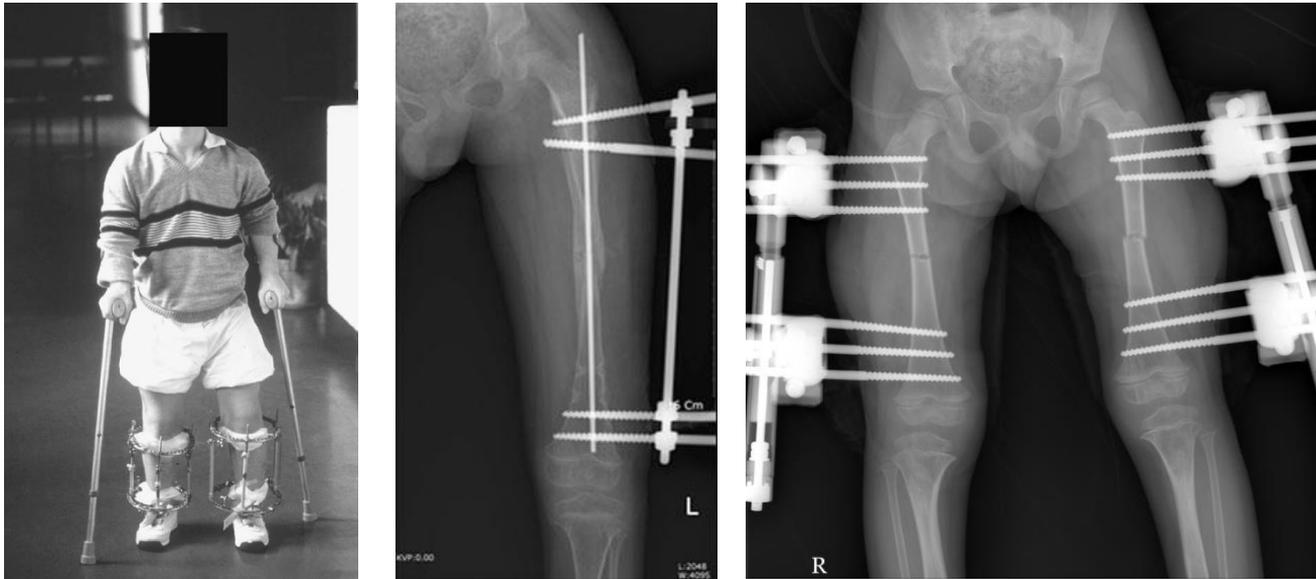


Extended Limb Lengthening in Dwarfs and Cosmetic Lengthening for Short Stature Advances and Future Perspectives of Ilizarov



Andreas Panagopoulos MD, PhD
Upper Limb and Sports Medicine Surgeon
Assistant Professor, University Hospital of Patras

Outline

- Features of Achondroplasia
- Techniques of limb lengthening in ACH
- Complications of lengthening in ACH
- Cosmetic LL for short stature
- Innovations and the future of DI

Achondroplasia

most common form of dwarfism

incidence 1/15,000-30,000 live births

fully penetrant autosomal dominant

disturbance in endochondral bone formation

short stature

neurological and skeletal complications

normal intelligence

Genetics



Available online at www.sciencedirect.com



Joint Bone Spine 75 (2008) 125–130

**JOINT
BONE
SPINE**

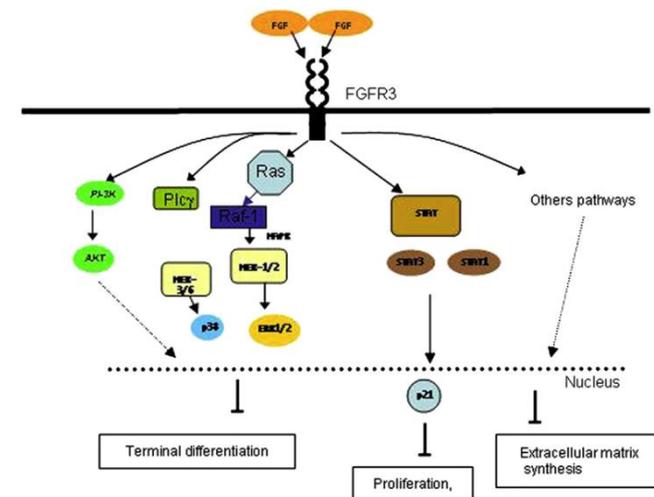
<http://france.elsevier.com/direct/BONSOI/>

Review

Achondroplasia: From genotype to phenotype

Pascal Richette ^{a,*}, Thomas Bardin ^a, Chantal Stheneur ^b

- The gene of ACH was assigned in 1994
- Tyrosine-kinase domain activation loop of FGFR3
- in **98%** substitution of arginine for a glycine residue at position 380 (**Gly380Arg**)
- other mutations (Gly375Cys, Gly346Glu and Ser279Cyst) have been exceptionally reported



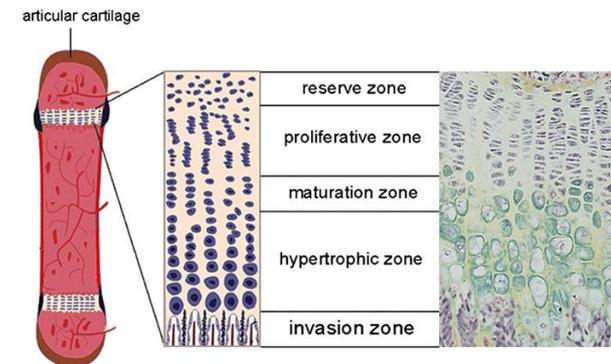
Achondroplasia

Geneviève Baujat MD

Laurence Legeai-Mallet PhD

Georges Finidori MD

- The phenotype observed in achondroplasia is the consequence of severe disturbances in endochondral bone growth induced by abnormal activity of FGFR3.
- Delayed maturation of chondrocytes in the hypertrophic zone (growth plate)
- Reduced longitudinal growth of bone



Phenotype

- disproportionate short stature
- rhizomelic shortening,
- trident hands,
- enlarged head, depressed nasal bridge & prominent forehead
- generalized joint laxity and mild hypotonia
- Medium adult heights are **131 ± 5.6 cm** for males and **124 ± 5.9 cm** for females



AMERICAN ACADEMY OF PEDIATRICS

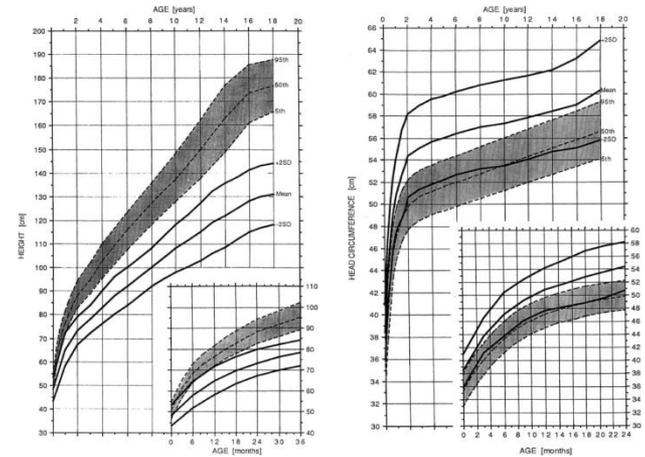
CLINICAL REPORT

Guidance for the Clinician in Rendering Pediatric Care

Tracy L. Trotter, MD; Judith G. Hall, OC, MD; and the Committee on Genetics

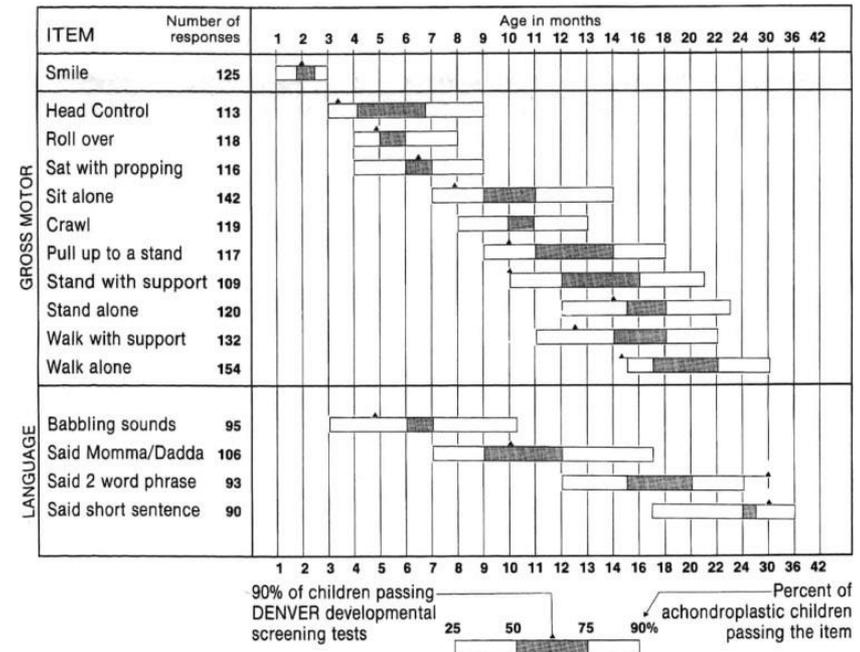
Health Supervision for Children With Achondroplasia

- delayed motor milestones
- recurrent middle-ear dysfunction
- hydrocephalus, foramen magnum stenosis
- craniocervical junction compression
- dental crowding
- upper-airway obstruction,
- psychosocial problems
- excessive weight gain



Height

Head circumference



Orthopaedic manifestations

- atlantoaxial instability
- thoracolumbar kyphosis (infancy),
(10% of may progress)
- excess lumbar lordosis (childhood) and prominent buttocks
- spinal stenosis (17%) and disc prolapse (adult life)
- hip flexion, contractures and limitation of elbow extension, genu varum, internal tibial torsion and varus deviation of the ankle



Life expectancy & QoL

- Children often have lower IQ
- overall and age-specific mortality rates are increased at all ages (cardiovascular and neurological diseases)
- The average life expectancy for this cohort was decreased by 10-15 years
- have lower annual incomes, less education, and are less likely to be married than people without achondroplasia

Gollust SE, et al. Living with achondroplasia in an average-sized world: an assessment of quality of life. Am J Med Genet A 2003; 120: 447–58.

REVIEW ARTICLE

Advances in bone dysplasias[☆]

E. Borrego^{*}, D.M. Farrington, F.J. Downey



Growth hormone has shown increase in growth velocity (65–75%) during the first year or a gain of 0.2–0.5 SD of height during the first year of treatment, short term studies

Treatment

Reduce the hyperactivity of FGFR

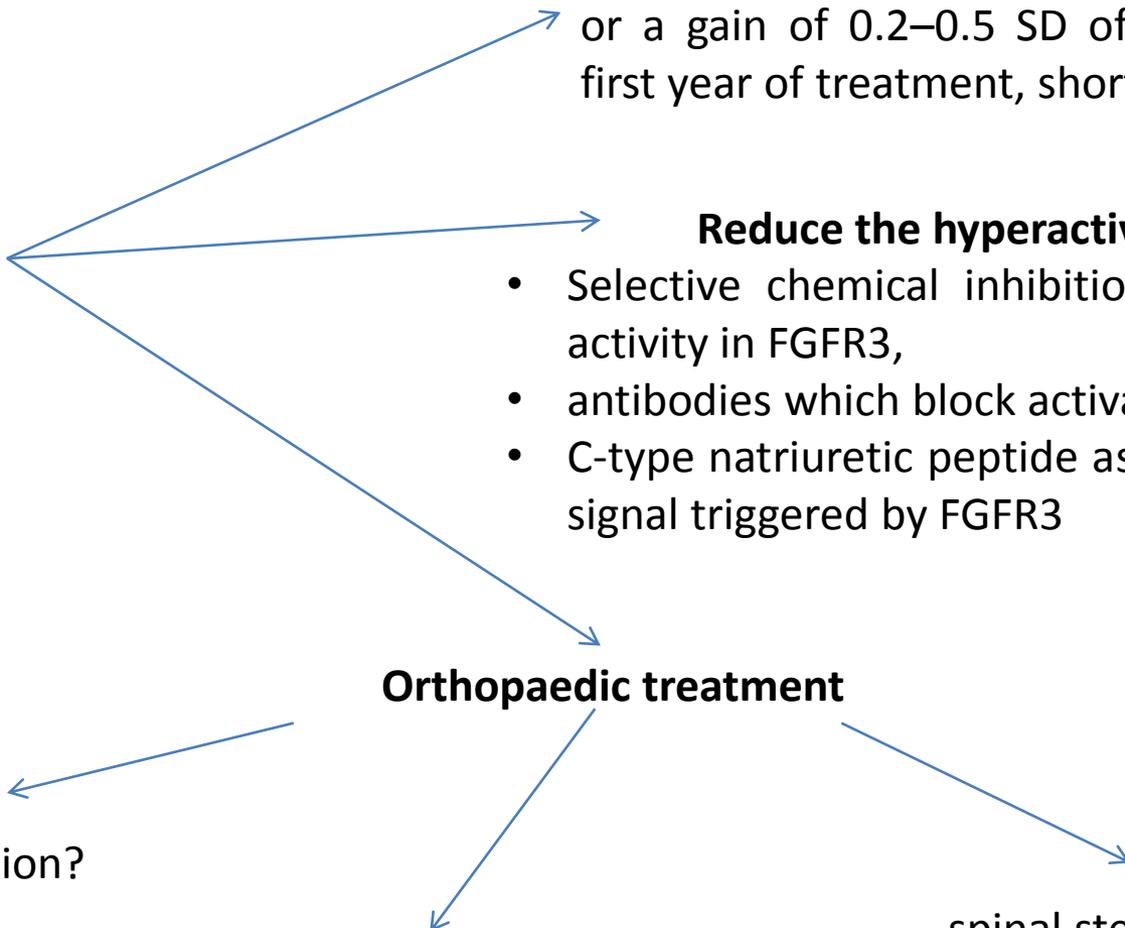
- Selective chemical inhibition of tyrosine kinase activity in FGFR3,
- antibodies which block activation of FGFR3
- C-type natriuretic peptide as an antagonist of the signal triggered by FGFR3

Orthopaedic treatment

bone elongation?

correction of axial deviations

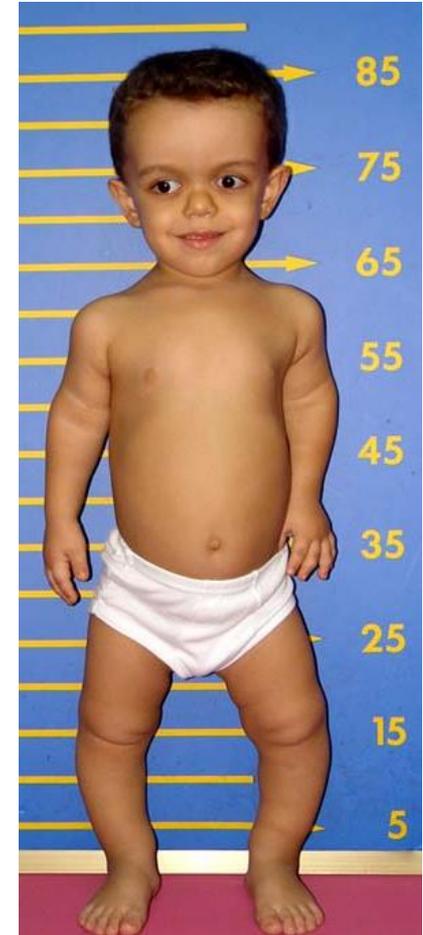
spinal stenosis & kyphosis



Extended lengthening for ACH

Still controversial, special considerations:

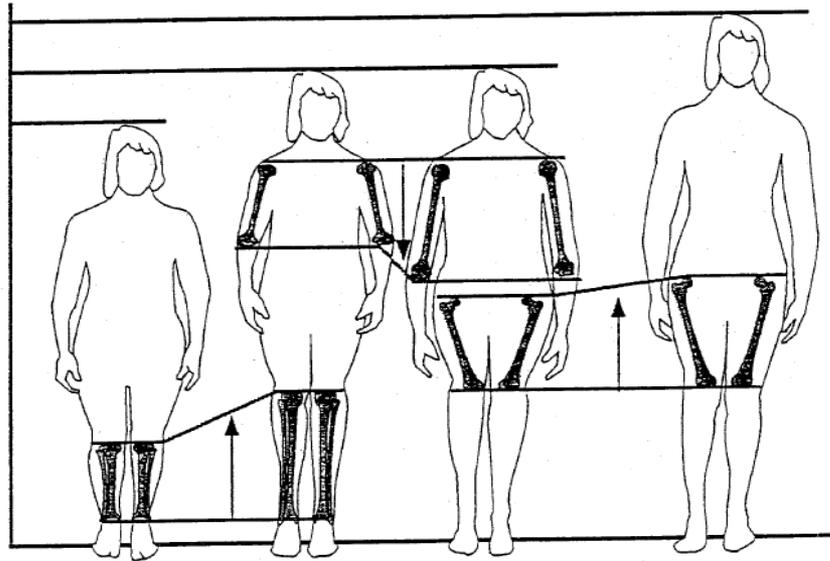
- age and sex of the patient
- initial segment length and axial deformities
- estimation of the potential lengthening
- elongation obtained
- type of fixator
- time for consolidation
- complications
- rehabilitation problems
- psychological aspects of the child and family



Methods and Strategies in Limb Lengthening and Realignment for Skeletal Dysplasia

John E. Herzenberg and Dror Paley

*University of Maryland Center for Limb Lengthening and Reconstruction,
Baltimore, Maryland, USA*



1st stage: 15 cm bilateral tibial lengthening at age 11

2nd stage: 10 cm bilateral humeral lengthening at age 13

3rd stage: 10 cm bilateral femoral lengthening at age 16

STAGED LENGTHENING IN ACHONDROPLASTIC DWARFS. 27 YEARS OF CLINICAL AND SURGICAL EXPERIENCE

G. PERETTI, W. ALBISETTI, O. DE BARTOLOMEO, A. MEMEO, G. M. PERETTI
and F. VERDONI

*Department of Surgical, Reconstructive and Diagnostic Sciences, Section of Orthopedics,
Traumatology, Rheumatology and Rehabilitation, University of Milan, Milan, Italy*

Protocol description					
surgical approach	age (yrs)	segment	initial length of the segment (cm)	forecast lengthening (cm)	final length (cm)
first	5 to 6	tibiae	13-16	5 to 6	18 to 22
second	6 to 7	femuri	15-19	5 to 7	20 to 26
third	11 to 12	tibiae	22-27	7 to 10	29 to 37
fourth	12 to 14	femuri	25-29	8 to 12	33 to 41
fifth	16	humeri	12-20	8 to 12	20 to 32



**STAGED LENGTHENING IN ACHONDROPLASTIC DWARFS.
27 YEARS OF CLINICAL AND SURGICAL EXPERIENCE**

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and F. VERDONI

*Department of Surgical, Reconstructive and Diagnostic Sciences, Section of Orthopedics,
Traumatology, Rheumatology and Rehabilitation, University of Milan, Milan, Italy*

99 patients/ 592 operations: satisfactory correction, improves limbs and body function and gives psychological support to these children, considered as a valid surgical procedure

- Skin infection 166 (75.5%)
- Transient nerve palsy 45 (20%)
- Tendon retraction 25 (11.36%)
- Incomplete osteotomy 8 (3.63%)
- Increased lumbar lordosis 4 (2%)
- Axial deformities 10 (4.5%)
- Others 55 (22%)



Distraction osteogenesis using a longitudinal corticotomy

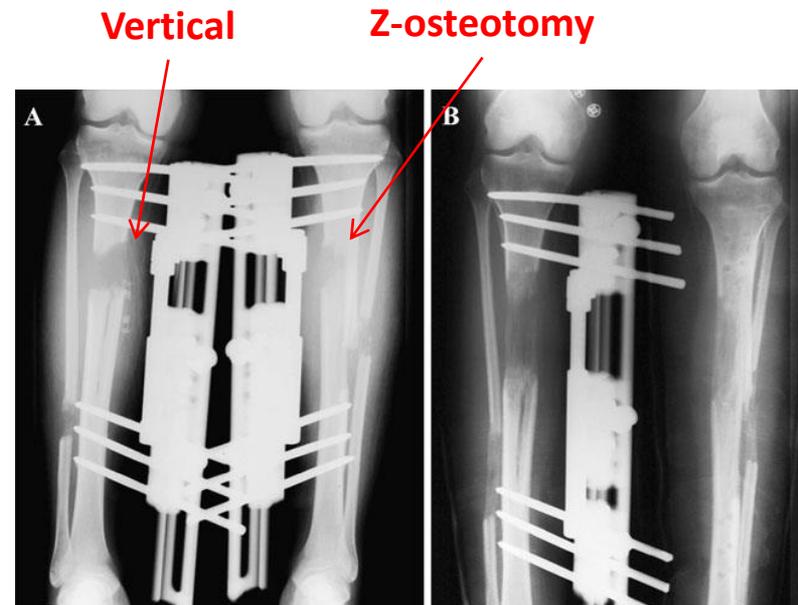
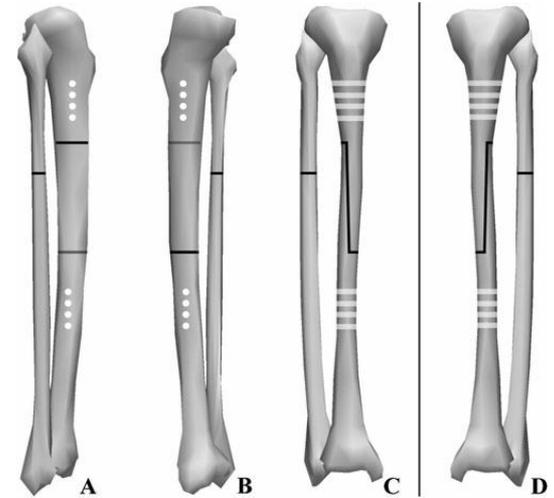
Ma'ad F. Al-Saati • Robert A. Magnussen •
Sebastien Lustig • Rodolphe Testa • Gazal Al-Saati •
Faisal Al-Saati

51 patients/67 procedures (**short stature 32 pt**)
45 longitudinal corticotomy,
22 transverse corticotomy.

Healing index was significantly lower in the **S-Z**
group (30.8 days/cm) than 46.8 days/cm

Mean lengthening was 6.6 cm in the S-Z group
and 5.8 in the transverse group

Mean consolidation time
was 6.3 ± 2.8 vs 8.1 ± 3.8



Is Bilateral Lower Limb Lengthening Appropriate for Achondroplasia?

Midterm Analysis of the Complications and Quality of Life

Seung-Ju Kim MD, Gracia Cielo Balce MD,
Mandar Vikas Agashe MD, Sang-Heon Song MD,
Hae-Ryong Song MD, PhD

22 ACH patients (average age, 12.7 years) who underwent bilateral lower limb lengthening

22 patients with achondroplasia for whom limb lengthening was not performed.

The 2 groups were assessed using the AAOS lower limb, SF-36, and Rosenberg self esteem scores.

Minimum follow up was **4.5 years**

Average length was 10.21 ± 2.39 cm for the femur and 9.13 ± 2.12 cm for the tibia

123 complications occurred in 88 segments.

The surgical group had higher Rosenberg self-esteem scores but no differences in the AAOS and the SF-36 scores

The self-esteem scores decreased with the increase in the number of complications

Physeal growth arrest after tibial lengthening in achondroplasia

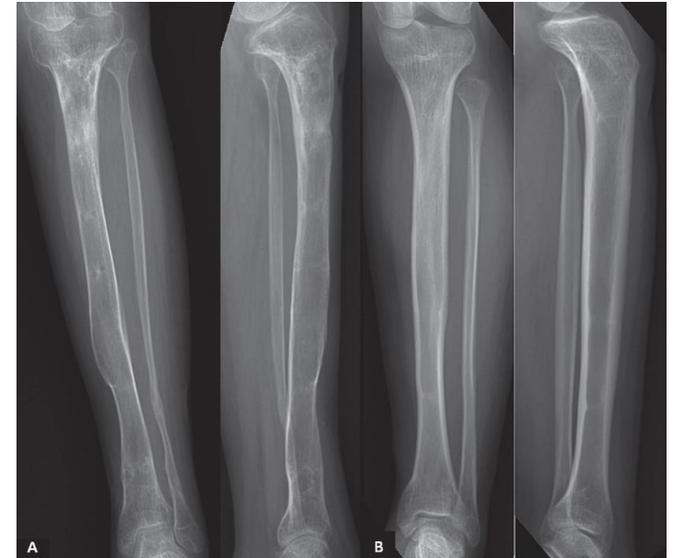
23 children followed to skeletal maturity

Sang-Heon Song¹, Mandar Vikas Agashe¹, Young-Jae Huh¹, Soon-Young Hwang² and Hae-Ryong Song¹

Physeal damage occurs after limb lengthening by over **50%** in achondroplasia.

This damage is a gradual process that manifests itself about 2 years after surgery, and it is most pronounced in the anterior-lateral portion of the proximal tibial physis

In **Korean** children, lengthening should preferably be started at around 11 years of age





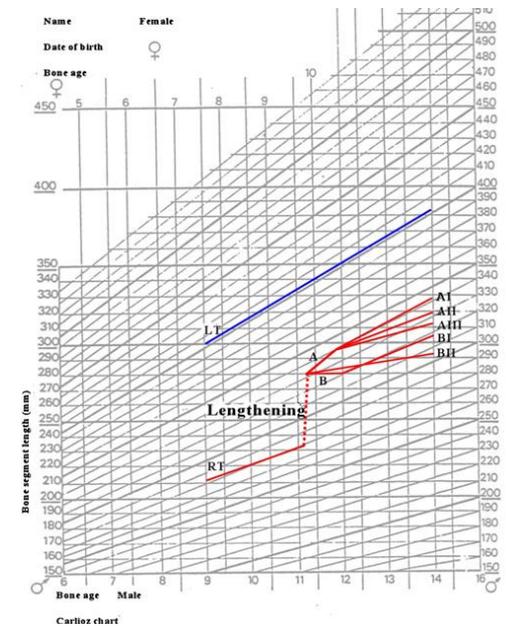
ORIGINAL ARTICLE

Analysis of segmental residual growth after progressive bone lengthening in congenital lower limb deformity

D. Popkov^a, P. Journeau^{b,*}, A. Popkov^c, B. Pedeutour^b, T. Haumont^b,
 P. Lascombes^d

Factors negatively impacting **growth stimulation rate**:

- Age at initiation of lengthening
 - bone age > 12 years in boys or 9 years in girls
- Number of lengthening procedures per segment
 - iterative lengthening, even when performed outside of the pubertal growth boost period
- Interval between lengthening procedures
 - when performed before pubertal growth boost and more than 3 years after the first procedure
- Percentage lengthening
 - more than 30% of initial segment length

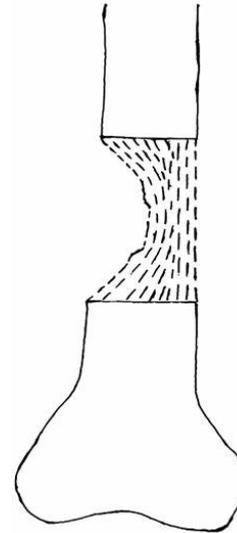


Callus features of regenerate fracture cases in femoral lengthening in achondroplasia

Kamlesh N. Devmurari • Hae Ryong Song •
Hitesh N. Modi • K. P. Venkatesh • Kim Seung Ju •

28 patients (14 with fracture and 14 without)

A lucent pathway was seen in all fracture cases with concave, lateral, and atypical shapes, and there was **more than 30% lengthening** and 30% reduction of the callus width compared with the natural width of the femur, which are the warning signs for regenerate fractures



Complications of Ilizarov leg lengthening: a comparative study between patients with leg length discrepancy and short stature

B. Vargas Barreto · J. Caton · Z. Merabet ·
J. C. Panisset · J. P. Pracros

during lengthening of the tibia with the Ilizarov device, approximately **one in two patients** requires a secondary surgical procedure not planned in the initial lengthening program

Table 2 Complications

	Group A ^a	Group B ^b	Total of complications
Category I	19	36	55
Category II	15	18	33
Category III	2	0	2
Total	36	54	90

^a Group A: patients with limb length discrepancy

^b Group B: short stature patients



Extended Limb Lengthening, Little People of America Medical Advisory Board Position Summary, 2006

There are no established medical indications for symmetric extended limb lengthening (ELL). While it **may have benefit** in preventing certain orthopedic and neurological complications in some skeletal dysplasias, the procedure is primarily being performed for **adaptive, cosmetic, and psychosocial** reasons.

“We are a contradiction in packaging, for encased in our small bodies are not small minds, not small needs and desires, not small goals and pleasures, and not small appetites for a full and enriching life”





Cosmetic bilateral leg lengthening

EXPERIENCE OF 54 CASES

J Bone Joint Surg [Br]
2005;87-B:1402-5.

M. A. Catagni,
L. Lovisetti,
F. Guerreschi,
A. Combi,
G. Ottaviani

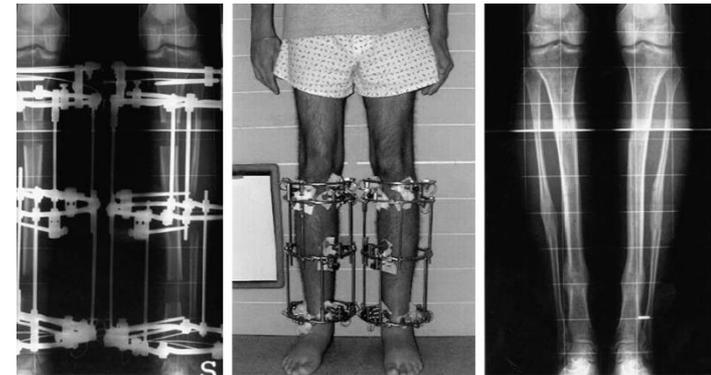
54 patients, mean age 25.8.years

mean lengthening 7 cm (5 to 11) at 9 months

19 (35.2%), bilateral Achilles tendon lengthening

48% pin site infection

90% will perform the operation again



Ilizarov technique of lengthening and then nailing for height increase

Khaled Emara, Amr Farouk, Rami Diab

Department of Orthopaedic Surgery, Ain Shams University Hospitals, Cairo, Egypt

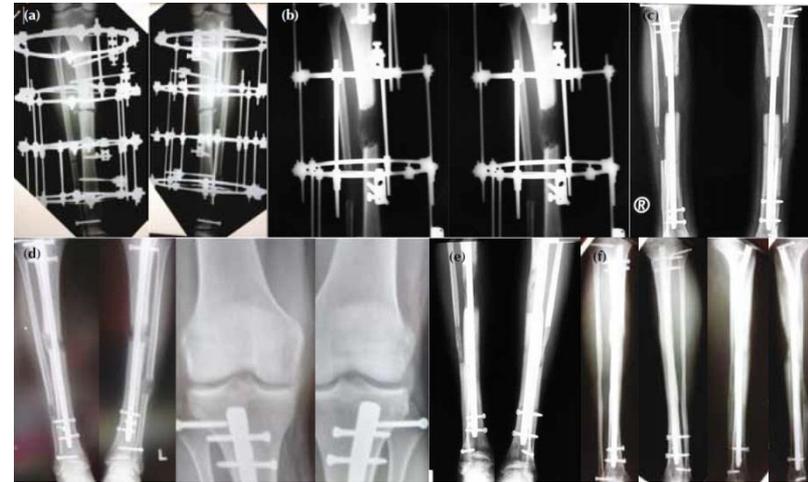
26 men and 6 women aged 21 to 47

body height of 160 to 176

mean lengthening **7.6 cm** or 26%

mean duration of external fixation 96 days

4 patients had revision operations



New perspectives of DI

Progress in and from Limb Lengthening

5

Dror Paley, MD, FRCSC

Director, Paley Advanced Limb Lengthening Institute, St. Mary's Hospital, FL

Byproduct advances

- Deformity analysis and nomenclature
- Prediction of limb length discrepancy (LLD), timing of epiphysiodesis and stature
- Lengthening over nail (**LON**), or plate (**LOP**) lengthening and then nailing (**LATN**) or plating (**LATP**)
- Fixator assisted nailing (**FAN**) and fixator assisted plating (**FAP**) for deformity correction

New product advances

- Modularity of monolateral external fixators
- Motorized circular external fixation
- Computer dependent external fixation
- Implantable limb lengthening
- Biological advantages and improvement of healing

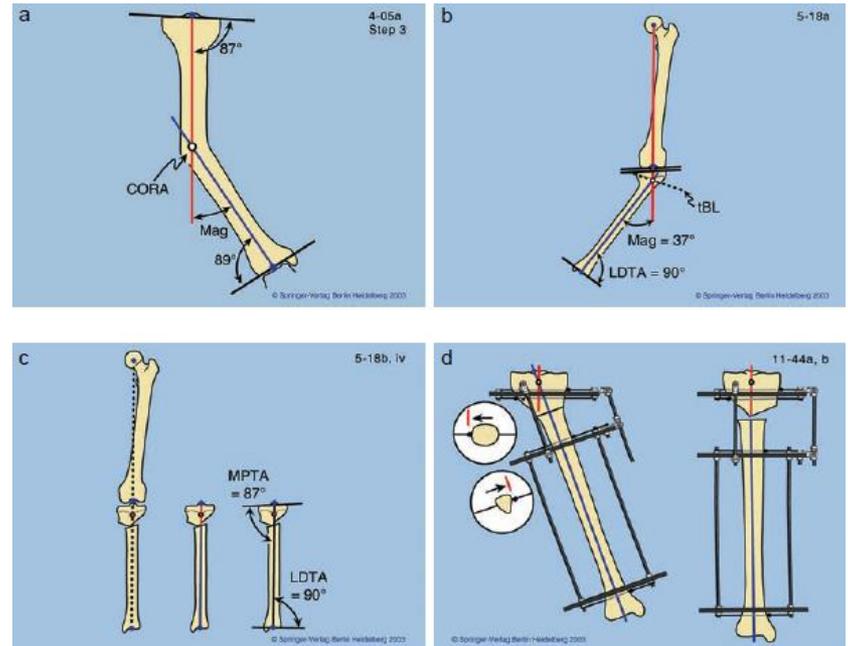
Deformity analysis and nomenclature

The **CORA** (center of rotation and angulation) method to accurately determine the level of the Ilizarov hinge

Plane of deformity

Six axis deformity correction

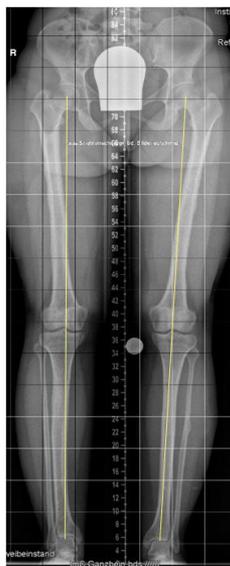
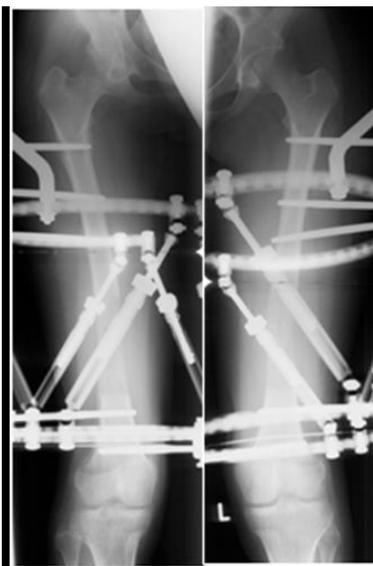
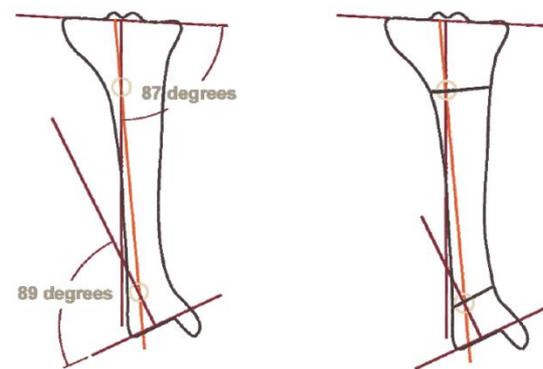
Joint orientation angles in the frontal and sagittal plane.



Treatment of Varus Deformities of the Lower Limbs in Patients with Achondroplasia and Hypochondroplasia

Ali Al Kaissi^{*,1,2}, Sebastian Farr², Rudolf Ganger², Jochen G. Hofstaetter^{1,3}, Klaus Klaushofer¹ and Franz Grill²

Multi-apical planning, bilevel osteotomies
4 ACH and 2 Hypochondroplasias
Excellent results



Prediction of limb length discrepancy (LLD), timing of epiphysiodesis and stature

a coefficient could be calculated for each age to represent the reciprocal of growth remaining

That coefficient was independent of percentile, race, nationality, and generation.

For the lower extremity the coefficients (multipliers) for the femur, tibia, and foot height were the same.

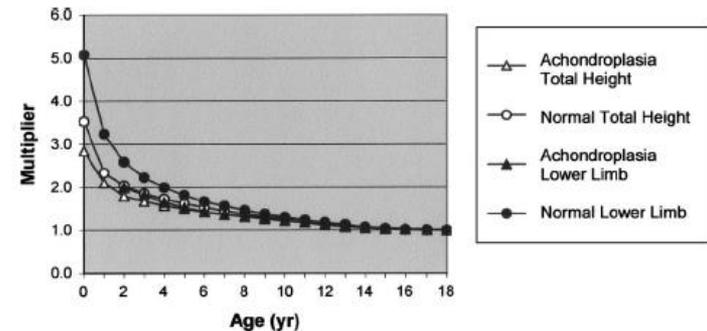
Therefore a single set of multipliers could be used to determine bone or limb length

Multiplier Method for Prediction of Adult Height in Patients with Achondroplasia

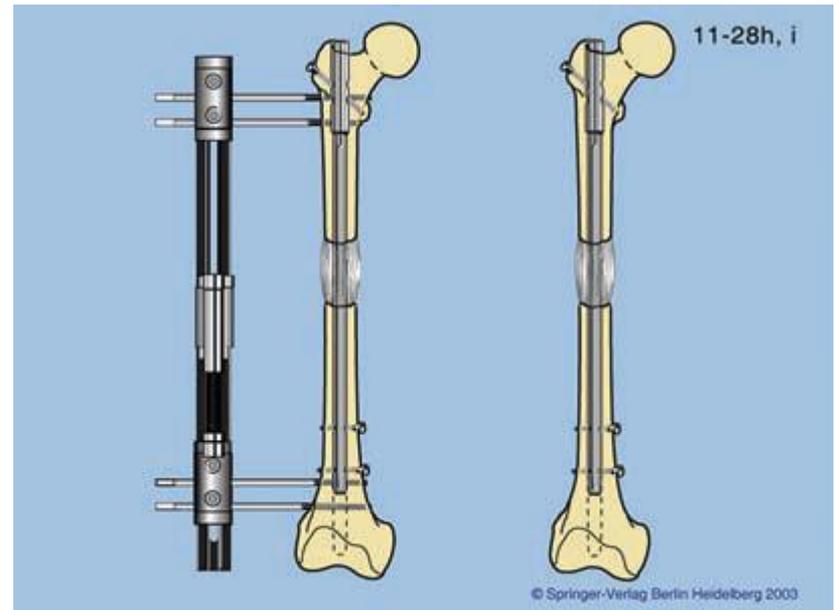
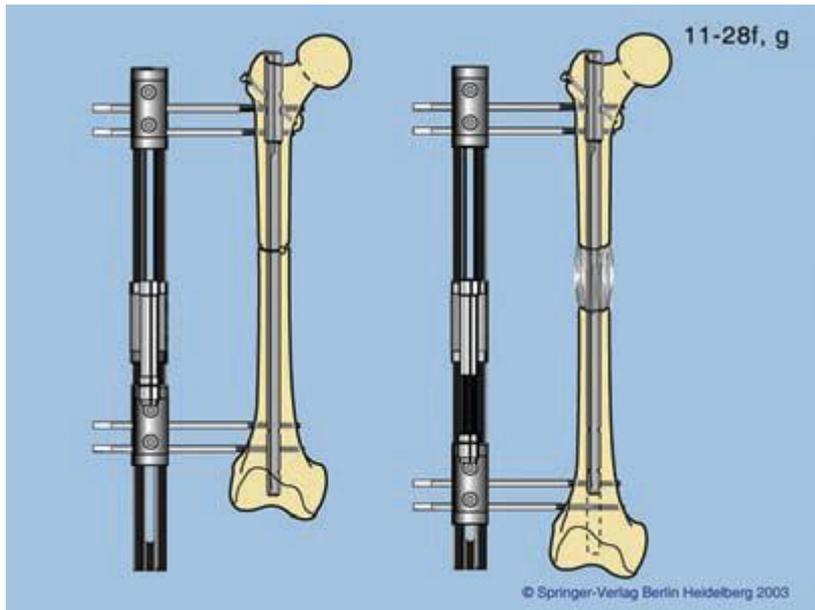
Dror Paley, MD, Alexander L. Matz, David B. Kurland, Bradley M. Lamm, DPM, and John E. Herzenberg, MD

Lower limb and **total height growth** rates were slower in achondroplastic dwarves compared with healthy persons. However, **sitting height** multipliers were closely related

Predicting maturity height for achondroplastic dwarves also helps their families to decide about stature-increasing methods, such as **limb lengthening** and growth hormone treatments



Lengthening over nails or plates (LON, LOP) lengthening and then nailing or plating (LATN, LATP)



Tibial lengthening over an intramedullary nail in patients with short stature or leg-length discrepancy: a comparative study

Qianchen Guo · Tao Zhang · Yongfa Zheng ·
Shiqing Feng · Xinlong Ma · Feng Zhao

Table 1 Patient clinical and demographic data

Parameter	Group A ^a	Group B ^b
Number of patients	13	26
Number of tibiae	23	51
Age in years (range)	22.7 (18–42)	25.4 (19–47)
Gender (female/male)	10/3	21/5
Bilateral (short stature)	10	25
Congenital leg-length discrepancy	3	1

^a Conventional Ilizarov method

^b Lengthening over a nail

281.5 versus 129.0 days
external fixation index (40.0 versus 17.4 day/cm).
Ilizarov group had a higher complication rate
(1.0 versus 0.47 per tibia)



RESEARCH ARTICLE

Open Access

Prophylactic titanium elastic nailing (TEN) following femoral lengthening (Lengthening then rodding) with one or two nails reduces the risk for secondary interventions after regenerate fractures: a cohort study in monolateral vs. bilateral lengthening procedures

Frank Schiedel^{1*}, Ulrich Elsner², Georg Gosheger², Björn Vogt¹ and Robert Rödl¹

67 patients with 101 femoral lengthening

32 with ACH

12 fractures in 101 cases (12%).

The rate of secondary interventions was markedly reduced.

Usage of one or two TENs did not influence the fracture rate

Group	Diagnosis	Male (n)	Female (n)	Total (n)
A	Achondroplasia	17	15	32
	Hypochondroplasia	0	2	2
B	Congenital disorders, hemimelia	11	9	20
	acquired LLD	1	6	7
	Other causes and idiopathic LLD	3	3	6
Sum		32	35	67



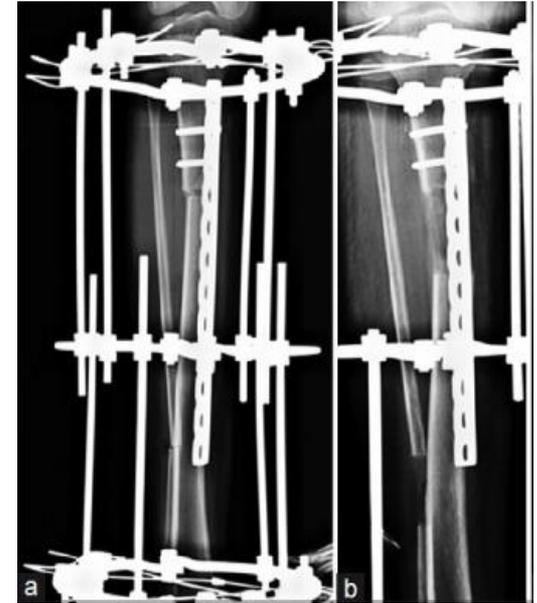
Limb lengthening over plate

[Ruta Kulkarni](#), [Nishant Singh](#), [Govind S Kulkarni](#), [Milind Kulkarni](#), [Sunil Kulkarni](#), and [Vidisha Kulkarni](#)

[Author information](#) ▶ [Copyright and License information](#) ▶

15 patients (7 females, 8 males)
average age was 18.1 years (range 8–35 years).
15 tibiae and 1 femur in 15 patients.
Rate at 1 mm/day followed by **distal segment fixation**
with 3-4 screws on reaching the target length.

Target length was achieved in all pt (mean of 4.1 cm)
mean duration of Ex-Fix 75.3 days
mean external fixation index at 19.2 days/cm
1 patient suffered deep infection
3 patients had mild procurvatum deformities
1 patient developed mild tendo achilles contracture



Plating after tibial lengthening: unilateral monoaxial external fixator and locking plate

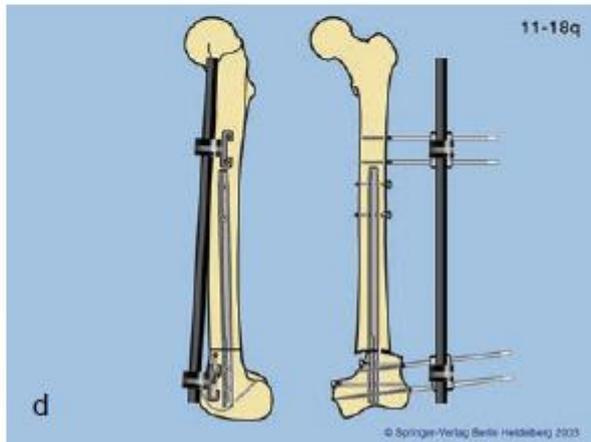
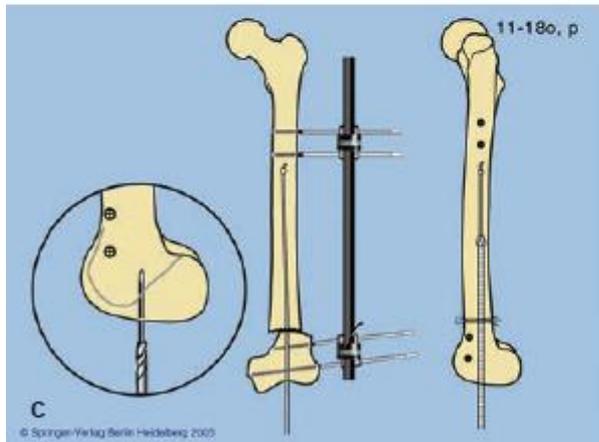
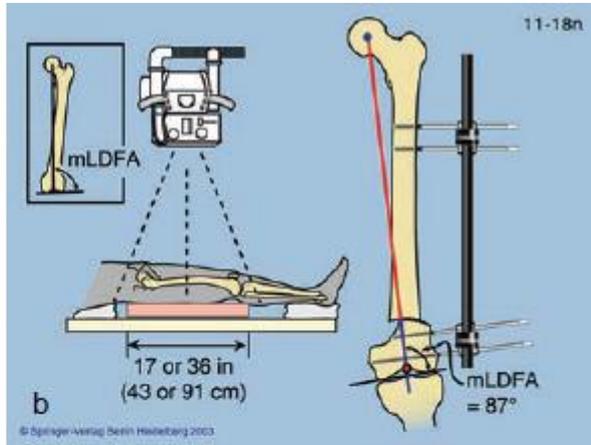
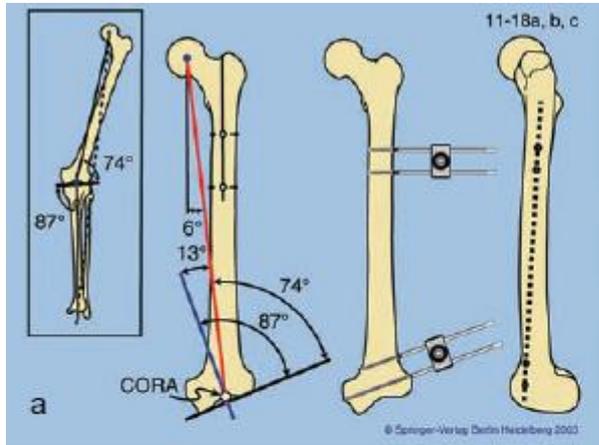
Soo-Min Cha, Hyun-Dae Shin, Kyung-Cheon Kim and Jae-Hwang Song

Journal of Pediatric Orthopaedics B 2013, 22:571–576



Fixator in the lateral side – plating at the medial
Application immediately after the distraction phase
Few complications – full consolidation – no infections

Fixator assisted nailing (FAN) and fixator assisted plating (FAP) for deformity correction



Distal tibial hypertrophic nonunion with deformity: treatment by fixator-assisted acute deformity correction and LCP fixation

Mahmoud A. El-Rosasy · Sameh A. El-Sallakh



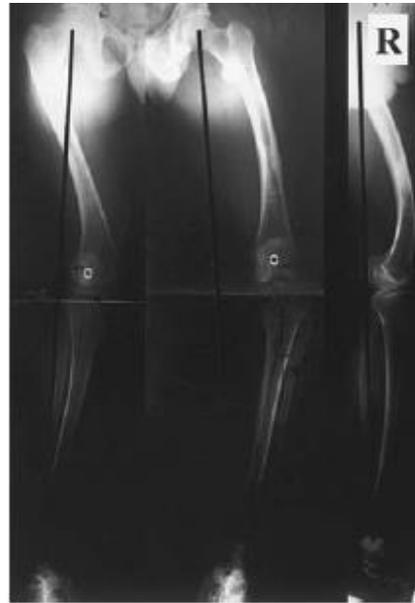
■ CASE REPORT

A correction of windswept deformity by fixator assisted nailing

A REPORT OF TWO CASES

L. Eralp,
M. Kocaoglu,
M. Çakmak,
V. Emre Özden

J Bone Joint Surg [Br]
2004;86-B:1065-8.



Modularity of monolateral external fixators



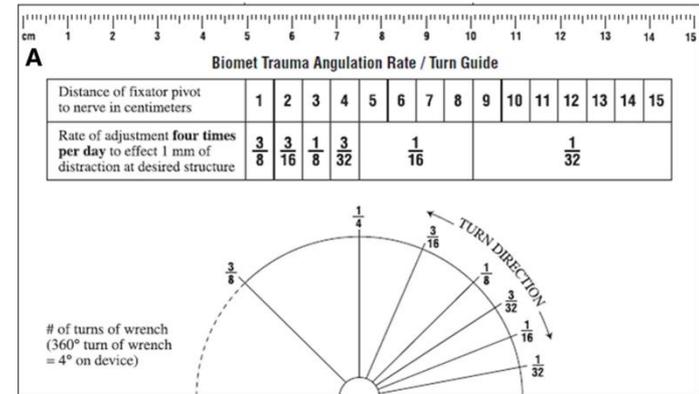
The MAC (Multi-Axial Correcting) Monolateral External Fixation System (Biomet/EBI) Technique: An Easier Way to Correct Deformity

Richard S. Davidson, MD

2 planes of angulation, 2 planes of translation, compression, distraction, and rotation

requires only measurement of length and angular deformity on the anteroposterior and lateral x-rays

Correction is accomplished by sequentially turning one screw to lengthen 0.25 mm 4 times per day (1 mm per d), then turning another screw to correct angulation 1° 4 times per day (4°/d).



Motorized circular external fixation

Strat Traum Limb Recon
DOI 10.1007/s11751-014-0191-1

TECHNICAL REPORT

Preliminary experience with motorized distraction for tibial lengthening

Published online: 15 March 2014

Adam S. Bright · John E. Herzenberg ·
Dror Paley · Ian Weiner · Rolf D. Burghardt

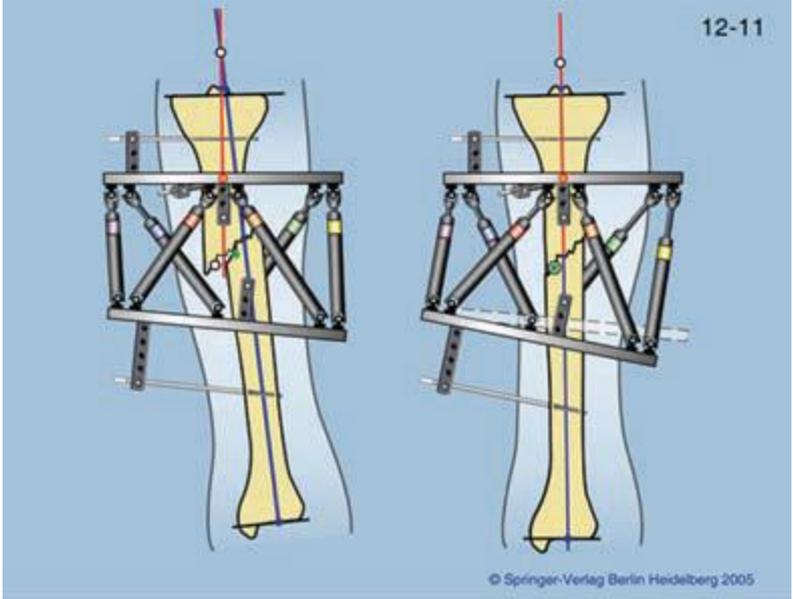
Manual distraction (0.25 mm four times a day) in a group containing 43 tibiae was compared with **motorized high frequency distraction** (1/1,440 mm 1,400 times a day) in a group containing 27 tibiae.

There was no significant difference in time to union or in the incidence of complications

improved compliance vs cost, weight (1 Kg) and possibility of mechanical failure



Computer dependent external fixation





Available online at
ScienceDirect
www.sciencedirect.com

Elsevier Masson France
EM|consulte
www.em-consulte.com



ORIGINAL ARTICLE

Limb lengthening and deformity correction in children using hexapodal external fixation: Preliminary results for 36 cases

B. Blondel, F. Launay*, Y. Glard, S. Jacopin, J.-L. Jouve, G. Bollini

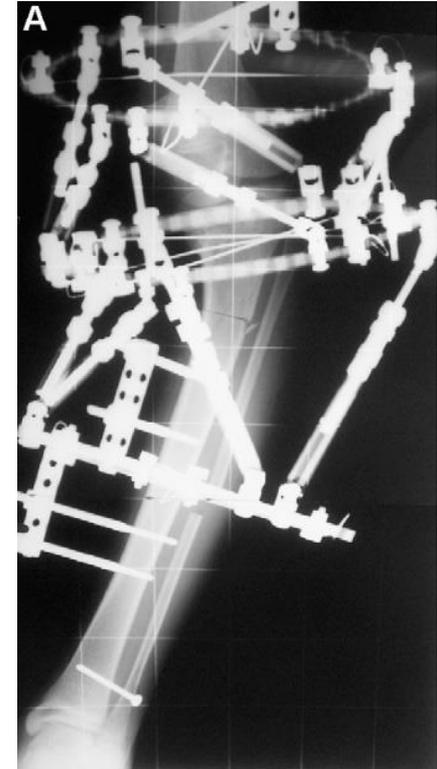
All the patients were managed with the same protocol: placement of an external fixator, AP and lateral X-rays, and planning of the correction using dedicated **software**

3/36 cases with achondroplasia

healing index 38.2 days/cm.

superficial infection 22.2%

3 regenerate fractures



Implantable limb lengthening

Albizzia/ Guichet nail

ISKD (Orthofix)

Fitbone

PHENIX

Precise

Generally successful outcomes

Complications

“run away nails”

Inaccurate and unreliable distraction

Premature consolidation

Technical problems

Nerve injuries

Joint contractures

ALBIZZIA nail (1987), Guichet-advanced ALBIZZIA (2009)

Internal telescopic nail

Lengthening achieved by rotation

Rotation makes “click” noise,
allowing higher accuracy

15 clicks ~ 1 mm

Can achieve 9-10 cm of lengthening



Complications of Albizzia femoral lengthening nail: an analysis of 36 cases

Philippe Mazeau, Chahine Assi, Djamel Louahem, Mohamed L'Kaissi, Marion Delpont and Jérôme Cottalorda

Journal of Pediatric Orthopaedics B 2012, 21:394–399

36 cases (3 short-statured)

average lengthening 4.7 cm

faster consolidation

patient compliance

Table 2 Complications in the literature

	Ratcheting under anesthesia	Bone grafting	Deep infection	Program failure
Garcia-Cimbrelo series (24 cases)	5	2	0	3
Guichet series (41 cases)	12	2	2	2
Our series (36 cases)	8	3	1	3
Total (101 cases)	25	7	3	8

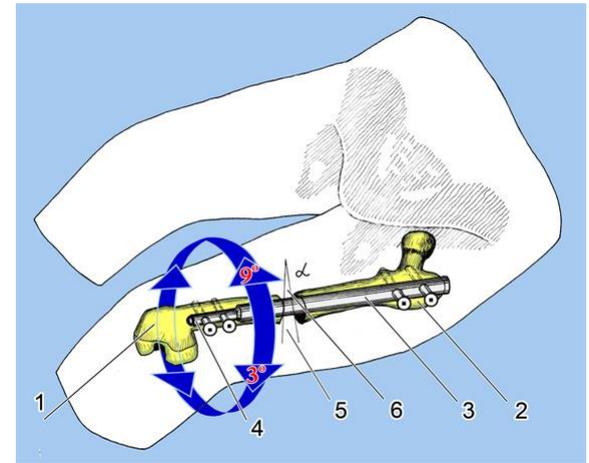


ISKD (INTRAMEDULLARY SKELETAL KINETIC DISTRACTOR)

Activated by polar movements through small rotation of bone segment being lengthened

Amount of length is determined pre-op and set at time of insertion

Allows 7 cm height gain



ORIGINAL ARTICLE

Stefan Hankemeier · Hans-Christoph Pape
Thomas Gosling · Tobias Hufner · Martinus Richter
Christian Krettek

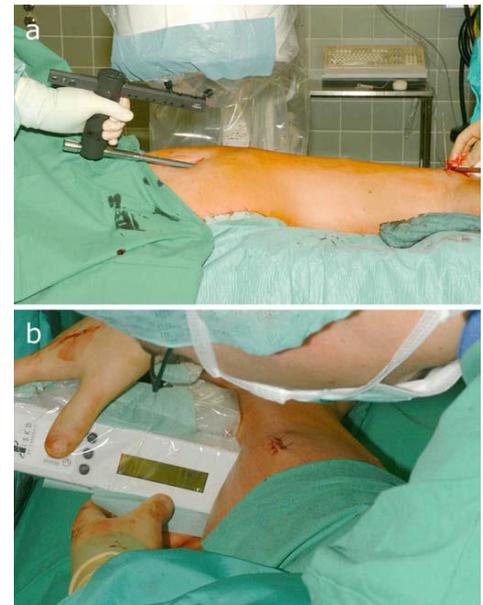
Improved comfort in lower limb lengthening with the intramedullary skeletal kinetic distractor

Principles and preliminary clinical experiences

A distraction of 1 mm is achieved by 160 rotations of 3°.

The actual amount of distraction is controlled by an external handheld monitor, which measures the orientation of a magnet on the distal part of the internal threaded rod.

maximal distraction length by the ISKD is 80 mm



Femoral Lengthening with Lengthening over a Nail has Fewer Complications than Intramedullary Skeletal Kinetic Distraction

Shahab Mahboubian DO, MPH, Matthew Seah MBChB,
Austin T. Fragomen MD, S. Robert Rozbruch MD

11 pt who had 12 femoral ISKD
21 patients with 22 femoral LON

No difference in lengthening goals

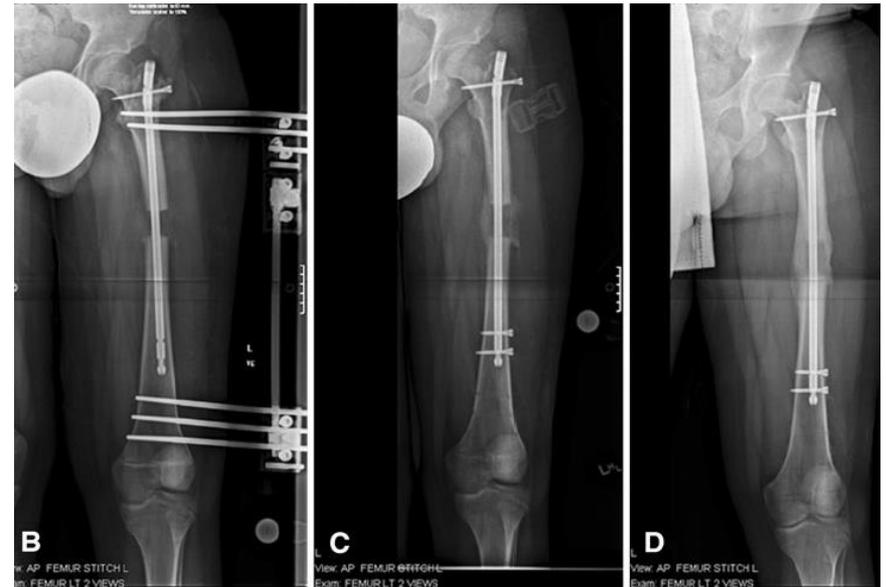
Distraction rates:

fast ISKD group: 1.7 mm/day

slow ISKD group: 0.84 mm/day

LON group: 0.88 mm/day

1 pt in LON and **6/12** pt in IKDC group
requiring additional unanticipated surgeries



FITBONE (FULLY INTEGRATED TELESCOPIC BONE)

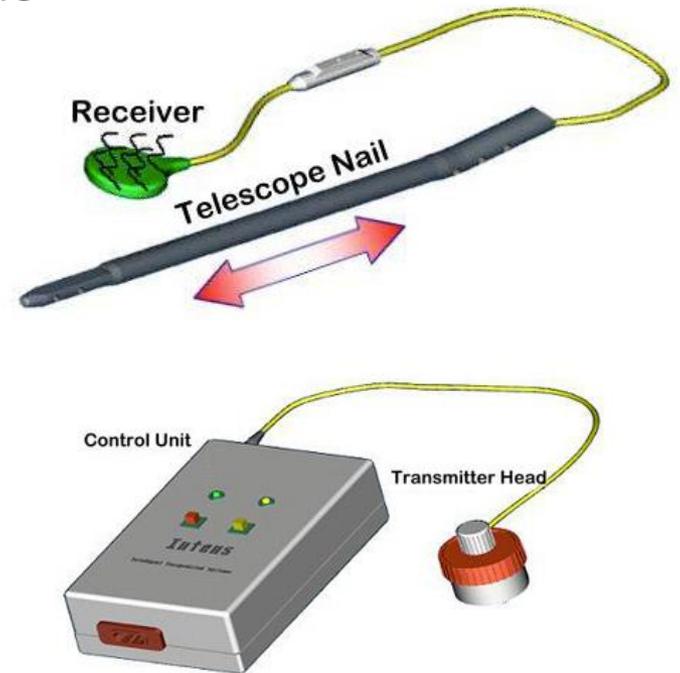
Nail is distraction device powered by internal engine

Engine activated by hand remote

Activates distraction by sending messages to receiver below skin

Similar function as car antenna

Fitbone elongation is propelled by gear



The results of limb lengthening by callus distraction using an extending intramedullary nail (Fitbone) in non-traumatic disorders

S. Singh,
A. Lahiri,
M. Iqbal

J Bone Joint Surg [Br]
2006;88-B:938-42.

13 femora and 11 tibiae in ten patients
mean age of 32 years
short stature in 6/10 patients

mean lengthening 40 mm (27 to 60)

mean healing index was 35 days/cm

There were no cases of implant-related
infection or malunion





Limb lengthening with fully implantable magnetically actuated mechanical nails (PHENIX[®])—Preliminary results



Peter Helmut Thaller^{a,*}, Julian Fürmetz^b, Florian Wolf^a, Thorsten Eilers^a, Wolf Mutschler^a

The mechanism is driven by a strong external magnet, can provide lengthening, **shortening** and bone transport

10 patients with an average age of 25 years (6 femoral / 4 tibial), distraction goal was achieved in 8 of 10 patients

mean lengthening 4.6 cm, distraction index 0.85 mm/day

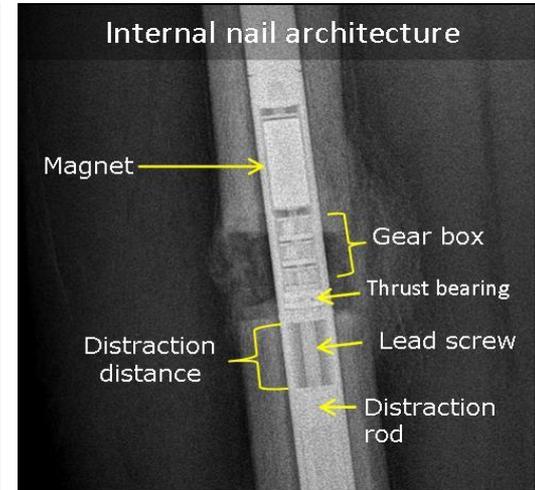
3 patients revised due to early distraction arrest



Precice[®] Nail, Ellipse Technologies Inc., Irvine, CA

Telescopic, magnet-operated device, recent FDA approval

An external remote controller (ERC) is required, which causes the magnets that are integrated into the drive thread rod to rotate, making a thinner nail element telescope out of a thicker surrounding nail



How precise is the PRECICE compared to the ISKD in intra-medullary limb lengthening?

Reliability and safety in 26 procedures

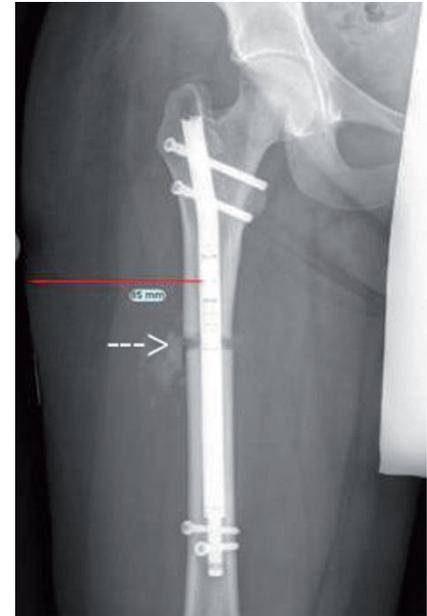
Frank M Schiedel¹, Björn Vogt¹, Henning L Tretow¹, Britta Schuhknecht², Georg Gosheger², Melanie J Horter¹, and Robert Röd¹

2 nails were primarily without function

24/26 nails lengthened over the desired distance (planned 38 – achieved 37)

2 nail breakages, mostly in patients with femoral lengthening

Other complications in 5 cases



Biological advantages and improvement of healing

- systemic administration of recombinant GH
- platelet-rich plasma
- concentrated bone marrow cells
- cultured periosteal cells
- recombinant human bone morphogenetic proteins
- frozen embryonic stem cells

Distraction Osteogenesis of the Lower Extremity in Patients With Achondroplasia/Hypochondroplasia Treated With Transplantation of Culture-Expanded Bone Marrow Cells and Platelet-Rich Plasma

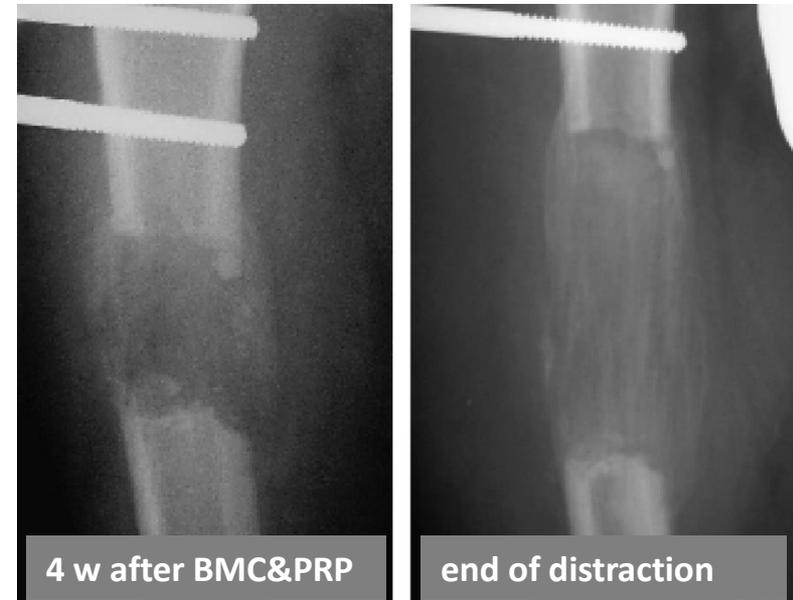
(*J Pediatr Orthop* 2007;27:629–634)

Hiroshi Kitoh, MD, Takahiko Kitakoji, MD, Hiroki Tsuchiya, MD, Mitsuyasu Katoh, MD, and Naoki Ishiguro, MD

56 bones in 20 patients (ACH 16 & HCH, 4)
24 bones in 11 patients (BMC and PRP)
32 bones in 9 patients (no cell therapy)

No differences in the length gained but
average healing index
of the BMC-PRP **6.89 d/cm**
control group 10.4 d/cm

Femoral lengthening faster healing than
tibial lengthening in the BMC-PRP group



Waiting period of 9 days, and transplantation was performed 21 days after the distraction

Bone Marrow Aspirate Concentrate and Platelet-rich Plasma Enhanced Bone Healing in Distraction Osteogenesis of the Tibia

Dong Hoon Lee MD, PhD, Keun Jung Ryu MD,
Jin Woo Kim MD, Kyung Chung Kang MD, PhD,
Young Rak Choi MD

20 patients (40 segments), who underwent bilateral stature lengthening (familiar shortening) with the **LON technique**

10 patients received BMAC & PRP injection at tibial osteotomy site at the end of the index surgery, 10 patients no injection

Mean distraction rates similar (0.75 mm/day vs 0.72 mm/day)

No difference in mean external fixator index

Mean cortical healing indexes better in BMAC group

Full weightbearing was permitted earlier in BMAC group

Conclusions

While the first 100 years was the story of external fixation and distraction osteogenesis, the next 100 years will be the story of:

- Implantable distraction devices
- bone transport nails
- gradual deformity correction plates
- special lengthening plates
- biofeedback controls for internal and external fixation
- modulation of molecular and regenerative biology

Also many of the genetic conditions currently being treated will have **medical** instead of surgical solutions and new applications of distraction biology will be found