Understanding Deformity Correction and TSF Principles
Advanced TSF Course, Memphis, TN; August 2-3, 2013

S. Robert Rozbruch, MD
Chief, Limb Lengthening & Complex Reconstruction Service
Professor of Clinical Orthopedic Surgery
Radiographic analysis
Normal alignment parameters

**Mechanical**

- **LPFA = 90° (85–95°)**
- **mLDFA = 88° (85–90°)**
- **JLCA = 0–2°**
- **MPTA = 87° (85–90°)**
- **LDTA = 89° (86–92°)**

**Sagittal**

- **PPFA = 90°**
- **ANSA = 170° (165–175°)**
- **PDFA = 83° (79–87°)**
- **PPTA = 81° (77–84°)**
- **ADTA = 80° (78–82°)**
What is the source of deformity?
Rotational deformity - tibia

- Patella forward
- Tibial torsion angle

9-03c

9-03a

+ ve  TFA = 0  - ve
Rotational deformity - femur
Hip and ankle deformities do not affect MAD much.
Physical Exam

- Large Varus deformity
- Mild Procurvatum deformity
- 5’8” tall, 155 lbs.
Radiographs

- 51” Erect Leg (10ft)
- 5% magnification
- MAD 7.8 cm medial
- LLD 3.2 cm
- Hypertrophic Nonunion, Stiff
Normal Femur and Varus Tibia

Use extension of femur mech axis for proximal tibia mech. axis
39 degrees varus deformity
Radiographs

- 11 degrees procurvatum
- Anterior translation
  - 9 mm
- Hypertrophic Nonunion
End Distraction, day #38
Better ways to use the computer
Terminology
Reference Fragment
Origin / Corresponding Point

Parameters
Deformity
Mounting Frame
Structure at Risk
Safe Velocity

Computer Program

Frame
Deformity Correction with External Fixation

- 3 Frame Parameters
- 4 Mounting Parameters
- 6 Deformity Parameters
DEFORMITY
Crooked frame / crooked bone

Total Residual Deformity Correction

CORRECTION
Deformity Parameters
Six Axis Deformity Correction

- **Frontal plane**
  - Angulation (e.g., varus)
  - Translation

- **Sagittal Plane**
  - Angulation (e.g., procurvatum)
  - Translation

- **Axial Plane**
  - Angulation (rotational deformity)
  - Translation (length, e.g., short)
Chronic Deformity - Deformity Parameters

ANATOMIC AXIS
DISTAL FRAGMENT

ANATOMIC AXIS
PROXIMAL FRAGMENT

AP VIEW
ANGULATION

LATERAL VIEW
ANGULATION

AXIAL VIEW
ANGULATION

○ = Origin
● = Corresponding Point
Chronic Deformity - Deformity Parameters

AP VIEW
TRANSLATION

LATERAL VIEW
TRANSLATION

AXIAL
TRANSLATION

○ = Origin
• = Corresponding Point
Chronic Deformity - Mounting Parameters

AP VIEW FRAME OFFSET

AXIAL FRAME OFFSET

LATERAL VIEW FRAME OFFSET

ROTARY FRAME OFFSET

• = Center of Ring
○ = Origin
OR Taylor Spatial Frame worksheet
Limb Lengthening & Deformity Service, HSS

SIDE:__________
REFERENCE RING:____________

DEFORMITY:
AP angulation_________ Lateral angulation_________ Axial angulation_________
AP translation_________ Lateral translation_________ Axial translation_________

PROXIMAL RING SIZE:__________ opening_bt. ______________________
DISTAL RING SIZE:__________ opening__bt. _________________________

STRUTS: 1. _______ L M S XS XXS
2. _______ L M S XS XXS
3. _______ L M S XS XXS
4. _______ L M S XS XXS
5. _______ L M S XS XXS
6. _______ L M S XS XXS

MOUNTING PARAMETERS (frame offset relative to origin):
AP _______ Med / Lat LATERAL_______ Ant / Post
AXIAL__________ Prox / Dist ROTARY_frame offset_________

SAR:_____________
RATE:_____________ START POD #_________
Normal Femur and Varus Tibia Metaphyseal deformity

Step 2

LDTA = 89°

Step 3

CORA

Mag = 12°
Min length = \( w \sin 20 \)

= 4 mm
25 year old: This may change her future
PREOP
Normal femur, distal tibia varus

Use extension of femur mech axis for proximal tibia mech. axis
5 months
Osteotomy principle

Gain length

Loose length
Osteotomy rule 2

If you make your osteotomy away from the CORA, you need to translate
Normal tibia and Varus femur

Step 1

Step 2a

LPFA = 90°

Step 2b

Mag = 22°

Step 3

COR

MPTA = 87°

© Springer-Verlag Berlin Heidelberg 2003
LDFA 79

87 line

CORA 13 deg

Osteotomy level

6 deg off anatomic axis

LDFA 79
Normal tibia, valgus femur

- LLD: 4 cm
- MAD: 36 mm lateral
- CORA: 13 deg
- VALGUS: 13 deg
Flexion deformity of knee
- femur
- tibia
- contracture of knee
Correction of Tibial Deformity with Use of the Ilizarov-Taylor Spatial Frame

By S. Robert Rozbruch, MD, Austin T. Fragomen, MD, and Svetlana Ilizarov, MD

Introduction

The Ilizarov-Taylor Spatial Frame (TSF; Memphis, Tennessee) is a powerful tibial deformity. A specialized fixation virtual hinge, which allows for the simultaneous correction of multiplanar deformities and limb-length osteotomy site. The power of the spatiality of the TSF provides an ideal environment for both new and soft tissue healing. The classic principles of the TSF method are followed to ensure proper frame fitting and easy-to-use struts. This framework can be complemented by utilizing standard anterior-posterior radiographic measurements.

Surgical Technique

Preoperative Planning

Patients are evaluated clinically by history and examination including observation of gait, steering of the assessment of leg length, and rotational alignment (Fig. 1). A lateral view in the frontal plan is a leg-length discrepancy, then blocks are placed on the foot to level the pelvis, and the block height is recorded. Accurate limb lengths are measured in this position. The knee is elevated to a 30° angle with the knee in full extension, with posterior and lateral radiographs of the well. Ankle deformity should be evaluated with the patient in standing. Mechanical axis deviation with use of the malalignment test is measured (Fig. 2). Femoral angle, medial proximal tibial angle, and lateral distal tibial angle are measured to analyze the coronal, sagittal, and axial planes of the tibial. The lateral distal tibial angle is measured with a varus deformity and from 96° to 85° in patients with a valgus deformity. In the middle ostectomy group, all patients had less than 5° coronal plane deformity and 15 of 17 patients had less than 5° sagittal plane deformity. In the distal ostectomy group, the lateral distal tibial angle improved from 77° to 86° in patients with a valgus deformity and from 101° to 90° for patients with a varus deformity.

Background

Optimal leg alignment is the goal of tibial ostectomy. The Taylor Spatial Frame (TSF) and the Ilizarov method enable gradual realignment of angulation and translation in the coronal, sagittal, and axial planes, thereby, the term six-axis correction.

Questions/purposes

We asked whether this approach would allow precise correction of tibial deformities.

Methods

We retrospectively reviewed 102 patients (122 tibias) with deformities treated with percutaneous osteotomy and gradual correction with the TSF. The proximal ostectomy group was subdivided into two subgroups with a varus deformity and from 96° to 85° in patients with a valgus deformity. In the middle ostectomy group, all patients had less than 5° coronal plane deformity and 15 of 17 patients had less than 5° sagittal plane deformity. In the distal ostectomy group, the lateral distal tibial angle improved from 77° to 86° in patients with a valgus deformity and from 101° to 90° for patients with a varus deformity.

Conclusions

Gradual correction of all tibial deformities with the TSF was accurate and with few complications.

Level of Evidence

Level IV, therapeutic study. See the Guidelines for Authors for a complete description of levels.
mLDFA = 95°
MPTA = 80°
JLCA = 3°

© Springer-Verlag
Berlin Heidelberg 2003
15 y/o M
LLD one inch
Tension band plate done 1 yr. earlier
not effective and screws broke
35 year old, femur + tibial deformity, LCL laxity, LLD, ACL laxity
65 y/o M
Old trauma 30 yrs ago
Knee: unstable, valgus recurvatum
Tibia: valgus def
Ankle/foot: valgus & arthrosis
LLD = 6 cm
SPATIALFRAME.COM VERSION 3.0™

Welcome to SPATIALFRAME.COM 3.0. For eight years Spatial Frame has been correcting post traumatic and congenital orthopaedic deformities. The TAYLOR SPATIAL FRAME external fixator is uniquely designed for those orthopaedic surgeons that require a 100% accurate, minimally invasive, easily explantable device.

SPATIALFRAME.COM is a one-of-a-kind web application designed to provide the orthopaedist with all the software tools necessary to preoperatively plan or postoperatively adjust the TAYLOR SPATIAL FRAME external fixator.

To begin using TAYLOR SPATIAL FRAME contact your local Smith & Nephew sales representative, then click “Request an Account” at the bottom of this screen. Learn the latest techniques by attending an upcoming course. Click the “Spatial Frame Courses 2004-2005” link below to get the latest details.

Our next course will be April 8-10 in Atlanta, GA.

Welcome, Robert Rozbruch!

Useful Links
  Software License
<table>
<thead>
<tr>
<th>Patient</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Case Number:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case Name:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient Initials:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient Number:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date:</td>
<td>04/04/2005</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correction Type:</td>
<td>Select</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anatomy:</td>
<td>Select</td>
<td>Long Bone</td>
<td>Forefoot 6x6 Miller</td>
<td>Forefoot 6x6 Butt</td>
</tr>
<tr>
<td>Case Notes:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Long Bone

<table>
<thead>
<tr>
<th>AP View Angulation (deg)</th>
<th>Lateral View Angulation (deg)</th>
<th>Axial View Angulation (deg)</th>
<th>Case Name: Maciocco, Richard 3.10.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valgus</td>
<td>Apex Posterior</td>
<td>Apex Anterior</td>
<td></td>
</tr>
<tr>
<td>Varus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.0</td>
<td>7.0</td>
<td>10.0</td>
<td></td>
</tr>
</tbody>
</table>

| AP View Translation (mm) | Lateral View Translation (mm) | Axial Translation (mm) | |
|--------------------------|-------------------------------|------------------------|-
| 5.0                      | 7.0                           | 5.0                    | |

### Reference Fragment

- Proximal

### Case Information

- Right AP View
- Right Lateral View
- Right Axial View

### Views

- Lateral
- Medial
- Posterior
- Anterior
- Medial
- Lateral
Mouting Parameters:
center ring is 20 mm posterior to origin
### Long Bone

**Operative Mode?**
- Total Residual
- Chronic
- Residual

#### Mounting Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP View Frame Offset (mm)</td>
<td>5.0</td>
</tr>
<tr>
<td>Lateral View Frame Offset (mm)</td>
<td>24.0</td>
</tr>
<tr>
<td>Axial Frame Offset (mm)</td>
<td>120.0</td>
</tr>
<tr>
<td>Rotary Frame Angle (deg)</td>
<td>10.0</td>
</tr>
</tbody>
</table>

#### Views

- **Right AP View**
- **Right Lateral View**
- **Right Axial View**

Clicking on graphic will enlarge?
### Long Bone

**Initial Settings for Total Residual Operative Mode**

<table>
<thead>
<tr>
<th>Strut 1 (mm)</th>
<th>Strut 2 (mm)</th>
<th>Strut 3 (mm)</th>
<th>Strut 4 (mm)</th>
<th>Strut 5 (mm)</th>
<th>Strut 6 (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Orange</td>
<td>Yellow</td>
<td>Green</td>
<td>Blue</td>
<td>Violet</td>
</tr>
<tr>
<td>162</td>
<td>176</td>
<td>170</td>
<td>187</td>
<td>145</td>
<td>146</td>
</tr>
</tbody>
</table>

### Deformity Parameters

- **AP View Angulation:** 15.0° Valgus
- **AP View Translation:** 5.0 mm Lateral
- **Lateral View Angulation:** 7.0° Apex Anterior
- **Lateral View Translation:** 7.0 mm Anterior
- **Axial View Angulation:** 10.0° Internal
- **Axial Translation:** 5.0 mm Short

### Mounting Parameters

- **AP View Frame Offset:** 5.0 mm Lateral to Origin
- **Lateral View Frame Offset:** 24.0 mm Posterior to Origin
- **Rotary Frame Angle:** 15.0° Frame Externally Rotated
- **Axial Frame Offset:** 123.0 mm Proximal to Origin

### Right AP View

![Right AP View](image1)

### Right Lateral View

![Right Lateral View](image2)

### Right Axial View

![Right Axial View](image3)
### Final Settings for Total Residual Operative Mode

<table>
<thead>
<tr>
<th>Strut 1 (mm) (Red)</th>
<th>Strut 2 (mm) (Orange)</th>
<th>Strut 3 (mm) (Yellow)</th>
<th>Strut 4 (mm) (Green)</th>
<th>Strut 5 (mm) (Blue)</th>
<th>Strut 6 (mm) (Violet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>183</td>
<td>164</td>
<td>156</td>
<td>154</td>
<td>181</td>
<td>185</td>
</tr>
</tbody>
</table>

### Final Deformity Parameters

- **AP View**
  - Angulation: 0.0°
  - Translation: 0.0 mm
- **Lateral View**
  - Angulation: 0.0°
  - Translation: 0.0 mm
- **Axial View**
  - Angulation: 0.0°
  - Translation: 0.0 mm

### Mounting Parameters

- **AP View Frame Offset**: 4.0 mm Lateral to Origin
- **Lateral View Frame Offset**: 24.0 mm Posterior to Origin
- **Rotary Frame Angle**: 10.0° Frame Externally Rotated
  - Axial Frame Offset: 120.0 mm Proximal to Origin

Clicking on graphic will enlarge.
Define structure at risk
- Concavity of the deformity
- Bone
- Soft-tissue

Not more than 1mm per day
- Tailored to specific patient
- Based on postop assessments
### Prescription

<table>
<thead>
<tr>
<th>Date</th>
<th>Day</th>
<th>Status 1 (Red)</th>
<th>Status 2 (Orange)</th>
<th>Status 3 (Yellow)</th>
<th>Status 4 (Green)</th>
<th>Status 5 (Blue)</th>
<th>Status 6 (Violet)</th>
<th>View</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/1/05</td>
<td>0</td>
<td>162</td>
<td>176</td>
<td>170</td>
<td>137</td>
<td>145</td>
<td>145</td>
<td>View</td>
</tr>
<tr>
<td>3/1/05</td>
<td>1</td>
<td>163</td>
<td>176</td>
<td>170</td>
<td>137</td>
<td>147</td>
<td>147</td>
<td>View</td>
</tr>
<tr>
<td>3/1/05</td>
<td>2</td>
<td>164</td>
<td>175</td>
<td>169</td>
<td>137</td>
<td>143</td>
<td>143</td>
<td>View</td>
</tr>
<tr>
<td>3/1/05</td>
<td>3</td>
<td>165</td>
<td>175</td>
<td>169</td>
<td>137</td>
<td>150</td>
<td>143</td>
<td>View</td>
</tr>
<tr>
<td>3/1/05</td>
<td>4</td>
<td>166</td>
<td>174</td>
<td>168</td>
<td>137</td>
<td>151</td>
<td>143</td>
<td>View</td>
</tr>
<tr>
<td>3/1/05</td>
<td>5</td>
<td>167</td>
<td>174</td>
<td>168</td>
<td>136</td>
<td>153</td>
<td>150</td>
<td>View</td>
</tr>
<tr>
<td>3/1/05</td>
<td>6</td>
<td>168</td>
<td>174</td>
<td>169</td>
<td>136</td>
<td>155</td>
<td>151</td>
<td>View</td>
</tr>
<tr>
<td>3/1/05</td>
<td>7</td>
<td>169</td>
<td>173</td>
<td>167</td>
<td>136</td>
<td>155</td>
<td>151</td>
<td>View</td>
</tr>
<tr>
<td>3/2/05</td>
<td>8</td>
<td>171</td>
<td>173</td>
<td>157</td>
<td>136</td>
<td>158</td>
<td>162</td>
<td>View</td>
</tr>
<tr>
<td>3/2/05</td>
<td>9</td>
<td>172</td>
<td>172</td>
<td>166</td>
<td>136</td>
<td>159</td>
<td>153</td>
<td>View</td>
</tr>
<tr>
<td>3/2/05</td>
<td>10</td>
<td>173</td>
<td>172</td>
<td>166</td>
<td>136</td>
<td>161</td>
<td>154</td>
<td>View</td>
</tr>
<tr>
<td>3/2/05</td>
<td>11</td>
<td>174</td>
<td>171</td>
<td>165</td>
<td>136</td>
<td>162</td>
<td>154</td>
<td>View</td>
</tr>
<tr>
<td>3/2/05</td>
<td>12</td>
<td>175</td>
<td>171</td>
<td>165</td>
<td>136</td>
<td>164</td>
<td>166</td>
<td>View</td>
</tr>
<tr>
<td>3/2/05</td>
<td>13</td>
<td>176</td>
<td>171</td>
<td>165</td>
<td>136</td>
<td>166</td>
<td>156</td>
<td>View</td>
</tr>
<tr>
<td>3/2/05</td>
<td>14</td>
<td>177</td>
<td>171</td>
<td>164</td>
<td>136</td>
<td>157</td>
<td>157</td>
<td>View</td>
</tr>
<tr>
<td>3/2/05</td>
<td>15</td>
<td>178</td>
<td>170</td>
<td>164</td>
<td>195</td>
<td>163</td>
<td>157</td>
<td>View</td>
</tr>
<tr>
<td>3/2/05</td>
<td>16</td>
<td>179</td>
<td>169</td>
<td>163</td>
<td>185</td>
<td>170</td>
<td>168</td>
<td>View</td>
</tr>
<tr>
<td>3/2/05</td>
<td>17</td>
<td>180</td>
<td>168</td>
<td>163</td>
<td>185</td>
<td>172</td>
<td>169</td>
<td>View</td>
</tr>
<tr>
<td>3/2/05</td>
<td>18</td>
<td>181</td>
<td>168</td>
<td>163</td>
<td>195</td>
<td>174</td>
<td>160</td>
<td>View</td>
</tr>
<tr>
<td>3/2/05</td>
<td>19</td>
<td>182</td>
<td>168</td>
<td>162</td>
<td>195</td>
<td>175</td>
<td>163</td>
<td>View</td>
</tr>
</tbody>
</table>
### Strut Change-Outs

<table>
<thead>
<tr>
<th>Change-Out</th>
<th>Stutt</th>
<th>First Day</th>
<th>Last Day</th>
<th>Overlap Interval</th>
<th>Strut Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>1 (Red)</td>
<td>7 (3/19/05)</td>
<td>15 (3/27/05)</td>
<td>7107-0220</td>
<td>7107-0230 Medium Standard</td>
</tr>
<tr>
<td>b</td>
<td>5 (Blue)</td>
<td>15 (3/27/05)</td>
<td>21 (4/2/05)</td>
<td>7107-0220</td>
<td>7107-0230 Long Standard</td>
</tr>
</tbody>
</table>