

DISTRACTIONS

**The Newsletter of
The Limb Lengthening and Reconstruction Society: ASAMI-North America**

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Proposed Society Bylaw Changes

submitted by J. John Gugenheim, MD

At the February meeting, the Executive Committee unanimously approved two changes in the Bylaws, to be submitted to the membership for approval at the Scientific Session in July.

Article III, Section 1: The proposed amendment would delete the Editor of the Society Newsletter as a voting member from the Executive Committee. The original intent of the Editor being a member of the Executive Committee was to allow him or her to attend the meetings in order to include a report of the Committee's actions in *Distractions*, the LLRS newsletter. Under the current Bylaws, the Editor, who is appointed by the Executive Committee, is the only member of the Executive Committee who is not elected by the membership and does not have any limits on his or her term. The Executive Committee believes that all its members should be elected representatives of the members. The Editor can still attend the meetings, as stated in Article III, Section 2 E, but would not vote.

Article V, Section 1: The proposed amendment would include the two past Presidents of the Society in the Nominating Committee instead of only the immediate past President. The two past Presidents were members of the Nominating Committee in the previous Bylaws. The current Bylaws include only the immediate past President in the Nominating Committee. Under the proposed amendment, the Nominating Committee would benefit from the experience of both former Presidents.

These amendments will be discussed and voted on in the annual business meeting. If you have any questions or suggestions, please do not hesitate to contact any member of the Executive Committee.

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Letter from the President

Dear Fellow Society Members,

It was good to see everyone at the LLRS' third annual Specialty Day meeting in DC. Special thanks go Rob Rozbruch and Dave Feldman for putting together a great educational program. We also appreciate the time spent by the speakers to participate. Mark your calendar for Specialty Day 2006 to be held on March 11th in New Orleans.

More than sixty interesting scientific abstracts were received to be considered for presentation at the upcoming LLRS annual meeting, July 29–31, 2005, in New York. We're pleased to announce that the guest speakers will be George Cierny and Maurizio Catagni. I'm sure both will entertain and inform us. The program will be finalized and made available within the next couple of weeks. Visit www.llrs.org for the registration form and general information pertaining to the meeting. Don't forget, hotel reservations must be made prior to July 8, 2005.

COMSS representatives, Jim Binski and myself, continue to work hard on the Society's behalf. An update regarding COMSS activities will be given at the annual business meeting on Sunday, July 31.

I look forward to seeing you in New York!

Sincerely,



William G. Mackenzie, MD

Abstracts in A Minute

The purpose of Abstracts in A Minute is to facilitate members' self-study. Because of the brevity, these abstracts are not intended to be an authoritative or critical review.

Deformity Correction

Baums MH, Esenwein SA, Klinger HM. [Continuous distraction corticotomy and callotasis open-wedge osteotomy for osteoarthritic genu varum. Alternative procedure for treatment of medial osteoarthritis]. *Unfallchirurg* 2005; 108:43–48. Review of prospective series of 41 patients (44 knees) undergoing external fixation and callotasis of proximal tibia for medial knee joint osteoarthritis. Good/excellent results were achieved in 70.5%; fair/poor results were achieved in 29.5%. Pre- and postoperative alignment was measured by the femoral-tibial angle.

El-Mowafi H. Assessment of percutaneous V osteotomy of the calcaneus with Ilizarov application for correction of complex foot deformities. *Acta Orthop Belg* 2004; 70:586–590. Review of 20 feet in 15 patients treated with the percutaneous V osteotomy of the calcaneus and Ilizarov method for deformity due to clubfoot (13) and polio (2). Mean duration of the fixator application was 9.5 (range 6–13) months. A plantigrade foot was achieved in 18 feet; gait improved in all patients. Percutaneous V osteotomy is particularly useful for complex foot deformities that have poor skin coverage with poor blood supply. Gradual correction with the Ilizarov method yields good results for complex foot deformities.

Fadel M, Hosny G. The Taylor spatial frame for deformity correction in the lower limbs. *Int Orthop* 2005; 29:125–129. Authors report use of the Taylor spatial frame to treat 22 patients with lower extremity lengthening (8), deformity correction (8), or both (6). Authors concluded that their results (18 excellent, 2 good, 2 fair) were encouraging but less favorable than with the Ilizarov external fixator.

Hosalkar HS, Jones S, Hartley J, Hill R. Three-dimensional tomography of relapsed infantile Blount's disease. *Clin Orthop* 2005; 431:176–180. Three-dimensional computed tomography reconstructions were done in five patients undergoing Ilizarov correction for relapsed infantile Blount disease. Three patterns of medial plateau deformities were noted: medial slope, medial slope with central depression, and posterior and medial slopes with central depression. Authors report that these results are useful in preoperative planning to facilitate correct orientation of the Ilizarov fixator.

Deformity Correction

Kolodziej L, Kolban M, Zacha S, Chmielnicki M. The use of the Ilizarov technique in the treatment of upper limb deformity in patients with Ollier's disease. *J Pediatr Orthop* 2005; 25:202–205. Three children, ages 13–16 years, underwent lengthening and correction of angular deformities of five segments. Average length discrepancy was 8.4 cm in the arm and 4.5 cm in the forearm, but large angular deformities were the major problem. Full correction of angular deformity was achieved in all cases and restoration of arm length was achieved in all arms, but there was persistent forearm length discrepancy. One ulna required bone grafting. All patients reported great improvement in function and appearance and were satisfied. Enchondromas at lengthening sites resolved radiographically.

HMyers TG, Fishman MK, McCarthy JJ, Davidson RS, Gaughan J. Incidence of distal femoral and distal tibial deformities in infantile and adolescent Blount disease. *J Pediatr Orthop* 2005; 25:211. Values of the aL DFA at the distal femur, aLDTA at the distal tibia, and tibiofemoral angle (TFA) were measured on radiographs of 21 infantile and 17 adolescent Blount disease patients. The adolescent aL DFA was greater than for the infantile group and the normal database. The aLDTA (ankle) measurements did not differ significantly between the infantile and adolescent groups or from the normal database.

Price CT, Izuka B. Osteotomy planning using the anatomic method; a simple method for lower extremity deformity analysis. *Orthopedics* 2005; 28:20–25. Authors present a simplified method for deformity analysis and osteotomy planning based on plotting the normal joint orientation angles of the proximal and distal ends of the bone and the shaft axis of the bone. The intersection points determine the location and magnitude of the corrective osteotomy. Method was compared with previously described methods (paper tracing and mechanical axis methods); agreement was within surgical margin of error. Translational deformities, seen in post-traumatic but rarely in developmental conditions, can be identified with the method, but the location of the osteotomy site is not readily predicted.

Roukis TS, Zgonis T. Postoperative shoe modifications for weightbearing with the Ilizarov external fixation system. *J Foot Ankle Surg* 2004; 43:433–435.

Sabharwal S, Mittal R, Cox G. Percutaneous triplanar femoral osteotomy correction for developmental coxa vara: a new technique. *J Pediatr Orthop* 2005; 25:28–33. Authors report a series of five children (six hips), mean age of 8+4 (range 5+11 to 10+5) years, who underwent percutaneous proximal femoral osteotomies for treatment of developmental coxa vara. Average time in the fixator was 95 (range 77–106) days. Average improvement in Hilgenreiner's epiphyseal angle was from 74° preop to 33° postop. Neck-shaft angles improved from 86° preop to 137° postop. Articulotrochanteric distance improved from -6 to +11 mm postop. At mean follow up of 2.1 (range 0.35 to 3.8) years, there was no loss of correction.

Treadwell JR. Triple arthrodesis with an external rail fixator: a review of 8 cases. *J Foot Ankle Surg* 2004; 43:400–406. Eight patients underwent triple arthrodesis with a rail frame, which allowed immediate axial loading and unrestricted ankle joint mobilization. Periodic adjustment to compression was performed weekly until there was evidence of radiographic consolidation. Fusion occurred in all joints. Mean duration of frame application was 11.5 weeks.

Wang JW, Hsu CC. Distal femoral varus osteotomy for osteoarthritis of the knee. *J Bone Joint Surg Am* 2005; 87-A:127–133. Thirty patients underwent a distal femoral osteotomy, fixed with a 90° blade plate, for treatment of a valgus deformity, quantified by the tibiofemoral angle. Results were measured by the radiographic tibiofemoral angle, HSS knee score, ten-year survival, and the knee ROM.

Infection

Jain AK, Sinha S. Infected nonunion of the long bones. *Clin Orthop* 2005; 431:57–65. (See "Nonunion.")

Kolker D, Wilson MG. Tibiocalcaneal arthrodesis after total talectomy for treatment of osteomyelitis of the talus. *Foot Ankle Int* 2004; 25:861–865. Three patients underwent combined tibiocalcaneal and tibionavicular fusions for treatment of chronic talar infections secondary to complex fracture-dislocations of the talus. Staged radical debridement, total talectomy, and application of an articulated Synthes external fixator was done as Stage I; autologous interpositional bone graft and external fixator adjustment was done after 6 weeks of antibiotics. Solid union was achieved in an average of 14 (range 10–16) weeks.

Rozbruch SR, Ilizarov S, Blyakher A. Knee arthrodesis with simultaneous lengthening using the Ilizarov method. *J Orthop Trauma* 2005; 19:171–179. Four patients with a history of trauma, multiple surgical operations, and infection underwent knee arthrodesis and simultaneous lengthening of the tibia (3) or femur and tibia (1) with the Ilizarov method. Lengthening osteotomy was performed approximately 6 weeks after the fixator application. Three underwent acute compression at the arthrodesis site; one underwent bone transport with subsequent bone grafting. Mean lengthening was 5.4 (range 2.5–11.5) cm. Average time in frame was 11 (range 6–17) months. Limb length discrepancy after treatment averaged 18 (range 0.6–3.7) cm. Average length gained was 5.4 (range 2.5–11.5) cm. At follow up, there were no recurrences of infection or pain. SF-36 and AAOS lower limb modules improved in all cases.

Zalavras CG, Patzakis MJ, Thordarson DB, et al. Infected fractures of the distal tibial metaphysis and plafond: achievement of limb salvage with free muscle flaps, bone grafting, and ankle fusion. *Clin Orthop* 2004; 427:57–62. Six patients (age 20–63 years, mean 46) had distal tibia osteomyelitis following a fracture. Limb salvage protocol included (1) radical debridement and stabilization of the ankle with a bridging external fixator, (2) soft tissue coverage with free muscle flaps, and (3) ankle fusion using iliac crest graft for filling defects (average 4.2 cm). External fixator remained in place for 5–14 months. One patient needed an additional bone grafting. Mean leg length discrepancy was 1.7 (range 0–3.5) cm. Limb salvage is not recommended in patients with inadequate vascularity and other comorbid conditions.

Lengthening

Aguilar JA, Paley D, Paley J, et al. Clinical validation of the multiplier method for predicting limb length at maturity, part I. *J Pediatr Orthop* 2005; 25:186–191. Radiographs of 60 patients with LLD were measured to derive longitudinal data to validate multiplier method (MM) and to compare it to the Moseley and Anderson methods. Mean errors for prediction were 1.1 cm and 1.5 cm for the MM using chronological and skeletal age, respectively. Highest 90% error bound values of 4.4 cm in boys and 2.6 cm in girls occurred at ≤ 5 years, reached lowest values of 1.8 cm for boys at 9 years and 0.9 cm for girls at age 7, then peaked again at age 13 years and 10 years for boys and girls, respectively. Using chronological age had a lower mean prediction error and a narrower range of error because it is independent of percentile and ethnic differences. Skeletal age is more accurate during adolescence. MM has greater tendency to over-predict (58%) than under-predict (39%), but the tendency is to err in the same direction (81%) for both limbs. MM and Moseley methods are equally accurate, but MM can be used for one measurement, whereas Moseley method requires three.

Aguilar JA, Paley D, Paley J, et al. Clinical validation of the multiplier method for predicting limb length discrepancy and outcome of epiphysiodesis, part II. *J Pediatr Orthop* 2005; 25:192–196. Radiographs of 60 patients who underwent epiphysiodesis were measured to obtain longitudinal data. Residual discrepancy (RD), defined as LLD at maturity after epiphysiodesis, was measured. Residual discrepancy was also calculated using Moseley method and multiplier method (MM). The differences between the actual RD's and the predicted RD's using the MM and chronological age, MM and skeletal age, and Moseley method were not statistically significant. MM using chronological age had the lowest mean error; Moseley method had the highest mean error. The difference in the prediction error between the MM and Moseley method was statistically significant, due to the greater percentage of errors in the same direction using the MM.

Bosch M, Granell F, Faig–Martí J, Henríquez A. First metacarpal lengthening following traumatic amputation of the thumb: long-term follow-up. *Chir Main* 2004; 23:284–288. Report of 18 first metacarpal elongations in patients who sustained a non-replantable thumb amputation at the metacarpophalangeal level. A unilateral external fixator was used.

Gross RH. Limb lengthening for stature: another view. *J Pediatr Orthop* 2005; 25:128–129. Author recommends that patients being considered for lengthening for short stature should be at least in high school. If well informed, they will make the decision about lengthening that is right for them.

Grzegorzewski A, Synder M, Kozłowski P, et al. Leg length discrepancy in Legg–Calvé–Perthes disease. *J Pediatr Orthop* 2005; 25:206–209. The radiographs of 261 patients with unilateral LCP disease were reviewed at maturity to determine the incidence of LLD and to determine correlations between LLD and other parameters. LLD was more common but not greater in Herring C (average 2.82 cm). Average shortening for the whole group was 0.32 cm. 12.6% had a LLD of ≤ 1 cm. In patients with a LLD, average LLD was 2.51 (range 1–5.2) cm. A varus osteotomy produced greater LLD than the other treatment methods. The amount of residual shortening seems to depend on the extent of involvement and the presence of a growth arrest. There was no difference between patients with a LLD greater or less than 2.5 cm with regard to final Stulberg classification. Age, onset of symptoms, and sex did not influence amount of LLD.

Hatzokos I, Gigis I, Marinou A, Pournaras J. Bone lengthening for correction of limb length discrepancy in a patient with Klippel–Trenaunay syndrome: a case report. *Acta Orthop Belg* 2004; 70:623–626.

Inan M, Bomar JD, Kucukkaya M, Harma A. [A comparison between the use of a monolateral external fixator and the Ilizarov technique for pelvic support osteotomies]. *Acta Orthop Traumatol Turc* 2004; 38:252–260. Authors performed 17 pelvic support osteotomies for the treatment of neglected congenital hip dislocation. Seven had a monolateral external fixator (MEF); ten had a hybrid advanced Ilizarov method (HAIM). The MEF seems to be preferable because it was associated with a lower rate of pin tract infections and higher degree of patient comfort. Although knee ROM was similar in both groups, the MEF patients achieved knee flexion of 90 degrees in a shorter time.

Kennedy JG, Harty JA, Philips MC, et al. Bilateral femoral head osteonecrosis after femoral leg lengthening. *Am J Orthop* 2004; 33:612–614. Case report of a 15-year-old boy with hypochondroplasia who underwent bilateral femoral lengthenings and developed bilateral femoral head avascular necrosis seven weeks after the index procedure. Four cm of lengthening were achieved before stopping the distraction. Hypothesized etiologies include (1) deficiency in the intraosseous vascularity compounded by occlusion of the origin of the lateral ascending artery generated by the distraction forces and (2) intraosseous hypertension due to compression across the hip joint.

Machen MS, Stevens PM. Should full-length standing anteroposterior radiographs replace the scanogram for measurement of limb length discrepancy? *J Pediatr Orthop B* 2005; 14:30–37. Review article discusses the advantages of a full-length standing radiograph for measurement of limb length discrepancy and compares it to the scanogram, computed tomography, and microdose digital radiographs. Because of availability, cost, ability to quantify angular deformities, accuracy, ability to perform while weight bearing, and ability to quantify magnification, authors recommend the full-length standing radiograph.

Lengthening

Terry MA, Winell JJ, Green DW, Widman RF, et al. Measurement variance in limb length discrepancy. Clinical and radiographic assessment of interobserver and intraobserver variability. *J Pediatr Orthop* 2005; 25:197–201. Authors assessed interobserver and intraobserver variability in the assessment of clinical and radiographic measurements of limb length discrepancy. Clinical methods had excelled reliability but the large mean differences and large 95% confidence intervals limit the usefulness of these methods for timing of epiphyseodeses. Direct measurement of slit scanograms was the most reliable and had lowest inter- and intraobserver variance and lowest 95% confidence intervals.

Vucetic CS. Forearm elongation after hand replantation. *J Bone Joint Surg [Am]* 2005; 87:181–186. Case report of an 8 cm lengthening of the radius and ulna performed six months after a combined compression, avulsion, and third degree friction burn injury to the wrist area. Original injury resulted in a traumatic amputation through the wrist area, treated with replantation requiring 13 cm of bone shortening.

Nonunion

Babulkar S, Pande K, Babulkar S. Nonunion of the diaphysis of long bones. *Clin Orthop Rel Research* 2005; 431:50–55. Review of 113 patients with diaphyseal nonunions of the tibia (36), femur (23), humerus (21), radius (13), ulna (18), and clavicle (2). Nonunions were classified as hypertrophic or atrophic, septic or aseptic. All healed. Protocol A consisted of removal of the internal fixation device, excision of the nonunion, and restabilization with plate and screw. Protocol B consisted of removal of the IM nail, overreaming, and exchange nailing. Eleven patients, all with 2–4 cm of bone loss, had treatment with the Ilizarov technique.

El-Mowafi H, Mohsen M. The effect of low-intensity pulsed ultrasound on callus maturation in tibial distraction osteogenesis. *Int Orthop* 2005; 29: 121–124. Twenty tibial defects were treated with distraction osteogenesis. Ten received low-intensity pulsed ultrasound (LIPUS) at the bone lengthening site at the end of distraction; ten did not. Weekly radiographs showed the LIPUS group had a mean healing index of 30 (range 27–36) days/cm, whereas the controls had a mean healing index of 48 (42–75) days/cm. LIPUS is highly effective in achieving maturation of bone and reducing the time of distraction osteogenesis.

Giannikas KA, Maganaris CN, Karski MT, et al. Functional outcome following bone transport reconstruction of distal tibial defects. *J Bone Joint Surg Am* 2005; 87-A:145–152. Eight patients who had undergone bone transport for a distal tibial defect were reviewed. Gait parameters and strength were measured. There was significant loss of strength of the dorsiflexors and plantar flexors in the treated legs, attributed to shortening of the muscles originating on the transported segment.

Gold SM, Wasserman R. Preliminary results of tibial bone transports with pulsed low intensity ultrasound (Exogen). *J Orthop Trauma* 2005; 19:10–16. Eight patients with tibial defects (mean 10.25, range 8–14 cm) were treated with single-level bone transport. Exogen was applied at the regenerate site in the second postoperative site and at the docking site after docking was complete for 20 minutes daily at each site. This series was compared to a previously treated control group. Mean external fixation time was 13.9 (range 9–25.5) months. Mean external fixation index was 1.34 months/cm transported for the Exogen group; 2.02 months/cm for the control group, a difference of 17.21%. This reduction was not statistically significant due to the small number.

Jain AK, Sinha S. Infected nonunion of the long bones. *Clin Orthop* 2005; 431:57–65. Forty-two consecutive patients with infected nonunions of long bones were treated between 1990 and 2002. Bones affected include femur (10), tibia (10), humerus (7), forearm (9). Authors classify infection as Type A (infected nonunion with no drainage; quiescent) and Type B (infected nonunion with active drainage). Both are classified into subtypes: (1) nonunion with a bone gap smaller than 4 cm, (2) nonunion with a gap larger than 4 cm. Authors recommend treatment as follows: A1: Single-stage debridement, fracture stabilization, and bone grafting. B1: Debridement, fracture stabilization and second-stage bone grafting. A2 and B2: Distraction histogenesis. The autogenous non-vascularized fibular graft, posterolateral bone grafting of the tibia, and single bone forearm may be good treatment options in selected cases.

Katsenis D, Bhave A, Paley D, Herzenberg JE. Treatment of malunion and nonunion at the site of an ankle fusion with the Ilizarov apparatus. *J Bone Joint Surg Am* 2005; 87-A:302–309. Review of 21 ankles undergoing revision arthrodesis, average of 104 (range 10–480) months after primary fusion. Indications were malunion (11), aseptic nonunion (8), and infected nonunion (2). Ilizarov apparatus was used. Malunions were treated with supramalleolar osteotomies. Eight underwent single level lengthening; two underwent double level lengthening. Goals of treatment were limb length 1–1.5 cm shorter than contralateral side, neutral or slight hindfoot valgus, external rotation of the foot. Bone and functional results and complications are presented. Ability to correct the hindfoot and forefoot by adjusting the frame as needed during the regenerate phase is a unique advantage of the Ilizarov method, allowing correction of any intraoperative errors.

Knothe UR, Springfield DS. A novel surgical procedure for bridging of massive bone defects. *World J Surg Oncol* 2005; 3:7. New surgical procedure to bridge a massive long bone defect is described. An in situ periosteal sleeve is elevated circumferentially off of healthy diaphyseal bone adjacent to the defect. Then, the adjacent bone is osteotomized and the transport segment is moved along an intramedullary nail, out of the periosteal sleeve and into the original defect, where it is docked. Vascularity is maintained through retention of the soft tissue attachments to the in situ periosteal sleeve. Periosteal osteogenesis can be augmented with bone graft. This procedure requires no special implants or expensive orthobiologics and affords rapid patient mobilization.

Nonunion

Lee M. Nonunions of the humerus. *J Hand Ther* 2005; 18:51–53. Review article of proximal, diaphyseal, and distal nonunion treatment options. Plating is generally successful, but intramedullary nailing or external fixators may be used when adequate compression can be achieved. In so-called malignant nonunions, Ilizarov external fixators, resection arthroplasty, or accepting very limited use of the extremity may be necessary.

Ohnishi I, Sato W, Matsuyama J, et al. Treatment of congenital pseudarthrosis of the tibia: A multicenter study in Japan. *J Pediatr Orthop* 2005; 25:219–224. Seventy-three patients from 32 Japanese hospitals were treated for CPT between 1980 and 2002. Surgical techniques included Ilizarov technique (26), free vascularized fibular graft (25), combination of the two techniques (7), intramedullary nailing with free bone graft (6), plating with free bone graft (5), and other (4). A total of 188 procedures were performed. Fifty-four achieved union. Twenty-nine had no residual deformity. Average residual shortening was 3.2 ± 3.3 (range 0–15) cm. All patients treated with the Ilizarov method, with or without vascularized fibular graft, achieved union, with 5 refractures.

Ring D, Prommersberger K, Jupiter JB. Posttraumatic radial club hand. *J Surg Orthop Adv* 2004; 13:161–165. Retrospective review of 15 adults with nonunions of the distal radius and severe radial deviation. Mean age was 57 (range 33–79) years. Six had concomitant ulnar fractures; four had distal radioulnar dislocations. Three were treated with wrist arthrodesis; twelve with plate fixation and autogenous bone grafting. Correction of the deformity was facilitated by Z-lengthening of the brachioradialis and flexor carpi radialis in four, distraction histogenesis (Ilizarov) in two. One patient failed to heal the nonunion and was treated with wrist arthrodesis. Functional alignment and use of the hand was restored in all patients.

Other

Gabos PG, El Rassi G, Pahys J. Knee reconstruction in syndromes with congenital absence of the anterior cruciate ligament. *J Pediatr Orthop* 2005; 25:210–214. Four patients with mean age of 15.8 (range 14–17) years underwent ACL reconstruction. Etiologies were skeletal dysplasia, fibular hemimelia, and congenital short femur. All had previous surgery for lengthening and deformity correction. All had knee instability with walking. Complete absence of ACL (4) and hypertrophy of the meniscofemoral ligament (3) of Humphrey were noted. At followup, Lachman was negative in one patient and +1 in the other three. Lysholm II scores improved dramatically, but long-term outcomes are unknown.

Sikka RS, Fischer DA, Swiontkowski MF. Reprocessing single-use devices: an orthopaedic perspective. *J Bone Joint Surg* 2005; 87A:450–457. Article discusses risks and benefits, legal and ethical issues of reusing single-use devices, including external fixators. Reprocessors of external fixation frames must submit 510(k) data (information on performance, sterilization, and the maximum number of times that the device may be reprocessed) indicating that the device is equivalent to the original device. Yet, despite validation data and FDA approval for reuse of single-use devices, only one-quarter of hospitals claim reuse of them.

Thacker MM, Feldman DS, Madan SS, et al. Hinged distraction of the adolescent arthritic hip. *J Pediatr Orthop* 2005; 25:178–182. EBI articulated external fixator distracted hip joint in eleven adolescents (age 9–17) with hip arthritis due to idiopathic chondrolysis (3) or osteonecrosis (8). Patients used a CPM and had vigorous ROM therapy postoperatively. Distraction of at least 5mm was performed for an average of 132 days (range 3–7 months). Mean joint space increase from 2.6 mm preop to 4.8 mm at latest follow up. Seven had an excellent outcome; three had good outcome. One failed treatment. Complications occurred in 4/11 (36%) of patients.

Zarutsky E, Rush SM, Schuberth JM. The use of circular wire external fixation in the treatment of salvage ankle arthrodesis. *J Foot Ankle Surg* 2005; 44:22–31. Forty-three patients underwent ankle arthrodesis with a circular external fixator. Solid fusion or stable pseudarthrosis was achieved in 80.5%. Major complication rate was 51.2%, including BK amputation (3), unstable nonunion (7), malunion (3), tibial stress fracture (2), and osteomyelitis and/or deep space infection (7). Incidence of complications was higher in diabetes, smokers, and an increased BMI. Incidence of nonunion increased with longer followup, suggesting the early presumption of a solid union may be erroneous.

Research

Antoci V, Roberts CS, Antoci V, Voor MJ. The effect of transfixion wire number and spacing between two levels of fixation on the stiffness of proximal tibial external fixation. *J Orthop Trauma* 2005; 19:180–186. Stiffness of an idealized circular external fixator on a composite tibia model was measured after various wire numbers (2–5) at the same level (within 1 cm) on a single ring and after two wires on a single proximal ring combined with two wires on a second more distal ring at various distances (2–10 cm) from the proximal ring. A four-ring Ilizarov frame was also tested to compare the rigidity of the idealized frame to the Ilizarov frame to isolate wire behavior from frame behavior. Each incremental increase in wire number led to a significant increase in stiffness. There was also increased bending stiffness with increasing separation between the first and second levels of fixation. Axial and torsional stiffness was proportional to the total number of wires, regardless of the number of levels of fixation. (Wires were inserted at the same level instead of opposite sides of the rings. Some wire placement patterns would not be practical due to anatomic constraints.)

Research

Carinci F, Pezzetti F, Spina AM, et al. An in vitro model for dissecting distraction osteogenesis. *J Craniofac Surg* 2005; 16:71–78; discussion 78–79. Authors used a preosteoblast MC3T3–E1 cell line to detect the early molecular effects of distraction on mesenchymal cells and identified several genes that were significantly up – or down – regulated. The differentially expressed genes cover a broad range of biological processes: cell growth, metabolism, morphogenesis, cell communication, response to stress, and cell death. The data reported one of the first genetic portraits of stretched osteoblasts.

Li G, Ryaby JT, Carney DH, Wang H. Bone formation is enhanced by thrombin-related peptide TP508 during distraction osteogenesis. *J Orthop Res* 2005; 23:196–202. Thrombin-related peptide TP508 has been shown to promote soft tissue healing and fracture repair. Authors studied effect of TP508 on lengthened rabbit tibias by injecting TP508 into the distraction site at the beginning and completion of lengthening. Animals with TP508 injections had significantly greater BMD than saline controls, but there was no difference between higher and lower TP508 doses. Bone consolidation and bone remodeling was greater in the higher dose animals than in the lower dose animals, which showed focal bone defects and discontinuities of the new cortices. TP508 may be useful in promoting osteogenesis in situations when augmentative treatment for bone formation and consolidation is needed.

Liu RW, Kim YH, Lee DC, et al. Computational simulation of axial dynamization on long bone fractures. *Clin Biomech (Bristol, Avon)* 2005; 20:83–90. Study of two unilateral external fixators (DynaFlex and Orthofix) to analyze the fixator joint adjustments used and the fracture site movements generated during dynamization. When the sliding joints were not parallel to the long axis of the bone, nonaxial movement occurred during dynamization. The dual sliding joint design of the DynaFlex fixator was beneficial in reducing nonaxial movements. When all the fixator joints were allowed to adjust simultaneously during dynamization, exact axial movement or uniform compression of a complicated fracture site was achievable. In conclusion, the nonaxial movement can be corrected by relaxing certain fixator joints in addition to the sliding mechanism.

Luo QF, Wang X, Wang XX, et al. [The effect of platelet-rich plasma on the distraction osteogenesis]. *Zhonghua Zheng Xing Wai Ke Za Zhi* 2004; 20:376–379. Platelet-rich plasma (PRP) stimulated the proliferation of osteoblasts and facilitated distraction osteogenesis as seen in osteoblasts cultured in vitro and in rabbits, respectively. PRP might shorten the period of distraction osteogenesis in humans.

Mueller CA, Eingartner C, Schreitmueller E, et al. Primary stability of various forms of osteosynthesis in the treatment of fractures of the proximal tibia. *J Bone Joint Surg [Br]* 2005; 87:426–432. Stability of six fixation methods (lateral buttress plate, LISS plate, unreamed tibial nail, cannulated tibial nail, external fixator, and hybrid external fixator) was measured for fracture model of tibia fracture at metaphyseal–diaphyseal junction. Nailing systems tolerated the highest forces. Varus and valgus stability was greatest with the nailing systems. Rotational stability was the least with the buttress plate; the other five devices were quite similar to each other. Sagittal stability was within the same range for all the implants, with no implant showing clear superiority.

Muller MC, Kramer FJ, Swennen GR, et al. A comparison of two types of free bone grafts as transport discs in segmental distraction for reconstruction of calvarial bone defects: an experimental study. *Arch Orthop Trauma Surg* 2004; 124:665–674. Authors investigated the use of free bone grafts to reconstruct calvarial defects in sheep. Six sheep underwent bone transport with an autotopical calvarium segment to reconstruct a 6 x 5 cm calvarial defect; six sheep underwent transport with a heterotopical enchondral material from the iliac crest. Better quality regenerate was seen in the calvarial transport model. Authors concluded high mechanical stability, as seen in the calvarium segment model, was very important when selecting a free graft for use as a transport disc in local bone transport, especially if transport is necessary over long segments. The importance of preserving the blood supply to the transport disc has been overestimated.

Srouji S, Bwmenfeld I, Rachmiel A, Livine E. Bone defect repair in rat tibia by TGF- β 1 and IGF-1 released from hydrogel scaffold. *Cell Tissue Bank* 2004; 5:223–230. Rat tibial defects were treated with external fixation and insertion of hydrogels containing TGF- β , IGF-1, TGF- β + IGF-1, or saline, or saline alone. Bone treated with growth factors showed better bone formation at 4 and 6 weeks than controls. Percent closure ratio of bone defects after 6 weeks were 40, 80, 89, and 97% for saline, hydrogel, IGF-1, TGF- β , and TGF- β + IGF-1 groups. Hydrogel scaffold can serve as a good osteoconductive matrix for growth factor and could be used as an alternative graft material.

Windhagen H, Witte F, Thorey F, et al. [Injectable carrier system for growth factor application in minimally invasive stimulation of bone healing]. *Orthopade* 2004; 33:1378–1385. Authors investigated the use of two carrier systems for growth factors during distraction osteogenesis. Collagen carriers provided a higher practicability for injection procedures and higher efficiency compared to calcium phosphate carriers, which showed a rather low user-friendliness and less efficiency.

Trauma – Lower Extremity

Assal M, Stern R. Total extrusion of the talus. A case report. *J Bone Joint Surg [Am]* 2004; 86:2726–2731. Case report of total talar extrusion in a 26-year-old motorbike rider, treated with pulsatile lavage and replacement without external fixation. An external fixator with two tibial pins and one pin in the calcaneus, fifth metatarsal and first metatarsal immobilized the foot and ankle in neutral. At five-year follow up there was slightly decreased ROM but no instability and no AVN.

Trauma – Lower Extremity

Bhandari M, Zlowodzki M, Tornetta P, 3rd, et al. Intramedullary nailing following external fixation in femoral and tibial shaft fractures. *J Orthop Trauma* 2005; 19:140–144. Authors reviewed studies between 1980 and 2003 to evaluate infection and nonunion rates in patients treated with temporary external fixation and secondary intramedullary nailing for lower extremity long bone fractures and to evaluate whether the duration of external fixation and time to internal intramedullary nailing influence the rate of infection. Based on current available evidence, plausible infection rate of nailing following external fixation averages 3.6% in the femur, 9% in the tibia. Length of external fixation \leq 28 days reduces the rate of infection in the tibia.

Braten M, Helland P, Grontvedt T, et al. External fixation versus locked intramedullary nailing in tibial shaft fractures: a prospective, randomised study of 78 patients. *Arch Orthop Trauma Surg* 2004; 125:21–26. This randomized study of 79 closed tibial shaft fractures in 78 patients compared results of a unilateral dynamic axial fixator (EF) with results of locked intramedullary nails (IMN). Time to radiographic and full weightbearing was similar. Unprotected weightbearing was achieved earlier with IMN. There were more reoperations in the EF group. At six months and one year, there was no difference in knee motion, ankle motion, fracture site pain, or ankle pain. Sixty-four percent of IMN patients complained of anterior knee pain after one year.

Carr JB. Surgical treatment of intra-articular calcaneal fractures. A review of small incision approaches. *J Orthop Trauma* 2005; 19:109–117. Internal and external fixation methods are discussed. An Ilizarov fixator can be used to control the extraarticular shape with or without a limited lateral approach for the posterior facet. It should be considered for severely displaced fractures and difficult soft-tissue problems.

Celikoz B, Sengezer M, Isik S, et al. Subacute reconstruction of lower leg and foot defects due to high velocity-high energy injuries caused by gunshots, missiles, and land mines. *Microsurgery* 2005; 25:3–15. Review of 215 patients with bony defects of the leg or foot treated with amputation or various bony and soft tissue reconstructive techniques. Early aggressive serial debridements of osseous and soft tissue, early restoration of bone and soft-tissue defects at the same stage, rehabilitation, and patient education were the key points in the management of these injuries.

Eimori K, Ogose A, Hotta T, et al. Treatment of pathological fracture of the femur due to diffuse haemangioma in the lower limb. A report of two cases. *J Bone Joint Surg [Br]* 2005; 87:412–414. Two cases of pathologic femoral shaft fractures in patients with diffuse hemangiomas of the thigh. A 78-year-old woman had a pathologic femoral shaft fracture, treated with an external fixator and autogenous bone marrow injections every 2–3 months. The fixator was removed two years after the fracture.

Georgiadis GM, Haman SP. Temporary external fixation across the ankle after tibial nailing. *J Orthop Trauma* 2005; 19:201–204. Authors report using an intramedullary nail for treatment of tibial fractures associated with extensive soft tissue injury, combined with an external fixator spanning the tibia and ankle for 3–6 weeks. Purposes of the fixator are to prevent equinus and to prevent muscle movement and shear forces on soft tissue reconstruction.

Giannoudis PV, Roberts CS, Parikh AP, et al. Knee dislocation with ipsilateral femoral shaft fracture. A report of five cases. *J Orthop Trauma* 2005; 19:205–210. Authors report management and outcome of 4 patients with 5 knee dislocations and ipsilateral femoral shaft fracture, treated with immediate reduction of the knee dislocations, intramedullary nailing of the femur, and angiography, followed by a hinged knee brace (3) or a spanning external fixator (1). Authors prefer a hinged knee brace but recommend external fixation when bracing is not feasible, such as in the presence of major soft-tissue injuries.

Hedin H, Larsson S. Technique and considerations when using external fixation as a standard treatment of femoral fractures in children. *Injury* 2004; 35:1255–1263. Prospective report on consecutive series of 98 femoral shaft fractures in 96 children ages 3–15 years treated with Stryker unilateral four-pin fixator. Fracture table was used to avoid malrotation and to minimize shortening. Dynamization was not used because it would require more office visits and x-rays. Nihilistic approach to pin care was used. There was one refracture through a pin site, one refracture through the original fracture site. Minor complication rate was 10%; major complication rate was 5%. None of these complications caused long-term problems.

Kesemenli CC, Necmioglu S, Kayikci C. Treatment of refracture occurring after external fixation in paediatric femoral fractures. *Acta Orthop Belg* 2004; 70:540–544. Eleven fractures occurred in 104 children with femoral fractures originally treated with external fixation. Treatment consisted of immediate placement in a hip spica cast. Refracture occurred an average of 8 (range 1–21) days after fixator removal. Mean time to union was 55 (range 35–62) days. On final evaluation, mean LLD was 0.9 cm; mean anterior angulation was 7.4 degrees; and mean lateral angulation was 5.6 degrees. Closed reduction and hip spica immobilization were sufficient in this series, but surgical treatment should be considered when satisfactory reduction cannot be achieved.

Melichar J, Horalek F, Novotny F, et al. [Conversion of an external fixation to that with an intramedullary pin in cases of complicated diaphyseal fractures]. *Rozhl Chir* 2004; 83:396–398. Authors present a technique of conversion from external fixation to intramedullary fixation of femur and tibia fractures and report it is advantageous in polytrauma and in threatening or present compartment syndrome.

Trauma – Lower Extremity

Piper KJ, Won HY, Ellis AM. Hybrid external fixation in complex tibial plateau and plafond fractures: an Australian audit of outcomes. *Injury* 2005; 36:178–184. Review of 24 consecutive patients treated with a hybrid external fixator. Twelve had tibial pilon fractures; twelve had tibial plateau fractures. Initially the ACE–Fisher frame was used, more recently the Stryker–Tenxor frame. Twelve patients had limited internal fixation. Four had primary bone grafts. At follow up (mean 13 months, range 4–29 months), outcomes were similar to international standards.

Poelstra KA, Kahler DM. Supra–acetabular placement of external fixator pins: a safe and expedient method of providing the injured pelvis with stability. *Am J Orthop* 2005; 34:148–151. Authors prefer a supra–acetabular pin placement technique versus iliac wing site because the former is in a thick area of the ilium, can be inserted without x–ray guidance, and is well tolerated by the patient. Pin is inserted 2 cm distal to the ASIS in the narrow anterior edge, aiming 10° cephalad and 15–20° medial to the sagittal plane.

Roberts CS, Pape H–C, Jones AL, et al. Damage control orthopaedics. Evolving concepts in the treatment of patients who have sustained orthopaedic trauma. *J Bone Joint Surg* 2005; 87A:434–449. Use of spanning external fixation in damage control orthopaedics reduces risks of adult respiratory distress syndrome and multisystem organ failure without increasing risk of infection.

Sangkaew C. Distraction osteogenesis for the treatment of post traumatic complications using a conventional external fixator. A novel technique. *Injury* 2005; 36:185–193. Author reports the use of an AO/ASIF conventional external fixator to correct post–trauma sequelae by lengthening, angulation and bone transport. There were 33 femurs, 43 tibias, and one ulna. Distraction rate was 1 mm in one step on alternate days (1 mm/48 hours). New bone was achieved in the distraction gap in 73/77 limbs. Technique and results are illustrated. Although author recommends this technique as simple and cost–effective, his illustrations show incomplete correction of deformities.

Stavlas P, Polyzois D. Septic arthritis of the major joints of the lower limb after periarticular external fixation application: are conventional safe corridors enough to prevent it? *Injury* 2005; 36:239–247. Authors review previous studies about wire and pin placement near the hip, knee, and ankle joints. Safe distance from the knee is 14 mm from the subchondral line of the tibia. Safe distance from the ankle is probably 10 mm. Safe distance above the hip is 2 cm. Detailed pin hygiene protocol is also important to avoid infections.

Topliss C, Jackson M, Atkins RM. Dermal traction on the Ilizarov frame. *Injury* 2005; 36:194–198. Seven patients with open tibial fractures were treated with external fixation, incorporating skin traction. Traction was exerted by multiple 3–0 nylon sutures through the dermis, pulling perpendicular to the skin edge, attached to a traction toggle anchored to a ring or Rancho cube. Alteration of the toggle position created tension to progressively close wound. Mean area of wound was 41 (range 16.5–85) cm². In 4 cases, the wound was closed by the end of the operative procedure. In one patient, closure was obtained in 5 days. In 2 cases, complete closure could not be achieved, but the size of the defects was reduced dramatically. One patient, a heavy smoker, had wound breakdown after 21 days and then healed satisfactorily. By avoiding additional wires and motors, patients' confusion and frame weight are decreased.

Trauma – Upper Extremity

Attias N, Lehman RE, Bodell LS, Lindsey RW. Surgical management of a long segment defect of the humerus using a cylindrical titanium mesh cage and plates. A case report. *J Orthop Trauma* 2005; 19:211–216. Case report of a 19–year–old man who sustained a III–B open fracture of his right humerus due to gun shot, associated with segmental bone and soft tissue loss. A titanium mesh cage packed with allograft and demineralized bone matrix putty and 2 limited contact DCP plates were used to treat an 8cm bone defect. At 13 months, the plain radiographs and CT scan showed healing. This procedure was performed 4 months after the injury, following soft tissue reconstruction and external fixator stabilization.

Badia A, Riano F, Ravikoff J, et al. Dynamic intradigital external fixation for proximal interphalangeal joint fracture dislocations. *J Hand Surg [Am]* 2005; 30:154–160. Six fingers with fracture–dislocations of the PIP joint underwent treatment with an external fixator designed to maintain reduction and to allow ROM. One 0.045 inch wire transversely crosses the proximal phalanx at the center of its head. A second 0.045 inch wire crosses the center of the head of the middle phalanx. Reduction is achieved with either closed or limited open reduction. The proximal wire is bent and hooked to the distal wire to maintain length, yet allow flexion and extension. At follow up, average ROM was 5° to 89° (range 0–100°). Proper reduction and congruency of the joint was achieved in all cases.

Bednar DA, Al–Harran H. Nonbridging external fixation for fractures of the distal radius. *Can J Surg* 2004; 47:426–430. Six cases of distal radius fractures were treated with a nonbridging small AO external fixator, incorporating distal fixation in the periarticular fragment and allowing mobilization of the wrist during healing. Compared to historical controls treated with a bridging construct, the nonbridging fixator patients had improved radiographic alignment and similar incidence of pin tract sepsis.

Trauma – Upper Extremity

Hasler CC, Von Laer L, Hell AK. Open reduction, ulnar osteotomy and external fixation for chronic anterior dislocation of the head of the radius. *J Bone Joint Surg Br* 2005; 87:88–94. Review of 15 patients with chronic anterior radial head dislocation. Mean age was 9.5 (range 5–15) years. Twelve had a history of trauma, averaging 22 months (range 2 months to 7 years) prior to surgery. Main indications included loss of flexion, loss of extension, pain, valgus deformity. Contraindications were deformity of the radial head or capitellum. A 4 pin Stryker–Howmedica fixator was applied to the ulna. An ulnar osteotomy and, if closed reduction was unsuccessful, open reduction of the radiocapitellar joint was performed with no annular ligament reconstruction. The ulna was angulated into flexion, with varus or valgus angulation or elongation added to achieve a stable reduction under direct vision in all combinations of flexion, extension, and rotation. Exercises began on the first postoperative day. Results and comparisons to other treatment methods are presented.

Hegeman JH, Oskam J, Vierhout PA, ten Duis HJ. External fixation for unstable intraarticular distal radial fractures in women older than 55 years. Acceptable functional end results in the majority of patients despite significant secondary displacement. *Injury* 2005; 36:339–344. Sixteen women, ages 62–78, with unstable distal radial fractures were treated with an external fixator. K-wires were added if necessary. Secondary displacement occurred in eleven, probably due to comminution and perhaps osteoporosis. Functional results were good in 10, fair in 2, poor in 4 (reflex sympathetic dystrophy in 3). The degree of loss of reduction was related to the functional end result.

Lerner A, Stein H, Calif E. Unilateral hinged external fixation frame for elbow compression arthrodesis: the stepwise attainment of a stable 90-degree flexion position: a case report. *J Orthop Trauma* 2005; 19:52–55. Case report of a high-energy sideswipe injury of the elbow treated with serial irrigation and debridement. An external fixator was applied to gradually flex the elbow from full extension to 90° flexion in 23 days. Solid arthrodesis was achieved within two months. The need for flap coverage was obviated.

Lin C, Sun JS, Hou SM. External fixation with or without supplementary intramedullary Kirschner wires in the treatment of distal radial fractures. *Can J Surg* 2004; 47:431–437. Outcomes of 20 distal radius fractures treated with external fixation were compared to 36 distal radius fractures treated with external fixation supplemented with intramedullary Kirschner wires. Radial height, radial inclination, and avoidance of volar tilt were significantly better at follow up in the group treated with Kirschner wire supplementation.

Micc I, Mitkovic M, Mladenovic D, et al. [External fixator by Mitkovic in the treatment of comminuted intraarticular fractures of the distal radius]. *Med Pregl* 2004; 57:473–479. Seventy-three patients with closed comminuted intraarticular fractures of the distal radius were treated with a Mitkovic external fixator (30) or a Mitkovic external fixator and Kirschner wires (43). At follow up (minimum of 2 years), results are excellent (53.4%), good (26%), fair (13.7%), and poor (6.8%). Anatomic reduction of the articular fracture and healing of the fracture in a proper functional position were prerequisites for adequate wrist and hand function, achievable with the Mitkovic external fixator, with or without Kirschner wires.

Obert L, Leclerc G, Lepage D, et al. [Fractures of the distal radius treated by osteosynthesis and injectable bone substitute: a prospective study of 39 patients]. *Rev Chir Orthop Reparatrice Appar Mot* 2004; 90:613–620. Forty-eight patients with distal radius fractures were treated with injectable bone substitutes to fill the gap left by comminution. Fixation was achieved with pins (32), posterior plate (14), and an external fixator (2). One patient developed carpal tunnel syndrome, attributed to anterior cement leakage. This easy-to-use injectable bone substitute offers two advantages: adaptation to the primary bone defect and primary stability. It is resorbed slowly.

Okcu G, Aktuglu K. Management of shotgun induced open fractures of the humerus with Ilizarov external fixator. *Ulus Travma Derg* 2005; 11:23–28. Eleven shotgun-induced open humeral fractures treated emergently with the Ilizarov external fixator were reviewed. No patient had a neurovascular injury. Complete bony union occurred in all patients in an average of 21 (range 14–44) weeks. Good to excellent results were achieved in ten of the eleven patients.

Singh S, Trikha P, Twyman R. Superficial radial nerve damage due to Kirschner wiring of the radius. *Injury* 2005; 36:330–332. Eight patients (20%) with injury to the sensory branch of the superficial radial nerve were identified in a series of 40 patients with distal radius fractures. To minimize the chance of this iatrogenic problem, authors recommend using a tourniquet during insertion and during removal if wires are buried under skin, limited open technique, blunt dissection down to bone, and use of tissue guard to protect soft tissues.

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