The Effect of Bone Marrow Aspirate Concentrate (BMAC) and Platelet-Rich Plasma (PRP) during Distraction Osteogenesis of the Tibia

Dong Hoon Lee, MD, Ph.D, Keun Jung Ryu MD

Limb Lengthening and Deformity Correction Service
Department of Orthopaedic Surgery, CHA Bundang Medical Center
CHA university, Korea, Republic of.
A successful bone formation is the key during the DO. Many methods have been tried to enhance bone healing including...

**Physical stimulation**
- Mechanical
- Ultrasound
- Electromagnetic
- Shockwave
- Laser
- Vibration

**Local application**
- Cells: BMAC, stem cell
- PRP
- BMP
- Bone grafts

**Systemic application**
- PTH
- Growth hormone
- Anti-absorptive drugs
  - (eg. bisphosphonates)
@ Kitoh et al reported an encouraging results of local injection of both culture expanded BMCs and PRP to achondroplasia Pts.

But, Culture expansion tech. requires additional visit to the OR, special equipment and additional training to harvest the stem cells.
BMAC (Bone Marrow Aspirate Concentrate)

- Rich MSCs
- Can avoid time-consuming and technically difficult process of cell expansion and differentiation
- Enable us to do both harvesting and transplantation during the same surgery
- Can reduce the risk of infection/keep the viability of the cells

Limited clinical data! No results on human DO!
- **PRP (Platelet-Rich Plasma)**

  - **Osteo-inductive growth factors** that released from platelet may enhance bone formation in DO
  - It is a conflicting issue – if PRP enhances or inhibits the differentiation of osteoblast
  - Clinically, it is not clear if PRP have any supportive effect in healing the bone

  **No results on DO!**
Hypothesis of this study

Combination of Mono-nucleated cells (BMAC) + Osteo-inductive growth factors (PRP) may enhance bone formation in DO.
MATERIALS and METHODS

A prospective randomized comparison

- Total 40 segments
- Tibial lengthening with the LON technique
- Apr 2010 – Jan 2011

Exclusion criteria
- Skeletally immature
- History of medical illness, fracture, soft tissue compromise, bony deformities or infection
- Insufficient preop./follow-up radiographs

Random number generation

Inject BMAC and PRP (Group 1: 20 segments)

Not inject (Group 2: 20 segments)
## MATERIALS and METHODS

### Demographics

<table>
<thead>
<tr>
<th></th>
<th>Inject Group</th>
<th>No inject group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of tibia (segments)</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Age at the time of 1\textsuperscript{st} stage surgery (years)</td>
<td>20 (16-28)</td>
<td>23 (18-30)</td>
</tr>
<tr>
<td>Sex (M:F)</td>
<td>16:4</td>
<td>4:6</td>
</tr>
<tr>
<td>BMI (kg/cm\textsuperscript{2})</td>
<td>22 (18-26)</td>
<td>20 (19-22)</td>
</tr>
<tr>
<td>Smoking history (Yes:No)</td>
<td>8:12</td>
<td>13:7</td>
</tr>
<tr>
<td>Duration of follow up (months) (after the 1\textsuperscript{st} stage surgery)</td>
<td>32 (27-36)</td>
<td>34 (31-38)</td>
</tr>
</tbody>
</table>

‘No difference’
At the end of surgery

BM 50cc + ACD-A 10cc/ Periph.blood 55cc + ACD-A 5cc

Bilateral LON of tibia

Random allocation of a patient

GPS tube (Biomet, USA)

Group A
Injection group (BMAC+PRP)

Group B
No injection group

3,200 rpm x 15min
Surgical Protocol

2. Local injection

• 6cc BMAC/6cc PRP was obtained
• under the C-arm guidance
• 3cc BMAC + 3cc PRP were injected into the osteotomy site of each segment
# Evaluations

## Evaluation

- **Final length achieved (mm)**
- **Distraction rate (mm/days)**
- **External fixator index (months/cm)**
- **Callus shape***
- **Consolidation index, each cortex (months/cm)**
- **Full weight-bearing index (months/cm)**

## Complications

- **Problems, obstacles, and complications**

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#Paley D. Problems, obstacles, and complications of limb lengthening by the Ilizarov technique, Clin Orthop 1990;256:81-104
## RESULTS

‘No differences’

<table>
<thead>
<tr>
<th></th>
<th>Injection group</th>
<th>No injection group</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latent periods (days)</td>
<td>7.4 (7-8)</td>
<td>7.6 (7-8)</td>
<td>0.45</td>
</tr>
<tr>
<td>Distraction rate (mm/days)</td>
<td>0.75 (0.55-1.13)</td>
<td>0.72 (0.52-1.20)</td>
<td>0.24</td>
</tr>
<tr>
<td>Final length achieved (mm)</td>
<td>58 (43-70)</td>
<td>66 (46-73)</td>
<td>0.08</td>
</tr>
<tr>
<td>External fixator index (months/cm)</td>
<td>0.53 (0.37-0.63)</td>
<td>0.49 (0.43-0.53)</td>
<td>0.12</td>
</tr>
<tr>
<td>IM nail diameter (cm)</td>
<td>9.2 (8-10)</td>
<td>8.9 (8-10)</td>
<td>0.30</td>
</tr>
<tr>
<td>IM nail length (cm)</td>
<td>288 (270-300)</td>
<td>294 (285-300)</td>
<td>0.14</td>
</tr>
</tbody>
</table>
## Radiographic results


<table>
<thead>
<tr>
<th>Callus shape</th>
<th>Injection group</th>
<th>No injection group</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fusiform</td>
<td>2 tibiae</td>
<td>4 tibiae</td>
<td></td>
</tr>
<tr>
<td>Cylindrical</td>
<td>18 tibiae</td>
<td>16 tibiae</td>
<td>0.66</td>
</tr>
<tr>
<td>Concave</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Lateral</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Central</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>
## RESULTS

- **Radiographic results**

<table>
<thead>
<tr>
<th>Consolidation index (months/cm)</th>
<th>Injection group</th>
<th>No injection group</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior cortex</td>
<td>1.14</td>
<td>1.47</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Posterior cortex</td>
<td>0.81</td>
<td>1.26</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Medial cortex</td>
<td>0.96</td>
<td>1.42</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Lateral cortex</td>
<td>0.88</td>
<td>1.22</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Full weight-bearing index (months/cm)</td>
<td>0.99</td>
<td>1.38</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
AP view

1mo  2mo  3mo  4mo  5mo

Park 11448828 (No Injection Group)

Kang 11380461 (BMAC+PRP Injection group)
<table>
<thead>
<tr>
<th></th>
<th>1mo</th>
<th>2mo</th>
<th>3mo</th>
<th>4mo</th>
<th>5mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Park</td>
<td>11448828 (No Injection Group)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kang</td>
<td>11380461 (BMAC+PRP Injection group)</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
## Complications

‘no difference’

; No injection-related complications

<table>
<thead>
<tr>
<th>Cx. in details</th>
<th>Injection group</th>
<th>No injection group</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impending compartment SD</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Deep infections</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Superficial infections</td>
<td>9</td>
<td>6</td>
<td>0.73</td>
</tr>
<tr>
<td>Peroneal n Sx</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Fibular-related</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Fracture of regenerate</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Hardware problems</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Non-union</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
Conclusion

- The autologous BMAC combined with PRP injection at the osteotomy site during index surgery helps bone healing in distraction osteogenesis of the tibia
Conclusion

- Further investigation is necessary about
  - which one contributes more in bone healing, BMAC or PRP?
  - what is the optimal amount of injection?
  - what is the best application protocol?
    - single or multiple injections
    - optimal time of injection
Thank you for your attention!