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Specialty Update

What's New in Limb Lengthening and Deformity Correction

By Sanjeev Sabharwal, MD, Stuart Green, MD, Jim McCarthy, MD, and Reggie C. Hamdy, MD

This update summarizes select research highlights pertaining to limb lengthening and deformity correction that were either published in a peer-reviewed journal between January 2009 and June 2010 or presented at the annual meeting of the American Academy of Orthopaedic Surgeons (AAOS), the Limb Lengthening and Reconstruction Society (LLRS), the Pediatric Orthopaedic Society of North America (POSNA), the Orthopaedic Trauma Association (OTA), or the American Orthopaedic Foot & Ankle Society (AOFAS).

Pediatric Disorders

Assessment of Lower Limb Alignment in Children

The assessment of standard radiographic measurements such as the mechanical axis deviation with use of full-length standing radiographs has been found to be reliable in children[1]. However, the hip-knee-ankle angle does not reach the adult reference values until the age of seven years[2].

Guided Growth

Guided growth techniques continue to evolve. One study compared traditional physeal stapling with the more recently introduced non-locking plate hemiepiphysiodesis and demonstrated minimal difference between the two types of implants[3]. The rate of angular correction was approximately 10° per year in both groups, with comparable complication rates. In another study, anterior distal femoral hemiepiphysiodesis was evaluated for the management of children who had arthrogryposis and flexion contracture of the knee[4]. A mean improvement of 18° was noted in this challenging group of patients, with better results in those with flexion deformities of <45°. The use of guided growth techniques to alter growth around the hip was demonstrated in an animal study[5] and was the focus of a symposium at the recent POSNA meeting[5]. Although guided growth techniques with plate fixation are effective and are used for a variety of disorders, a higher rate of mechanical failure was reported for children with Blount disease[6]. New design modifications in these implants may decrease the prevalence of mechanical failure in such patients[7].

The results of hemiepiphysiodesis in patients with physeal abnormalities and multiplanar deformities have been unpredictable. Cho et al.[8] reviewed nine patients who were managed with hemiepiphyseal stapling for the treatment of angular deformity at the knee due to multiple epiphyseal dysplasia and reported a satisfactory outcome in two-thirds of the patients. Physeal behavior following staple removal may be unpredictable in patients with abnormal growth plates.

Blount Disease

In the study by Aird et al., computed tomography (CT) scan measurements demonstrated that children with Blount disease had increased femoral anteversion in addition to internal tibial torsion[9]. Using mathematical calculations to study the effect of varus or valgus osteotomies on femoral version, Liu et al. noted that proximal femoral varus osteotomies tended to decrease anteversion whereas valgus osteotomies tended to increase anteversion[10]. A number of authors have evaluated the results of surgery for the treatment of Blount disease. Multivariate analysis demonstrated that lateral hemiepiphyseodesis around the knee for the treatment of adolescent Blount disease was less effective for patients with an age of more than fourteen years, a body mass index (BMI) of ≥45 kg/m^2, or a severe proximal tibial deformity[11]. Rab revisited the use of oblique osteotomy for the treatment of Blount disease and found this technique to

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be safe and accurate[12]. He described several refinements to the original technique, such as performing a prophylactic partial fasciotomy; orienting the starting plane of the oblique osteotomy to correspond with the distal, internally rotated tibial surface; and using two screws perpendicular to the long axis of the tibia. The use of a monolateral fixator that allows for multiplanar adjustment for the treatment of Blount disease was associated with satisfactory correction, with a complication rate that was comparable with that associated with traditional ring fixators[13,14]. Functional outcomes after the treatment of Blount disease are affected by the accuracy of correction[15] and BMI[15,16] and appear to worsen with time[16].

Congenital Extremity Deficiencies

Congenital deficiencies are often difficult to treat, and even the most experienced surgeons have reported complications, especially when lengthening a congenitally short femur. One single-surgeon case series demonstrated regenerate deformation or fracture after lengthening in >50% of cases, regardless of the location of the corticotomy[17]. The risk of this complication can be substantially decreased with the use of intramedullary fixation during the lengthening procedure[18]. Hazra et al. reported hip and knee dislocation in association with a lengthening procedure in a patient with a congenitally short femur[19], emphasizing one of the worst hazards of treating this condition. The authors recommended avoiding lengthening of >6 cm or >20% of the original length of the femur and recommended using staged lengthenings for larger discrepancies. Besides protecting an unstable knee joint from dislocating during lengthening, using the external fixator to span the knee may also stimulate growth of the lengthened extremity[20]. In another study, CT angiography was used to delineate the abnormal vascular pattern associated with proximal femoral focal deficiency[21].

The debate regarding the treatment of fibular deficiency has been rekindled, with confirmation that surgical treatment can be highly successful[22]. The clinical results of limb lengthening have been reported to be similar to those of reconstructive amputation[23]. Lengthening for tibial deficiencies has not been as successful. Following tibial lengthening in nine patients with congenital tibial deficiencies, knee flexion was substantially limited in those with Jones type-I deficiencies[24].

Two studies evaluated the quality-of-life scores following limb lengthening in children[25,26]. Moraal et al. reported that, while there may be a small decrease in quality-of-life scores shortly after surgery, the long-term quality-of-life scores were similar to those for controls, especially when the remaining limb-length discrepancy was <2 cm[26].

Joint Distraction

Gradual correction with use of external fixation for the treatment of popliteal pterygium was recently revisited[27]. Although satisfactory correction could be attained, recurrent flexion deformities and tibial subluxation were commonly noted; these findings were similar to those of previous reports. Another study investigated the use of hip joint distraction (arthrodiatasis) for the treatment of Legg-Calvé-Perthes disease and demonstrated that >90% of the subjects had a satisfactory clinical and radiographic outcome[28]. However, the patients in that study were young at the time of the procedure (mean age, 6.8 years; range, five to eight years) and had a favorable natural history even without surgery.

Fibrous Dysplasia and Ollier Disease

Numerous surgical techniques have been described for the treatment of proximal femoral deformities in patients with fibrous dysplasia. Yang et al.[29] described a four-step surgical procedure for the correction of proximal femoral varus deformity in a study of thirteen children (fourteen femora) with fibrous dysplasia. The steps included (1) valgus osteotomy, (2) curettage of the lesion, (3) massive impaction allografting, and (4) the insertion of an intramedullary nail with fixation across the femoral neck. After an average duration of follow-up of seventy-five months, there were no cases of infection, recurrent fracture, or progression of the deformity.

Several authors have reported on the beneficial effects of lengthening over elastic intramedullary nails. In a large case series of patients with Ollier disease, Popkov et al.[30] assessed the effect of adding elastic stable intramedullary nailing to a circular fixator in the cases of forty-four patients who underwent limb lengthening. A substantially reduced duration of external fixation, limited postoperative complications, and prevention of fractures following fixator removal was noted with use of elastic stable intramedullary nailing.

Trauma

External fixation continues to play an important role in both acute and residual musculoskeletal trauma care. Experience during recent international conflicts has led armed forces around the world to adapt a policy of so-called damage-control orthopaedics, a surgical treatment protocol that includes immediate stabilization, usually in forward field hospitals, of complex open musculoskeletal limb and pelvic injuries with external fixation (combined with aggressive wound debridement and open treatment of soft-tissue wounds), followed by prompt evacuation to larger facilities for definitive management[31,32]. In some cases, a temporary external fixator spans the area of injury, especially when internal fixation is contemplated as part of the final reconstruction of the injured bones[33]. In other cases, however, external fixation may remain in place, or may be modified secondarily, when such treatment is appropriate, particularly when a large segmental bone defect exists, either in isolation or in combination with concomitant soft-tissue loss. Under such circumstances, the initial fixator, typically a monolateral configuration, is converted to a multiplanar circular frame to allow for what Ilizarov referred to as simultaneous bifocal distraction compression osteosynthesis, commonly called bone transport[34]. Recently, a case of tetrafocal

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bone transport for severe segmental bone loss following an open tibial fracture was described[35]. Using a logistic regression model, Oostenbroek et al. noted that bone loss was the main predictor for complications in patients undergoing Ilizarov reconstruction following failed fracture treatment[36].

In civilian situations with comparable trauma, external fixation continues to aid limb salvage in both early management and late reconstruction of serious injuries. The more devastating the injury, the greater the likelihood that a surgeon will rely on external fixation, often combined with early flap coverage[37-39]. Early involvement of plastic surgeons in limb salvage has become increasingly frequent[40]. In a recent review of seventy cases of open fractures in a pediatric population, the complication rate correlated most strongly with the involvement of plastic surgeons too late in the treatment of the injured extremity[41].

Frequently, an antibiotic-impregnated cement mass is used as a spacer to maintain a tunnel within the damaged soft tissues, allowing for subsequent bone transport[42]. Without such a tunnel, transposed soft-tissue flaps tend to collapse into the space formerly occupied by the missing tissues, creating problems as the transporting bone fragment tries to plow through the flaps. The use of a spacer also helps to reconstruct limbs when extensive debridement of already infected bone is required. A spacer made from Palacos bone cement with vancomycin (Biomet, Warsaw, Indiana) can be used both to sterilize the transport region and to form a membrane-lined bone tunnel for the intercalary segment to move through unimpeded[43].

In a recent study, Liodakis et al. compared femoral and tibial bone transports; monolateral fixators were used in both groups[44]. Surprisingly, the patients in the femoral transport group had fewer complications and a more satisfactory outcome than did those in the tibial fixator group. In another report, Iacobellis et al. concluded that monolateral fixators are better tolerated than circular frames in cases of femoral bone transport[45].

Intramedullary reaming prior to nailing of the tibia can cause excess heat build-up and can lead to extensive thermal necrosis of both the bone and its surrounding soft-tissue envelope. Lovisetti et al. recently reported on the management of seven such patients with use of Ilizarov techniques; all patients had favorable outcomes[46]. The treatment protocol, however, required about a year of fixation, with typical external fixation problems and obstacles along the way.

In spite of advances in trauma care, device-associated problems continue to plague external fixation. Many investigators have reported pin and wire-site infections in virtually all patients, with many individuals having painful or otherwise unpleasant fixator experiences[47-50]. In order to avoid soft-tissue problems and skin scarring in association with the use of traditional external fixator half-pins or transfixation wires in the transport fragment, Kucukkaya et al. designed an intramedullary cable technique that can aid in maintaining alignment while avoiding soft-tissue invagination at the docking site[51]. Attempts to decrease the time in fixation by converting to internal fixation systems part of the way through treatment, or eliminating external fixation altogether with fully implantable devices that allow for bone transport, are currently under investigation.

Upper Extremity

Reconstruction techniques to address congenital and posttraumatic shortening of the digits are evolving. Erdem et al. reported that lengthening of twelve congenitally short metacarpals by means of callus distraction was successfully achieved with use of a percutaneous osteotomy, with a mean increase of 2.4 cm of length[52]. The authors recommended preservation of the periosteum, lengthening at a rate of 0.25 mm twice a day, and avoiding distraction beyond 40% of the original bone length. In multiply mutilated digits, the donor digit may be too short for a single-stage pedicle transfer to be considered. A novel technique of performing a two-stage transfer of mutilated digits with use of the Ilizarov device to initially lengthen previously injured short digital stumps along with the neurovascular pedicles and soft tissues, with subsequent segment transfer, was applied to sixty-five patients (seventy-seven digits), with improvement in hand grip[53].

Forearm deformities due to asymmetric growth of the radius and ulna secondary to osteochondromas[54] and posttraumatic physeal arrest[55,56] can be treated with gradual correction with use of distraction osteogenesis. Similarly, gradual distraction of the distal part of the humerus with use of circular fixation was performed to correct posttraumatic cubitus varus in five adults, with minimal sequelae[57]. In another report, a circular or hybrid external fixator was applied for approximately five months to treat severe high-energy periarticular elbow injuries in fourteen adults[58]. The average Mayo Elbow Performance Index score was 84 after 1.5 to eleven years of follow-up.

Proximal Tibial Osteotomy for Osteoarthrosis

In a large prospective radiographic cohort study of older adults, leg-length inequality of >1 cm was associated with knee arthrosis in the shorter leg[59]. Although full-length standing radiographs are usually made in double-leg stance, single-leg stance radiographs may be more accurate for patients with varus deformities who demonstrate a varus thrust[60]. Despite the availability of various prosthetic knee implants, proximal tibial osteotomy for the treatment of genu varum has a distinct role in the management of adults who have isolated medial compartment arthritis. A variety of opening-wedge[61-63] and closing-wedge[64] osteotomies have been described. Benzakour et al., in a fifteen-year follow-up report on nearly 200 patients who underwent proximal tibial osteotomy for the treatment of medial compartment osteoarthrosis, reported that the clinical results were satisfactory for 42% of the patients, whereas twenty-eight patients needed revision and nineteen patients

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had other complications[65]. Despite a fairly high number of untoward events, the authors believed that this procedure was reliable and that correction to about 5° of mechanical valgus was appropriate. In another report, Masrouha et al. studied the management of younger adults undergoing corrective tibial osteotomy for the prevention of osteoarthrosis and noted good short-term results, with the mean functional score improving from 84 to 95 of 100[66].

High tibial osteotomy can affect patellar height and posterior tibial slope. In previous studies, an opening-wedge correction proximal to the insertion of the patellar tendon resulted in a decrease in patellar height[61,62] and a closing-wedge osteotomy was associated with patella alta[61]. A correlation between an opening-wedge high tibial osteotomy and an increase in the posterior tibial slope also has been noted[61,62,67]. Sterett et al. reported that the increase in posterior tibial slope with opening-wedge correction occurred to a similar extent irrespective of the choice of implant (wedge plate versus monolateral external fixator) and did not correlate with the Lysholm score[67]. The location of the intact lateral cortical hinge in an opening-wedge osteotomy also may affect the sagittal alignment, with a directly lateral hinge producing minimal change and a posterolateral hinge leading to a larger increase in the posterior tibial slope[68].

In the study by Kuremsky et al., allograft was compared with autograft for opening-wedge proximal tibial osteotomies[69]. The allograft group had sixfold higher failure rate. However, the failure rate decreased from 53% to 12% when the lateral cortex of the proximal part of the tibia was left intact. Poor outcome was more commonly noted in association with opening-wedge corrections of >11 mm. In another study involving plate fixation and an opening-wedge correction of up to 14 mm without additional bone graft, a satisfactory outcome was noted in 88% of cases[70].

Foot and Ankle

Charcot Arthropathy

Charcot arthropathy of the foot and ankle, a frequent consequence of diabetic peripheral neuropathy, usually results in midfoot collapse, plantar flexion of the talus, and ulceration of the skin in association with osteomyelitis of the exposed bones. Small-wire external fixation has become valuable for the treatment of such limb-threatening problems[71,72]. Although patient tolerance of the bulky fixator is always a consideration, a sufficient number of patients benefit from limb salvage with use of external skeletal fixation, resection of infected bone, and midfoot osteotomy. Such treatment may become the first line of treatment for midfoot Charcot arthropathy, with amputation being reserved as the secondary approach in many cases.

Arthrodiatasis

Concern about the long-term effects of ankle arthrodesis, combined with issues related to the longevity of total ankle replacement, has led clinicians to consider controlled joint distraction (arthrodiatasis) for ankle osteoarthritis. The concept is simple: permitting continuous joint motion without compressing the articular surfaces as a result of weight-bearing forces. To accomplish this, one needs an adaptable external fixator with hinges collinear with the rotation axis of the ankle joint. Tellisi et al.[73] reported on twenty-five patients with ankle osteoarthritis who were managed with a protocol that included joint distraction and mobilization while in an external fixator. The results were generally favorable, with 91% of the patients reporting improvement. How much of this improvement may be due to the placebo effect of a surgical procedure in a patient wanting to avoid an ankle arthrodesis remains unresolved.

Lengthening for Brachymetatarsia

A congenitally short metatarsal, usually the first or fourth, can be corrected by lengthening the bone with use of one of several strategies. W.C. Lee et al.[74] reported the results of a retrospective study of patients who were managed with fourth metatarsal lengthening with use of one of three different techniques: (1) intercalary graft, (2) distraction osteogenesis after osteotomy with an electric saw, or (3) distraction osteogenesis after percutaneous osteotomy with an osteotome. The highest rate of patient satisfaction was noted in the last group in association with the use of the percutaneous approach. In another series, K.B. Lee et al.[75] reported on sixteen patients (twenty-seven feet) who underwent first metatarsal lengthening with use of a unilateral external fixator. The most commonly reported problem was stiffness of the first metatarsophalangeal joint. Despite other complications such as cavus deformities, hallux valgus, and fracture of the regenerate, a satisfactory clinical outcome was achieved in the majority of patients.

Oncologic Reconstruction

The use of distraction osteogenesis to address skeletal defects following the resection of aggressive bone tumors is gaining popularity. This method of limb reconstruction can be applied as the initial treatment[76] or can be used to salvage failed reconstruction following other methods[77-80]. Courvoisier et al.[77] reported on three patients with residual limb shortening who underwent successful lengthening of the vascularized free fibular graft that had been used to reconstruct tibial defects following sarcoma resection. Han et al. recently reported successful lengthening of a composite allograft-vascularized fibular graft following the resection of an osteosarcoma affecting the femoral metaphysis in a child[79]. El-Alfy et al. reported on the use of bifocal and trifocal bone transport and knee arthrodesis to address failed limb reconstruction (due to infection or tumor recurrence) following tumor resection in thirteen patients[78]. Despite a prolonged treatment time (mean, 14.5 months) in an external fixator to address large defects (mean, 16.5 cm), the functional rating was acceptable in the majority of these patients.

Oncologic reconstruction for lesions adjacent to the physis has unique aspects related to future growth. Mechanical

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failure of an expandable prosthesis following oncologic resection around the knee can occur[81]. As an alternative to the use of an expandable prosthesis, with the potential for cost savings, Kong et al. described a three-stage procedure for the treatment of pediatric osteosarcoma around the knee[82]. The procedure involved temporary arthrodesis following resection, with subsequent soft-tissue lengthening with use of an external fixator (if no recurrence was noted within the following two to three years) and conversion to an adult-type mobile prosthetic replacement at skeletal maturity. Half of the fifty-six patients completed all three stages, with an average gain of 7.8 cm in length and with acceptable knee mobility, although an extensor lag was frequently noted.

Stature Lengthening

Skeletal Dysplasias

Individuals with skeletal dysplasia, including those with achondroplasia and hypochondroplasia, are typically short in stature and also may have angular deformities of the lower limb. Deformity correction with and without limb lengthening is practiced at some centers but has not been universally accepted. The few clinical series on lengthening for body height increase often have combined patients with skeletal dysplasias and constitutional short stature. Lie and Chow[83] reported on eight patients with short stature (five of whom had skeletal dysplasia and three of whom had constitutional short stature) who underwent lengthening with use of external fixation. The average time in the fixator was eight months, with a mean gain of 5.2 cm (21%) per lengthened segment. Besides pin-track infections and transient joint stiffness, the authors reported 0.6 complication per segment. In another report on twenty patients with achondroplasia, femoral lengthening of >50% of the initial femoral length was associated with poor bone formation and stiffness in adjacent joints[84].

Cosmetic Lengthening

Judging from the list of practitioners offering surgery to increase height on the Internet, the introduction of self-lengthening intramedullary nails appears to have overcome surgeon and patient-related apprehension regarding pin-site-related complications associated with lengthening with use of external fixation. However, the literature on the subject is scarce and can be misleading because clinicians typically incorporate limb-lengthening procedures that are performed to increase height with those that are performed for other reasons in a single publication. Thus, readers need to tease out bilateral cases from the data and assume that at least some of the reported procedures were performed for stature indications alone. There are several potential complications associated with internal lengthening devices, including temporary or permanent joint contractures, joint instability, weakness, numbness or dysesthesias, and mechanical problems with the device itself, such as breakage, the inability to lengthen, and "run-away" (too rapid) lengthening failures. Besides the typical early complications that may be associated with limb lengthening, the long-term effects on articular cartilage in the joints of the lengthened limb remain largely unknown. With femoral lengthening with use of an intramedullary device, the bone is lengthened along its anatomic axis, rather than along the biomechanical axis, which is perpendicular to the floor. The knee is pushed toward the midline, increasing valgus stresses during weight-bearing. Concern about lateral compartment osteoarthritis developing in patients undergoing intramedullary cosmetic femoral lengthening has become a contentious issue at meetings at which the subject of stature surgery is discussed.

Postoperative Complications and Their Treatment

Limb lengthening and reconstruction with use of gradual distraction is challenging and often is associated with untoward events. However, with vigilance and careful patient selection, a majority of these problems can be treated without long-term sequelae. While the use of hydroxyapatite-coated half-pins has substantially decreased the incidence of pin-site infection and loosening, there is no consensus regarding the efficacy of various pin-care regimens. In a prospective randomized study, Cavusoglu et al. reported no demonstrable decrease in the rate of transfixation wire site infection when ordinary soap was compared with iodine impregnated gauze[85].

Joint contractures can develop during limb lengthening. Khakharia et al. reported that a limited distal quadricepsplasty was effective for restoring knee flexion in patients who developed extension contractures following femoral lengthening[86]. Barker et al. prospectively studied the effect of limb lengthening on muscle function and noted a decrease in concentric muscle strength and leg power in patients undergoing lower limb lengthening six months following frame removal, with return to preoperative status by two years and with no adverse effect on functional activities[87]. Hamdy et al., in a randomized controlled trial, reported that the use botulinum toxin type A reduced pain and improved mobility in children undergoing limb lengthening and deformity correction[88]. Białoszewski et al. reported that the use of kinesiology taping was more effective than conventional physical therapy modalities for controlling postoperative swelling and lymphedema in limbs undergoing distraction osteogenesis[89].

Various methods to enhance bone formation in distraction osteogenesis are being studied. The use of bisphosphonates to block bone resorption seems an attractive option to enhance regenerate bone formation. However, Saghieh et al.[90] reported detrimental long-term effects of zoledronic acid on the regenerated and native bone after consolidation and removal of the external fixator in a rabbit model of distraction osteogenesis. The authors concluded that their results were not reassuring for the promotion of the clinical use of these drugs for distraction osteogenesis and recommended further investigation. The use of adult mesenchymal stem cells is gaining popularity. Kitoh et al.[91] reported that transplantation of culture-expanded

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bone marrow cells with platelet-enriched plasma enhanced bone regeneration in a series of twenty-eight patients undergoing femoral and tibial lengthening, with a greater effect seen in the femur than in the tibia.

Deciding when to allow unprotected weight-bearing following distraction osteogenesis remains challenging and largely depends on the interpretation of standard radiographs. Zhao et al.[92] retrospectively reviewed the records of seventeen patients who underwent bilateral tibial lengthening over an intramedullary nail and described using the pixel value ratio (defined as the ratio of the pixel value of the regenerate versus the mean pixel value of adjacent bone) of the lengthened area to determine weight-bearing status. As multiple radiographs are required during distraction osteogenesis, Schiedel et al.[93] evaluated the potential for excessive radiation exposure in a study of fifty-three patients who underwent limb-lengthening procedures. The authors concluded that the average patient exposure during such treatment was tolerable and that femoral lengthening resulted in a higher cumulative organ dose than tibial lengthening did.

New Tools and Techniques

Lengthening with Use of Intramedullary Nails and Plates

The availability of computer software has allowed surgeons to perform six-axis deformity correction with precison[94]. One of the challenges associated with standard lengthening with use of external fixators is the prolonged external fixation time until the newly formed bone consolidates enough to allow for fixator removal without the risk of refracture of the regenerated bone. In response to this problem, the techniques of lengthening with use of intramedullary nails and plates are emerging. However, the potential for deep infection as well as additional cost are concerns with such methods. H. Kim et al.[95], in a retrospective review of eighteen tibiae (thirteen patients), investigated the results of lengthening with use of a reamed intramedullary nail (minimum diameter, 10 mm) and a circular external fixator. No cases of infection, poor bone formation, or breakage of nails or screws were noted. Li et al.[96] used an intramedullary nail and a monolateral external fixator for bone transport for the reconstruction of massive post-osteomyelitis skeletal defects of the femur in seventeen patients. Bone union at the docking site was achieved without bone graft, and one patient experienced recurrence of deep infection. Bilen et al.[97], in a study of thirteen tibiae in nine patients, reviewed the results of acute fixator-assisted correction of deformity and subsequent lengthening over an intramedullary nail with use of a circular fixator. The mean external fixation index was 16 days/cm. Complications included two cases of poor bone formation that required bone-grafting and one case of compartment syndrome.

Oh et al.[98] reviewed the records of ten patients who underwent lower limb lengthening with use of an external fixator with a submuscular locking plate. The external fixation index was 15 days/cm, and no major complications were reported. The authors described advantages of this technique compared with lengthening over nails.

Despite the attractive option of internal lengthening devices with avoidance of overlying external fixation, numerous complications continue to be reported. Simpson et al.[99], in a review of thirty-three femora that were lengthened with use of the intramedullary skeletal kinetic distractor, reported difficulty in achieving length in eight cases and uncontrolled lengthening in seven cases. Kenawey et al.[100] reported their experience with thirty-seven consecutive femoral lengthening procedures that were performed with use of intramedullary lengthening nails. The device-related complications included failure of distraction (one case), uncontrolled lengthening (seven cases), and poor new-bone formation (eight cases). The authors concluded that problems related to that particular intramedullary device were largely due to internal malfunction of the lengthening mechanism and recommended careful patient selection and the avoidance of a distraction rate of >1.5 mm/day.

Digital Imaging and Intraoperative Navigation Tools

Despite the recent popularity of digital imaging and navigation systems for the preoperative and intraoperative assessment of lower limb alignment, their advantages over conventional imaging systems remain unresolved. Jamali[101] reported on the use of a universally available digital imaging software package for deformity analysis and surgical planning. Bae et al.[64] and S.J. Kim et al.[102] compared navigation systems with conventional radiography for preoperative planning and the intraoperative assessment of limb alignment in patients undergoing proximal tibial osteotomies and concluded that a navigation-guided procedure was associated with better clinical and radiographic outcomes. On the other hand, on the basis of a review of the current literature, Pearle et al.[103] concluded that while image-free navigation systems may be clinically useful for intraoperative monitoring of the coronal plane alignment, currently available devices were of limited value for accurately assessing axial and sagittal plane alignment of the lower extremity.

Upcoming Events

Specialty Day of the LLRS (Limb Lengthening and Reconstruction Society) will be held at the Annual Meeting of the AAOS on February 19, 2011, in San Diego, California. The Annual Scientific Meeting of the LLRS will be held on July 22 and 23, 2011, in Chicago, Illinois. Details are available at the LLRS website: www.llrs.org.

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