arising from the anteromedial aspect of the upper femur. The CT examination showed no extension of the lesion into the surrounding soft tissues and the lungs were clear, giving the provisional diagnosis of an aneurysmal bone cyst. Open biopsy of the lesion confirmed this diagnosis.

Because of the size of the lesion and the site from where it arose, it was decided not to proceed with curetage but to observe the patient closely, with regular clinical and radiological examinations.

Two years later the cyst had ossified almost completely and had regressed in size.

Only two other aneurysmal bone cysts with healing after biopsy have been documented in the literature.

216. Gigantic intraosseous Schwannoma

Constantinos Toptsis, Paraskevas Chatzidis, Demetrius Pouliopoulos, Panayotis Antonakakis and Afroditi Patzaki

Thessaloniki Greece

Schwannoma, a rare benign nerve sheath tumour, is even rarer in its intraosseous location. It is usually small, the largest reported not exceeding 4–6 cm in diameter.

We report on an unusually large tumour, 13cm in diameter in its spherical endothoracic portion. The tumour eroded nearly half of the Th11 vertebral body and its left pedicle and entered the spinal canal, embracing the cord. It expanded also and mainly in the left thoracic gutter. Here it attained a spherical shape, displacing the left Crus-diaphragm, left kidney and spleen forwards and caudally and the lung up and forwards. Although the tumour was studied extensively (blood cytology, chemistry, serology, plain radiographs, CT-scan, MRI), the diagnosis of Schwannoma was not suspected. Asymptomatic as such, the tumor was seen on the chest radiographs taken for mild tachycardia.

Through a posterolateral approach the tumour was found, encapsulated and easily removed. No relation of the tumour to the spinal cord or costal nerves was found. It was regarded as arising from inside the bone of the Th11 vertebra and, with time, expanding to areas of least resistance. Histology excluded malignancy.

After removal, a Th10–Th12 anterior spondylodesis was carried out. Eight months later the patient remains asymptomatic and well.

Leg distraction

217. Distraction osteogenesis and its clinical applications

Renato Spinelli

Instituto Ortopedico Rizzoli, Bologna, Italy

Distraction osteogenesis (DO) is the special regeneration which is the basis of the bone lengthening obtained in a bone, when two fragments, after osteotomy or fracture, are gradually pulled apart. Necessary conditions are the relative integrity of the periosteum and optimal mechanics of the fixation/distraction apparatus.

The experimental aspects of the regeneration during the lengthening period were studied by us before applying the methods to humans. Five subsequent stages can be recognized:

1) Hematoma; 2) Fibroblastic activity; 3) Osteoid; 4) Corticalization; 5) Remodelling.

Since 1975, when we first used distraction epiphyseolysis (DE) in adolescents, and after 1980, when we introduced Ilizarov's corticotomy (CT), we have performed 494 procedures of lengthening, from 3 to 27 cm in a single procedure in a single bone (mean 6.6). Including whole limbs up to 37 cm lengthenings were obtained (single lengthenings of tibia + femur).

Both DE and CT have mainly been used in cases of congenital shortness (65%) but also in other etiologies.

The patient's age has ranged between 5 and 36 years.

Cases treated to the end of 1990 are included here. Adverse events have been frequent but as a rule not severe, provided a constant surveillance was granted. Adverse events were divided: inconveniences, problems, complications and sequelae. There is a significant, rather long, learning curve. Distraction osteogenesis was used for other procedures than simple lengthenings, e.g. realignments under distraction of varus, valgus, pro-recurvatum, torsional deformities, associated distraction and compression modes in nonunions with shortening, filling bone defects with the "elevator" technique.

218. Treatment of large tibial defects by segmental callotasis with the Orthofix® apparatus

Klaus Bak, Sören W. Rasmussen, Cristen Krag[1] and Carsten Törholm

Departments of Orthopedics and [1]Plastic Surgery, Gentofte Hospital, University of Copenhagen, Hellerup, Denmark

Introduction: Callotasis is a new method for the treatment of bone defects which implies slowly controlled distraction thereby utilizing the patient's capability of osteogenesis. Segmental callotasis is preferred with large bone defects. Various types of external fixators have been used for this

purpose. By means of cone-formed pins and a single lateral bar, the Orthofix system gives sufficient stability to allow early weight-bearing.

Method: After applying the Orthofix external fixator a subperiosteal osteotomy (corticotomy) is performed. Segmental callotasis is initiated after 2 weeks. The patient moves the segment 1 mm a day by turning a screw on the side of the bar. The apparatus can be removed when the conjoining segments have merged and callus is seen.

Results: Since 1988 two patients with large tibial defects (8 cm) after complicated shin fractures have been treated by this method. The first patient was scheduled for a below-knee amputation when he accepted to undergo segmental callotasis. As a final result he walks without crutches and is content with the result. The other patient healed after 8 months and suffered no major complications. Both patients had unchanged joint mobility as compared with preoperatively.

Conclusion: The advantage of the method seems to be a shorter period of recovery and the possibility of full weight-bearing. Furthermore, joint mobility is preserved. When pin-hole care is carried out daily, the Orthofix apparatus can be worn for several months.

219. Bone remodelling after leg lengthening—evaluation with plain radiographs, CT, and MR scans

Björn Tjernström, Karl-Åke Thoumas[1] and Peter Pech[1]

Departments of Orthopedics and [1]Radiology, University Hospital, Uppsala, Sweden

Material: Callus distraction techniques were used to correct leg length inequality in 10 patients (age 14–21; 6 women, 4 men). The shortening was 4 to 9 cm, with an average of 5.9 cm. The femurs of 9 patients were lengthened with Orthofix and the tibia of one was lengthened with an Ilizarov frame. The lengthening achieved ranged from 3 to 9 cm, with an average of 5.4 cm. The fixator time varied from 129 to 254 days, with an index ranging from 23 to 46 days (average 32 days).

Technique: Following lengthening, clinical evaluation and plain radiography were used to determine the strength of the new bone before removal of the external fixation. After removal of the fixator, the patients were monitored with plain radiographs and CT scans at 3-month intervals. Four were also examined with MR scans.

Results: When the external fixator was removed MR scans could not visualize any continuous fat signals in the lengthened region, which suggested the absence of medullary cavity. CT scans disclosed a double cortex in three cases and irregular formation of the new bone in seven. After 6 months a medullary cavity could be detected and the irregularity of the new bone and the double cortex appearance were less evident. The remodelling of the new bone material takes at least one year to achieve and appearance similar to the surrounding bone.

Conclusions: Plain radiographs are needed for assessments of the degree of lengthening, axial deviations and callus formation. CT scan can show considerable irregularity of the new bone or double cortex. During the 12 months of this study the bone of the lengthened region was continuously remodelled. MRI scans showed fat signal in the lengthened region three to six months following the removal of the external fixator indicating the presence of a medullary cavity.

220. Leg length inequality—preoperative complaints and outcome 1–10 years after leg lengthening

Björn Tjernström

Department of Orthopedics, University Hospital, Uppsala, Sweden

Introduction: Leg length inequality (LLI) of more than 2–3 cm is believed to cause low back pain and complaints from the joints of the lower extremities. Leg lengthening has gained increasing popularity with the new techniques introduced by Ilizarov and DeBastiani. Most studies have dealt with the technical aspects rather than the patients opinion of the results.

Material and methods: 100 lengthenings on 85 patients were performed from 1980 to 1991. The LLI was 2.5–13 cm. Three different techniques have been used: direct lengthening, Wagner lengthening and callus distraction. The femur was lengthened in 67 cases and the tibia in 33 cases. The lengthening was 2–13 cm. The mean age of the patients was 21 (4–55) years. 77 patients (90%) have answered a questionnaire regarding preoperative and current complaints. Wilcoxon signed-rank test was used for paired comparisons.

Results: Patients younger than 20 years of age had very few complaints in spite of major LLI. Moderate to severe back ache was reported by 37 preoperatively and at follow up by 27 (p=0.01). 12 complained of pain from the hip of the long leg before equalisation and 5 after (ns). 20 complained of pain from the hip of the short leg before equalisation and 11 after (p=0.01). 13 complained of pain from the knee of the long leg before equalisation and 11 after (ns). 27 complained of pain from the knee of the short leg before equalisation and 22 after (ns). Moderate to severe limp was experienced by 54 patients before and by 24 after the lengthening (p=0.0001). The walking capacity improved in 60 patients but was impaired in 8 (p=0.0001). 37 found that the cosmetic apperance improved and 21 that it deteriorated (ns). 38 patients were working at the follow-up, 29 were studying, 6 were on sick-leave and 4 were retired; 38 stated that their working capacity was improved and 9 that it was impaired. 16 patients reported decreased and 15 improved range of knee motion, while 14 patients reported decreased

and 15 improved range of ankle motion. 61 patients were satisfied, 5 not satisfied and 11 were uncertain whether they had benefited from the leg lengthening.

Conclusions: Most patients seem to be satisfied with the results of leg lengthening. Patients younger than 20 years of age have very few complaints of LLI. After the age of 20 years the main complaints of LLI are back ache, pain from the knee on the short side and limp. Leg lengthening seems to reduce these problems.

221. Long time muscle function after femoral shortening—a follow up study of subtrochanteric and middiaphyseal osteotomies

L. Nordsletten, I. Holm, H. Steen, G. Folleråas and I. Bjerkreim

University of Oslo Orthopedic Hospital, Sophies Minde, Oslo, Norway

Shortening of the femur can be done at all levels of the diaphysis, including the neighbouring metaphyses (1, 2). Studies of femoral shortening have mostly focused on the healing potential and complications at different levels, while the post-operative muscle function related to osteotomy level and shortening length has gained little attendance. The aim of this follow-up study was to compare the muscle function of long subtrochanteric (ST) and mid-diaphyseal (MD) shortening osteotomies.

Material: 30 femoral shortenings performed between 1968 and 1989 in 15 skeletally mature patients bilaterally for unaccepted tallness were evaluated after mean 8.1 years (2–21.5). Follow-up time for 22 ST procedures was 9.9 years—mean shortening 66 (50–90) mm and for 8 MD shortenings 3.2 years—mean shortening 60 (50–78) mm. The ST Z-osteotomies fixed with AO-condylar plates healed after on an average 19.2 weeks. The open MD shortenings fixed with intramedullary locking nails healed after on an average 24.4 weeks. At follow up all patients were evaluated with isokinetic muscle tests on a Cybex 340 dynamometer at angular velocities of 60 degrees/sec and 180 degrees/sec. Muscle strength (peak torque at 60 degrees/sec) and endurance (ratio of last and first five repetitions out of 25 at 180 degrees/sec) of all patients were tested in knee extension and flexion. Values were corrected for body weight, and compared with the reference values for our laboratory. Clinical examinations were done with emphasis on joint movement, the Trendelenburg test, and a new clinical test where the patient tried to raise from a bent knee position on one leg.

Results: All Trendelenburg tests were negative. There was no significant correlation between isokinetic muscle strength and length-reduction of the femur (mean shortening 11.7% of femoral length). Endurance of the hamstrings and quadriceps muscles was within the normal range in both surgery groups, without significant group differences. Six ST shortened and four MD shortened legs (all in women) had isokinetic muscle strength below normal. In the ST group the ratio for peak torque in flexion over extension was 58% (reference values 36–71%), while in the MD group the ratio was 72% (p=0.01), due to relatively lower strength of the quadriceps. Eleven legs (8 ST, 3 MD) were strong enough to pass the one leg knee-raising test. The relation between normal isokinetic muscle strength and positive knee-raising test was significant (p<0.01).

Conclusion: In this study both subtrochanteric and midshaft shortening osteotomies gave satisfactory results in long term muscle function, with some advantage for the subtrochanteric approach. With midshaft osteotomy special quadriceps training should be encouraged for several years.

References

1. Kempf I, Grosse A, Abalo C. Clin Orthop 1986; 212: 165–73.
2. Kenwright J, Albinana J. J Bone Joint Surg [Br] 1991; 73: 671–5.

222. Ilizarov technique in correction of knee flexion contracture

Gunnar Hägglund, Urban Rydholm and Göran Sundén

Department of Orthopedics, University Hospital, Lund, Sweden

The Ilizarov technique was used in five knees with a flexion contracture not responding to nonoperative treatment. The contractures of 25°–75° were reduced to 0°–10°. After three months the knees had almost the same range of extension as immediately after frame removal, and all but one case with severe arthritis had the same range of flexion as before treatment. Compared with alternative operative methods, the Ilizarov technique has the advantage of a minor operative trauma with a gradually controlled correction, permitting the soft tissues to regenerate. There is also the possibility of simultaneous correction of leg shortening.

223. Correction of foot deformities with the Ilizarov external fixator

B. Tjernström, G. Hansson and L. Rehnberg

Department of Orthopedics, University Hospital, Uppsala, Sweden

Introduction: The management of residual foot deformities in patients treated for pes equino varus (PEV) by one or several surgical procedures, presents a major challenge for the orthopedic surgeon. The Ilizarov external fixator (IEF) offers a new approach for correcting these feet as well as other severe foot deformities.

Material: Fourteen feet in 12 patients (age 6–24 years) have been treated for residual foot deformities using the IEF at the Department of Orthopedics, University Hospital, Uppsala, since 1990. Eight of these feet, which have been followed for more than one year, will be presented. The number of surgical procedures performed on each of these eight feet prior to the application of the IEF was 2 (0–4). The foot deformities requiring correction included: 4 PEV with residual hindfoot and/or forefoot deformities, 2 equinus feet compensating for a short leg (also lengthened), 1 rigid equinus foot in a patient with arthrogryphosis multiplex congenita and 1 short foot as a sequele after a compartment syndrome.

Technique: Two rings are secured to the tibia by crossed K-wires. One half-ring is fixed to the calcaneus and one to the forefoot using two K-wires on each ring. The tibia rings and the two half-rings are joined together by threaded rods enabling correction of the deformities by successive distraction.

Results: The time in IEF was on an average two months for correcting the foot deformities, but considerable longer for those patients who also underwent lengthening. The IEFs were well tolerated. When correction was completed and the IEF removed, the feet were immobilised in a cast for 8–12 weeks. In all cases the feet were brought to a plantigrade position. No serious complications were recorded.

Conclusion: Our preliminary experiences with the IEF for correcting foot deformities have been promising. Further studies and longer follow-up will, however, be necessary until more definite results can be presented.

224. Computerised measurement of serial radiographs during leg lengthening

Björn Tjernström and Olafur Jakobsson[1]

Departments of Orthopedics and [1]Plastic Surgery, University Hospital, Uppsala, Sweden

Introduction: Leg length inequality is common. In cases with considerable discrepancy, i.e. >3 cm, lengthening can be justified and rewarding. The discrepancy is preoperatively assessed by clinical and radiographic methods. During lengthening AP and sagittal radiographs are obtained every 3rd week to measure the degree of lengthening and to reveal angular deviations. When lengthening is completed orthoradiographs can be performed to document that equal leg length is accomplished. During lengthening flexion contractures concerning hip and knee are common, making both clinical and radiographic measurements unreliable. Direct measurements on radiographs have to deal with an uncertain degree of magnification.

Material and methods: 33 lengthenings have been performed with callus distraction and the Orthofix external fixator. 25 femurs and 8 tibias with a preoperative discrepancy from 3 to 14 cm have been lenghened 3-14 cm. A computer programme "PROFILE" and a digitising table "ALTEK AC T23-2" have been employed. 16 fixed points on each AP view were registered. From these the incliniation of the bone screws, the long axis of both fragments, the angle between these and the lengthening is calculated. The screw diameter (6 mm) is the reference value.

Results: The degree of magnification varies from 5 to 30%. The magnification is of equal magnitude on most radiographs of the same individual. On the femur there is a tendency to varus angulation during lengthening.

Conclusion: Reliable measuring methods are needed to determine the degree of lengthening. Orthoradiographs and clinical assessments can be impaired by joint contractures during lengthening. CT scans are impaired by the external fixator. Direct measurements on the radiographs have to take in consideration a degree of magnification varying from 5 to 30%.

225. Limb lengthening with the use of the Orthofix external fixation system

Theologos T. Ioannidis, Constantinos Kavadias, Christos Sdrenias, John Mandrekas and Argirios Makris

Athens Greece

Limb lengthening was tried in the past with a varying degree of success that disheartened orthopedic surgeons. The introduction of newer and technically more advanced external fixation systems has made this still demanding operation uniformly successful, when indicated, and has increased its popularity.

Our experience is based on 10 cases of limb lengthening in 9 patients—5 female, 4 male, aged 18 (12–25) years —that have been operated on during the last 4 years using the Orthofix D.A.F.

In one patient, bilateral tibial lengthening of 6cm was performed because of short stature: in all the others (5 femurs, 2 tibias, 1 radius) there was limb inequality of 3 to 7cm. The osteotomy was performed at the proximal end of the bone in all but the radius. The forearm was also an exception, in the sense that the fracture apparatus was used instead of the special lengthening device used for the rest of the operations. We began lengthening on the 15th postoperative day. It was performed at an overall rate of 1mm per day, divided into three 8-hour intervals.

Our preoperatively planned objective was achieved in all but 2 femoral lengthenings, where we had to stop 2cm short because of persistent limitation of knee movement and the commencement of varus deformation. The time required was 48 days per cm gained. Our only complication was that usually about one pin per procedure drained serous fluid. Two had positive cultures. No antibiotics were administered and rigorous pin care was suggested. The drainage stopped on the removal of the implants with no further problems.

We have found the method to be reliable and rather simple to apply. The patients tolerate the frame well in their everyday activities and they or their parents have no trouble learning the elongation procedure.

Children

226. Growth disturbances in the radius after forearm fractures conservatively treated in children

Julio de Pablos, Marco Franzreb and Carlos Barrios

Traumatology Service, Tafalla County Health Center, Navarra and Orthopedics and Trauma Institute, Valencia, Spain

Stimulation of longitudinal growth in long bones secondary to a fracture is a well-known fact. The majority of reports dealing with the overgrowth phenomenon include series of fractured long bones of the lower extremity. We have studied the growth pattern of the radius following different types of forearm fractures treated by conservative method.

Patients and methods: 64 children younger than 15 with forearm fractures treated conservatively were included in a prospective study from 1986 to 1988. Comparative radiographic studies of the fractured and the uninjured radius were carried out in all patients at 3, 6, 12 and 18 months after fracture. The length of the radius was recorded by measuring the distance between the most proximal part of the growth plate of the radial head and the most distal part of the radial growth plate at the radiocarpal joint. Differences of 2 mm or more were considered as length discrepancies. Only 40 patients, 28 boys and 12 girls, with an average age of 9 (1–15) years completed the follow-up period of 18 months. The series included 19 buckle fractures of the radius, 11 green-stick and 10 complete fractures. Fracture of the ulna was associated in 11 cases.

Results: Neither consolidation defects nor angular deformities were found at the end of follow-up. Monitoring radial longitudinal growth according to patient's age, the maximal average growth was observed from the age of 9 to 12 years (2.6 cm in the fractured radius versus 2.4 in the uninjured side). Overall, the average length discrepancy between the fractured and the healthy radius at the end of follow-up was 0.03 (-0.50 to +1) cm. In 9 cases (22%) the fractured radius showed an average overgrowth of +0.44 cm (1–0.20; $p<0.002$). In 10 other patients (25%) a radial shortening could be detected (average discrepancy -0.29, [-0.50 to -0.20 cm]; $p<0.0001$). Five of the 9 cases with radial overgrowth had an associated fracture of the ulna. This association was not found in any of the 10 patients with radial shortening ($p<0.02$). In cases of overgrowth, it was mainly manifested after 12 months follow-up.

Conclusion: These results show that growth stimulation in the radius secondary to fracture can be found in very few cases, being minimal as compared with that reported in femur and tibia. Other etiopathogenic factors than the increased vascularity of the growth plate—as postulated for femur and tibia—must be investigated further in order to explain the frequent absence of radial overgrowth following fracture.

227. Grice subtalar arthrodesis—a review of 131 operations

Cato Hellum and Jan Roar Orlin

The National Center of Orthopedics, Sophies Minde, University of Oslo, Oslo, Norway

A retrospective study of subtalar, extraarticular arthrodesis in 83 patients with cerebral palsy (CP) or meningomyelocele (MMC) was carried out.

In the CP group, 68 feet were operated on in 42 patients with a mean age of 9.5 years without complications. The results were evaluated after a mean observation period of 4.5 years. All but one transplant healed, and the result was satisfactory in 54, acceptable in 9 and poor in 5 feet.

In the MMC group of predominately L4, L5 and S1 affection, 63 feet were operated on in 41 patients with a mean age of 8 years and the results evaluated after a mean observation period of 6.5 years. The transplants healed in 56 feet whereas a pseudarthrosis possibly occurred in 7. The result was satisfactory in 56 feet, acceptable in 3 and poor in 4 feet. One patient sustained necrosis of the talus and a subsequent physeolysis in the distal tibia.

Because Grice arthrodesis may possibly be compromised by ankle valgus, the value of preoperative bracing is discussed.

Conclusion: Grice arthrodesis in this material led to a good functional result in 110/131 feet (84%). The operation may be recommended for children with CP or MMC conditioned valgus deformities.

228. Timing of epiphysiodesis in lower limb length discrepancy with the straight line graph

Bart A. Swierstra, Harald I. H. Lampe and Ad F. M. Diepstraten

Department of Orthopedics, University Hospital Rotterdam, Rotterdam, The Netherlands

In a prospective study 30 children underwent 33 epiphysiodeses for lower limb length discrepancy (LLD). Timing of surgery was based on (bi)annual orthoroentgenograms and skeletal age, and in accordance with Moseley's