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The Ilizarov external fixation frame in compression arthrodesis of large, weight bearing joints

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Solid bony fusion of large joints affected with active chronic infections, is still the most effective surgical solution to establish a useful function of the affected limb. Even with extensive peri-articular bone loss and severe deformities, arthrodesis in a functional position can provide effective stability. The reported fusion rates in such patients are not encouraging however, and secondary amputations have been reported.

Compression arthrodesis using an Ilizarov external fixation frame was performed for 17 destroyed feet (14 tibiotalar and 3 subtalar joints) and 6 badly disrupted knees in a series of 20 patients. Evaluation of the results was based on the clinical and radiological joint alignment, achievement of fusion, presence or absence of infection, and functional outcome.

One patient after knee joint arthrodesis was lost to follow-up, and two knees had developed a clinically stable fibrous union. Solid fusion was obtained in all other joints. All joints were in anatomical alignment and the patients were fully functional at the time of review.

Our experience of using the Ilizarov fixation frame for achieving joint fusion is very rewarding. The results reported hereby justify the further use of this hybrid frame as an effective mechanical method to achieve bony joint fusion without bone grafts, and to ensure a low failure rate.

INTRODUCTION

Arthrodesis of large joints is a widely accepted surgical salvage procedure for various severe joint pathologies, including post-traumatic, degenerative, inflammatory or infectious arthritis, failed arthroplasty and selected paralytic disorders (20). Primary arthrodesis has been advocated as the treatment of choice for severe intra-articular fractures, where both bone and soft tissue injuries are so extensive as to preclude the anatomical restoration of articular surfaces (*9*).

A talocrural joint, fused in an acceptable position, is compatible with an excellent functional result (*15*). Albert was first to describe arthrodesis of the ankle in 1879. Since then, a number of fusion techniques have been described (*22, 26*). Davis first established the concept of simultaneous fusion of the talocalcaneal and talonavicular joints as a means of correcting varus-valgus and abduction-adduction deformities of the foot. Over the years, the concept of triple arthrodesis including the calcaneocuboid joint, the talonavicular and talocalcaneal joints, gained acceptance (*27*).

Knee arthrodesis was historically designed as a treatment for severe post-traumatic or degenerative arthritis, neuropathic degeneration, infection or severe ligamentous instability. Currently, knee arthrodesis is performed most commonly for a failed or infected knee arthroplasty (*8, 17*). Variable

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success rates were reported using various fusion techniques (*4, 24*).

The thin-wire ring tubular hybrid fixation frame, based upon Ilizarov's principles, has enabled us to achieve independent ambulation in all patients and resulted in fusion in all patients available for follow-up evaluation.

PATIENTS AND METHODS

Between 1992 and 2000, twenty-three affected joints (14 tibiotalar joints, 3 subtalar joints and 6 knees) in 20 consecutive adult patients, were fused. Fourteen were males (average age 38.4 years, range : 18-85) and 6 were females (average age 71.3 years, range : 50 to 84 years).

Of the 17 feet, 14 underwent tibiotalar joint arthrodesis and 3 triple arthrodesis. The underlying pathology was severe post-traumatic osteoarthritis in 11 ankles, including 8 ankles with a history of open fractures, and a Charcot joint in one patient. Primary arthrodesis was undertaken in 5 tibiotalar joints following severe intra-articular fractures associated with bone loss and extensive soft tissue damage where the restoration of appropriate articular anatomy was unfeasible.

Ten of these feet had been previously operated upon, at least once (average 2.4 times, ranging from 1 to 7). Prior surgical interventions included open reduction and internal fixation of fractures, arthrodesis using internal or external fixation devices and astragalectomy in one case of open fracture-dislocation of the ankle. Multiple associated problems existed, including chronic osteomyelitis with draining sinuses in 3 patients, significant limb length discrepancy in 2 patients, soft tissue loss in 3 patients, bone loss in 2 patients, joint deformities in 3 patients and failed previous fusion presenting as painful fibrous pseudoarthrosis in 4 ankles.

All six knees operated on, were failed infected arthroplasties, two of which had been revised once and one three times. Chronic osteomyelitis, draining sinuses and deficient bone stock were present in all knees.

The surgical approach depended on the particular underlying pathology. Residual cartilage was excised, all components of implanted devices were removed and meticulous surgical debridement of all infected tissues, including the excision of sinus tracts, was undertaken leaving the wound open for healing by secondary intention. The ring external fixation was customised and applied while achieving the desired alignment and compression across the fusion site. The external fixation frame for knee arthrodesis consisted of two full tibial rings, one femoral ring and a femoral arch transfixing the bone by thin wires and half pins. The external fixation frame for tibiotalar arthrodesis consisted of two full tibial rings (one mounted at the proximal leg and the second at the supramalleolar region) transfixed to bone with thin wires and half pins. An additional ring was mounted at the foot incorporating the talus, calcaneus and the metatarsal bones and consisted of two half-rings interconnected by two threaded rods. This configuration enabled the application of a compression force across the longitudinal foot axis to enhance pantalar fusion (fig 1, 2).

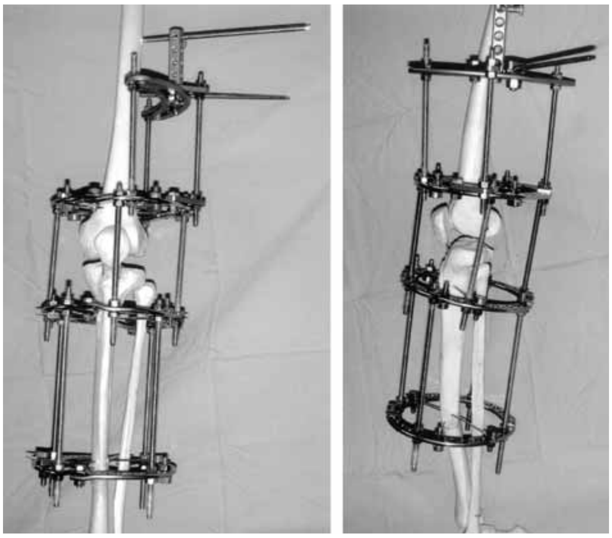

Fig. 1. — Anterior (1a) and medial (1b) views of the Ilizarov external fixation frame for knee compression arthrodesis, mounted on a plastic skeleton model.

In two patients with significant limb length discrepancy the tibiotalar arthrodesis was combined with a proximal tibial bone lengthening osteotomy at a distraction rate of 0.25 mm every six hours.

Compression across the fusing site was postoperatively maintained by applying a weekly shortening of 1 mm.

Bone grafting was not needed in any of the patients.

Results were evaluated looking at the presence or absence of clinical, radiological and laboratory signs of infection, radiological anatomy of joint alignment and fusion, and patients' return to daily function and activities.

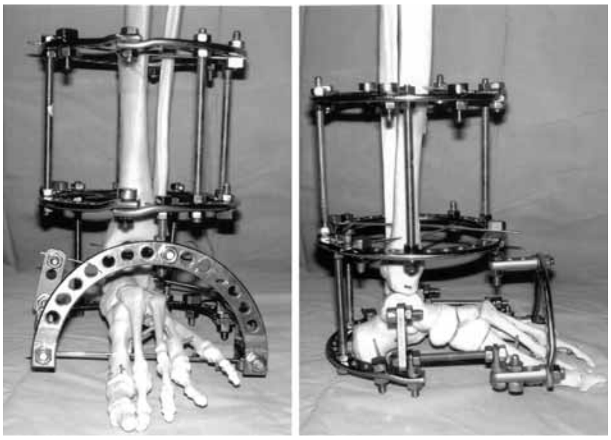

Fig. 2. — Anterior (2a) and medial (2b) views of the external fixation frame for both tibiotalar arthrodesis and triple arthrodesis, mounted on a plastic skeleton model.

Fig. 3. — Anteroposterior and lateral radiographs showing a successful tibiotalar fusion achieved 21 weeks after frame application in a 38-year-old male.

RESULTS

The average follow-up time was 34 months (range : 11 to 72 months). One patient was lost to follow-up a few weeks after frame application for knee fusion.

In all patients, drainage rapidly decreased after frame application, soft tissues recovered and wounds healed with good granulation tissue, including infected joints. No residual infections were evident at follow-up.

In the foot group (including tibiotalar joint arthrodesis and triple arthrodesis) solid fusion was obtained in all patients at an average of five months (range : 3 to 12 months) (fig 3).

In the knee group, solid consolidation was obtained in three out of five patients who were available for follow-up at an average of 4.5 months (range : 3 to 8 months) (fig 4) whereas stable radiological fibrous union persisted in two patients, 12 and 20 months after surgery.

All patients started ambulating shortly after frame application with full weight bearing. After frame removal, all limbs were protected in a Plaster of Paris walking cast for 30 days. All limbs healed in good alignment and without significant leg length discrepancy. Both patients with radiological fibrous union of their knees are independently ambulant and are functioning at an acceptable level. We keep them in a protective brace.

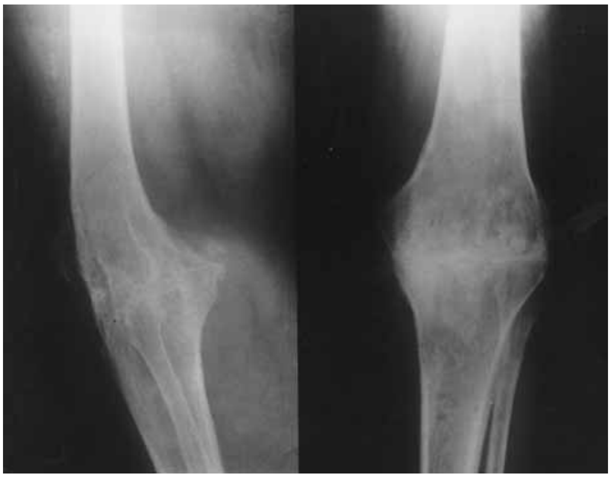

Fig. 4. — Radiographs of a 58-year-old female who underwent knee arthrodesis using the Ilizarov frame owing to an infected failed total knee arthroplasty. Solid fusion was achieved within eleven weeks.

After tibiotalar arthrodesis, two patients underwent surgical exchange of one transfixing thin-wire due to hardware failure.

Despite regular care given to pin sites, most patients developed superficial soft tissue infections around the pins. These were successfully managed by local debridement, meticulous pin site care but occasionally necessitated short-term antibiotic treatment. These infections were mostly observed in areas with abundant soft tissue, especially in the thigh in cases of knee arthrodesis. No deep infections had occurred, no neurovascular complications were encountered and none of the limbs was lost.

DISCUSSION

Multiple studies (14, 16, 18) have shown that patients after large joint arthrodesis function reasonably well with limited disability. Most patients can perform normal activities of daily living without much restriction. These patients may become gainfully employed and may be able to participate in recreational activities (*19*).

While there is a general consensus regarding the favourable functional outcome of solid fusion for some disabling articular diseases, the surgical means to reliably achieve fusion remains controversial. A number of methods and devices have been successively developed in a long evolutionary process since the early 1900’s. Each has been proposed as the ultimate method for attaining solid fusion of large joints. The multitude of different approaches and methods suggests that no single technique has definitively proved superior. Large joints are not always easily fused and the previously reported techniques possess a significant complications rate including non-union, infection and malunion (*1*).

These various methods can be grouped along two distinct approaches : internal versus external fixation (*21*). Once these methods are closely evaluated, they significantly differ in the surgical technique and in the choice of the fixation device. However, they all rely upon the concept of compression at the fusion site. John Albert Key (*13*) described as early as 1932 a positive pressure knee arthrodesis in tuberculous arthritis using a simple external fixation device. Charnley was a pioneer in utilising external fixation for compression arthrodesis nearly fifty years ago (*21*). The results of arthrodesis of large joints with this technique have been quite satisfactory and since that time this concept has gained wide acceptance. Biomechanical studies showed that even though the Charnley device is able to produce sufficient compression forces, the single axis fixator does not produce rigid external fixation in all planes. Calandruccio (*7*), in an attempt to improve rigidity of ankle fusion, developed a triangular compressive device that provides rigid external fixation in three planes. Similarly, in an attempt to enhance the rigidity of knee fusion, several authors have introduced different two-plane external fixators, such as the Ace-Fischer bi-planar apparatus (*1, 3, 24, 25*).

Still, certain complex cases necessitating arthrodesis in the presence of chronic active infection, failed arthroplasties with bone loss, inadequate soft tissue coverage, poor bone quality or the presence of established deformities, usually precluding the use of internal fixation devices, represent a surgical challenge. Large cantilever pin external fixation frames provide two-plane stability, which is not sufficient to eliminate persistent motions at the fusion site. The latter reduce the ability of both bone and surrounding soft tissue to heal and enhance the formation of chronic unstable pseudarthrosis.

Hawkins *et al* (*9*) reported 21 cases of ankle arthrodesis by external fixation with the Ilizarov ring and attained solid fusion in 80% and resolution of the associated underlying pathologies. Johnson *et al* (10) reported 6 cases of compression ankle arthrodesis using the Ilizarov external fixator due to failed infected ankle fusion in four cases and post-traumatic degenerative arthritis in two cases. Successful fusion was obtained in five cases, one of which subsequently sustained a refracture. Manzotti *et al* (*17*) reported six cases of knee arthrodesis after infected total knee arthroplasty using the Ilizarov method. Of the five patients who had completed treatment, all obtained a stable knee arthrodesis after a mean external fixation time of 6.8 months.

The small “pin and ring” Ilizarov fixation method is by no means a panacea (*9*). It is technically demanding, requires a compliant and dedicated patient and is definitely liable to develop complications including pin-tract infections, pin breakage, premature or delayed consolidation of regenerate bone, transient nerve palsies and distal joint contractures (*6, 23*). Nevertheless, this therapeutic modality has unique advantages over other techniques in fusing large joints, especially in the face of active infection coupled with poor bone quality, when the technical benefits it offers overshadow the potential complications, provided the treatment is undertaken by a skilled team, with strict adherence to indications. Competent knowledge of the modularity of the device and awareness of the potential complications, which are sometimes unforgivable, pays off in the high success rate of fusion.

When properly applied, this frame provides stable immobilisation of the joint in three planes with stable fixation against shear and torsion stress, while axial loading is allowed without detrimental effect on the fusion site (*10*). Micro-movements in the axial plane persist stimulating bone formation and enhance osseous healing (*2, 5, 11, 12*). The newly formed bone conforms in line with Wolf's law. Hence, early ambulation and weight bearing are encouraged and may be initiated almost immediately.

This versatile apparatus is highly modular and provides three-dimensional control over bone and joint deformities and instability. The frame is usually tailored for the particular patient and may be used for shortening, lengthening, compression, distraction and bone transport. These parameters are determined intra-operatively but may be repeatedly and reversibly refined post-operatively throughout the healing process in order to eliminate any residual deformity.

Furthermore, this configuration of thin wire frames minimises the surgical invasiveness and provides the surgeon a remote control over the fused joint. The transfixing wires are inserted extrafocally and, therefore, further damage to the involved tissue as well as embedding foreign material in a septic location are avoided. In our hands, the advantages of this method outweigh by far its disadvantages.

CONCLUSION

Based on our rewarding experience, we recommend the Ilizarov method as an efficient clinical tool for achieving large-joints arthrodesis, especially in the management of the challenging cases presenting with infected failed arthroplasty or fusion, extensive bone loss, limb shortening and bony deformities.

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