoid hindfoot improves biomechanics and ambulation. The potential for breakdown of soft tissues and problems related to wound healing remains a primary concern through the full spectrum of treatment of patients with rheumatoid arthritis of the foot and ankle.

References

1. Spiegel TM, Spiegel JS: Rheumatoid arthritis in the foot and ankle: Diagnosis, pathology, and treatment—The relationship between foot and ankle deformity and disease duration in 50 patients. *Foot Ankle* 1982;2:318-324.
2. Cracchiolo A III, Cimino WR, Lian G: Arthrodesis of the ankle in patients who have rheumatoid arthritis. *J Bone Joint Surg Am* 1992;74:903-909.
3. Vainio K: The rheumatoid foot: A clinical study with pathological and roentgenological comments. *Ann Chir Gynaecol Fenniae* 1956;45(suppl 1):1-107.
4. Keenan MA, Peabody TD, Gronley JK, et al: Valgus deformities of the feet and characteristics of gait in patients who have rheumatoid arthritis. *J Bone Joint Surg Am* 1991;73:237-247.
5. Beauchamp CG, Kirby T, Rudge SR, et al: Fusion of the first metatarsophalangeal joint in forefoot arthroplasty. *Clin Orthop* 1984;190:249-253.
6. Thompson FM, Mann RA: Arthritides, in Mann RA, Coughlin MJ (eds): *Surgery of the Foot and Ankle,* ed 6. St Louis: Mosby, 1993, vol 1, pp 637-667.
7. Hoffmann P: An operation for severe grades of contracted or clawed toes. *Am J Orthop Surg* 1912;9:441-449.
8. McGarvey SR, Johnson KA: Keller arthroplasty in combination with resection arthroplasty of the lesser metatarsophalangeal joints in rheumatoid arthritis. *Foot Ankle* 1988;9:75-80.
9. Fowler AW: A method of forefoot reconstruction. *J Bone Joint Surg Br* 1959;41:507-513.
10. Cracchiolo A III, Weltmer JB Jr, Lian G, et al: Arthroplasty of the first metatarsophalangeal joint with a double-stem silicone implant: Results in patients who have degenerative joint disease, failure of previous operations, or rheumatoid arthritis. *J Bone Joint Surg Am* 1992;74:552-563.
11. Moeckel BH, Sculco TP, Alexiades MM, et al: The double-stemmed silicone-rubber implant for rheumatoid arthritis of the first metatarsophalangeal joint: Long-term results. *J Bone Joint Surg Am* 1992;74:564-570.
12. Mann RA, Thompson FM: Arthrodesis of the first metatarsophalangeal joint for hallux valgus in rheumatoid arthritis. *J Bone Joint Surg Am* 1984;66:687-692.
13. Johnson JE, Johnson KA: Dowel arthrodesis for degenerative arthritis of the tarsometatarsal (Lisfranc) joints. *Foot Ankle* 1986;6:243-253.
14. Figgie MP, O'Malley MJ, Ranawat C, et al: Triple arthrodesis in rheumatoid arthritis. *Clin Orthop* 1993;292:250-254.
15. Ljung P, Kaij J, Knutson K, et al: Talonavicular arthrodesis in the rheumatoid foot. *Foot Ankle* 1992;13:313-316.
16. Abdo RV, Decker JE, Seldin DW, et al: SPECT bone scan imaging of the foot and ankle [exhibit]. Presented at the 61st Annual Meeting of the American Academy of Orthopaedic Surgeons, New Orleans, Feb 24-Mar 1, 1994.
17. Danziger MB, Abdo RV, Decker JE: Distal tibia bone graft for arthrodesis of the foot and ankle. Presented at the 24th Annual Winter Meeting of the American Orthopaedic Foot and Ankle Society, New Orleans, Feb 27, 1994.
18. Johnson KA, Strom DE: Tibialis posterior tendon dysfunction. *Clin Orthop* 1989;239:196-206.
19. Moeckel BH, Patterson BM, Inglis AE, et al: Ankle arthrodesis: A comparison of internal and external fixation. *Clin Orthop* 1991;268:78-83.
20. Myerson MS, Quill G: Ankle arthrodesis: A comparison of an arthroscopic and an open method of treatment. *Clin Orthop* 1991;268:84-95.