Can We Grow Mandibles?  
Who? How? When?

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I declare that neither I nor any member of my family have a financial arrangement or affiliation with any corporate organization offering financial support or grant monies for this continuing education presentation, nor do I have a financial interest in any commercial product(s) or services I will discuss in this presentation.

Pierre Robin Sequence (PRS)  
- small mandible (micrognathia)  
- posterior displacement of the tongue (glossoptosis)  
- upper airway obstruction

Pierre Robin's “Monobloc”  
In 1902 Pierre Robin described a “monobloc” in vulcanite that was able to induce:  
- forward repositioning of the mandible,  
- improvement in airway patency  
- expansion the arches

In 1902 the French physician Pierre Robin described a "monobloc" to treat the Pierre Robin Sequence

In 1879 Norman Kingsley first used a removable appliance with an anterior inclined plane. "The object was not to protrude the lower teeth, but to jump the bite in the case of an excessively retreating lower jaw."

In Europe the concepts of FJO were developed by Andresen and Häupl  
Andresen V, Häupl K. Funktionskieferorthopädie. Leipzig, H. Meusser, 1936

FJO in the US was introduced in 1969

Mechanism of Action of Functional Appliances  
All functional appliances induce a change in the postural activity of the craniofacial musculature

In 1979 Norman Kingsley first used a removable appliance with an anterior inclined plane. "The object was not to protrude the lower teeth, but to jump the bite in the case of an excessively retreating lower jaw."
During treatment of Class II malocclusion with functional appliances, does the mandible grow more than in matched untreated controls?

The amount of supplementary growth of the mandible when compared to untreated Class II controls varied widely among studies (range 0.5 mm - 6.5 mm).

Only 11 out of 37 samples (30%) in 28 studies described outcomes that exceeded 3.0 mm of supplementary growth at the completion of active treatment.

No one of the 4 RCTs reported a clinically significant change in mandibular length induced by functional appliances.
1. Timing of Treatment: Stage of Skeletal Maturity
2. Individual Patient Responsiveness

Treatment timing for functional jaw orthopedics in growing Class II patients: A systematic review and meta-analysis of controlled studies

Franchi L., Contardo L., Primozic J., Perinetti G.


Inclusion criteria
1. Longitudinal controlled studies, either prospective or retrospective, on healthy growing patients treated for a skeletal Class II malocclusion due to mandibular retrusion
2. Use of a matched control group of subjects with untreated Class II malocclusion
3. Use of a reliable indicator of skeletal maturity for the assessment of treatment timing
4. Use of removable or fixed functional appliances (NO headgear!)
Systematic Review and Meta-analysis on Treatment Timing for FJO

<table>
<thead>
<tr>
<th>Database</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medline</td>
<td>970</td>
</tr>
<tr>
<td>SCOPUS</td>
<td>2334</td>
</tr>
<tr>
<td>LILACS</td>
<td>196</td>
</tr>
<tr>
<td>Cochran</td>
<td>1292</td>
</tr>
<tr>
<td>SciELO</td>
<td>20</td>
</tr>
<tr>
<td><strong>TOTAL (without duplicate entries)</strong></td>
<td><strong>n = 2,456</strong></td>
</tr>
</tbody>
</table>

**FIXED (+/- FFA)**

- Systematic Review: n = 15
- Meta-analysis: n = 12

**REMOVABLE**

- Systematic Review: n = 14
- Meta-analysis: n = 11

Amount of Supplementary Mandibular Growth

**Removable Functional Appliances**

- Peak: 13 mm
- Pre-Peak: 2.5 mm
- Statistically Significant Difference: 2.5 mm

**Fixed Functional Appliances**

- Post-Peak: 4.3 mm
- Statistically Significant Difference: 0.3 mm

**Treatment effects produced by the Twin-Block appliance versus the Forsus Fatigue Resistant Device in growing Class II patients**

Giuntini V, Franchi L, Vangelisti A, Masucci C, McNamara JA Jr, DeFraila E

The Angle Orthodontist, submitted for publication

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Age at T1 (ys) Mean</th>
<th>Age at T2 (ys) Mean</th>
<th>T1-T2 interval (ys) Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Twin Block</strong> (n=28, 19f 9m)</td>
<td>12.4</td>
<td>14.7</td>
<td>2.3</td>
</tr>
<tr>
<td>16% prepubertal, 64% pubertal, 18% postpubertal</td>
<td>1.0</td>
<td>0.0</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Forsus</strong> (n=36, 18f 20m)</td>
<td>12.3</td>
<td>14.6</td>
<td>2.4</td>
</tr>
<tr>
<td>18% prepubertal, 70% pubertal, 15% postpubertal</td>
<td>1.2</td>
<td>1.2</td>
<td>0.4</td>
</tr>
<tr>
<td><strong>Controls</strong> (n=27, 13f 14m)</td>
<td>12.2</td>
<td>14.5</td>
<td>2.3</td>
</tr>
<tr>
<td>16% prepubertal, 64% pubertal, 18% postpubertal</td>
<td>0.8</td>
<td>0.8</td>
<td>0.5</td>
</tr>
</tbody>
</table>
Maxillary Sagittal Changes (vs ctrls) SNA (°)

<table>
<thead>
<tr>
<th></th>
<th>Twin Block</th>
<th>Forsus</th>
<th>Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNA</td>
<td>-1.8***</td>
<td>+1.0**</td>
<td></td>
</tr>
</tbody>
</table>

Mandibular Growth Changes (vs ctrls) Co-Gn (mm)

<table>
<thead>
<tr>
<th></th>
<th>Twin Block</th>
<th>Forsus</th>
<th>Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-Gn</td>
<td>+3.4***</td>
<td>1.4ns</td>
<td></td>
</tr>
</tbody>
</table>

Proclination of the lower incisor L1-Mand. Pl. (°)

<table>
<thead>
<tr>
<th></th>
<th>Twin Block</th>
<th>Forsus</th>
<th>Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proclination</td>
<td>2.7ns</td>
<td>5.6***</td>
<td>-2.9*</td>
</tr>
</tbody>
</table>

**Factors for Improving the Effectiveness of Functional Jaw Orthopedics**

1. Timing of Treatment: Stage of Skeletal Maturity
2. Individual Patient Responsiveness

**CONCLUSIONS**

The Twin Block produced greater skeletal effects than the Forsus in terms of mandibular advancement and growth stimulation.

The Class II correction induced by the FDR was more dentoalveolar than the TB with a larger amount of proclination of the lower incisors.

**5th Dimension in Dentofacial Orthopedics**

Patient Responsiveness

Why different subjects with similar dentoskeletal Class II disharmony respond to FJO differently, even when treated at the RIGHT time (CS 3)?

Is it possible to predict individual responsiveness to FJO?
**Prediction of individual mandibular changes induced by functional jaw orthopedics followed by fixed appliances in Class II patients.**

Franchi L., Baccetti T. *The Angle Orthodontist*, vol. 76, n.6, 950-4, 2006

**PREDICTIVE VARIABLE TO BE ASSESSED BEFORE Tx:**

**Co-Go-Me°**

**Good Responders:**

“Small” Co-Go-Me angle

**Bad Responders:**

“Large” Co-Go-Me angle

**DISCRIMINANT VARIABLE:**

**Co-Go-Me°**

**Bad Responders:**

Co-Go-Me angle > 128°

Average amount of mandibular growth +4.2 mm

Classification Error: 23%

Measurement Error: 1.5°

Error in Discrimination: 20%

(A compliance, management of the appliance, intensity of hormonal factors at puberty, etc.)

**DISCRIMINANT VARIABLE:**

**Co-Go-Me°**

**Good Responders:**

124° < Co-Go-Me angle < 128°

Average amount of mandibular growth +6.8 mm

Classification Error: 23%

Measurement Error: 1.5°

Error in Discrimination: 20%

(A compliance, management of the appliance, intensity of hormonal factors at puberty, etc.)

**Best Responders:**

Co-Go-Me angle < 123°

Average amount of mandibular growth +7.3 mm

Classification Error: 23%

Measurement Error: 1.5°

Error in Discrimination: 20%

(A compliance, management of the appliance, intensity of hormonal factors at puberty, etc.)

**HERITAGE PAPER**

Petrovic A

Axologic categorization and chronobiologic specification for the choice of appropriate orthodontic treatment

AJO-DO 1994;105:192-205

- Physiologically, the treatment is clinically relevant mostly in higher axologic categories, i.e., in the biologic categories where the growth potential and responsiveness to amplifying factors is relatively elevated (Fig. 1).
- Chronobiologically, the treatment is particularly significant when applied during the ascending portion of the pubertal growth spurt (Fig. 2).
1. Effectiveness (>3 mm extra mandibular growth)

2. Short duration of active therapy
   2.5 ys (vs 4 ys, when FJO is used as Phase I Tx)

3. Good stability (end of Tx at postpubertal stage; optimal final intercuspation)

FJO at the Adolescent Growth Spurt followed by Fixed Appliances

**A Critical Question:**

Can mandibular growth be altered in a clinically significant way with FJO in the long term?

**Evidence Based Treatment**

- Evidence
- Experimental Studies
- Clinical Studies
Primate Functional Protrusion Studies

The University of Michigan

Long-Term Mandibular Adaptations to Protrusive Function in the Rhesus Monkey (Macaca mulatta)
McNamara JA Jr, Bryan FA

Mandibular Length (144 Weeks)

<table>
<thead>
<tr>
<th>Control (N =12)</th>
<th>Experimental (N =9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean 78.7</td>
<td>Mean 83.6</td>
</tr>
<tr>
<td>S.D. 3.7</td>
<td>S.D. 2.9</td>
</tr>
</tbody>
</table>

Difference 4.9 mm *** *** p < .001

Evidence Based Treatment

Evidence

Experimental Studies

Clinical Studies

Non-human primate studies

Growth curve for true stimulation

Growth curve for temporary acceleration

Expected growth without treatment

% of Adult Mandibular Size

80 85 90 95 100

AGE

10 15 20 25 30 35

Evidence Based Treatment

Long-term Treatment Effects of the FR-2 Appliance of Fränkel

Freeman DS, McNamara JA Jr, Baccetti T, Franchi L, Fränkel C
Am J Orthod Dentofacial Orthop 2009;135:570.e1-6

Samples

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treated with FR-2</td>
<td>30</td>
</tr>
<tr>
<td>Untreated Class II</td>
<td>20</td>
</tr>
</tbody>
</table>

Timing of Tx: Prepubertal-Pubertal
Long-term observation: CS5-CS6 (18 ys)

Freeman et al., 2009
Long-term Changes
Mandibular Length (Co-Gn)

Difference FR-2 vs Untreated Cl II Controls
+3.0 mm

Freeman et al., 2009

Long-term Dentoskeletal Effects
Induced by Bionator Therapy

Malta LA, Baccetti T, Franchi L, Faltin K Jr, McNamara JA Jr

Angle Orthod 2010;80:10-17

Samples
Groups N
Treated with Bionator 34
Untreated Class II 32

Timing of Tx: Prepubertal-Pubertal
Long-term observation: CS5-CS6 (18.5 ys)

Malta et al., 2010

Long-term Changes
Mandibular Length (Co-Gn)

Difference Bionator vs Untreated Cl II Controls
+3.3 mm

Malta et al., 2010

Long-term Dentoskeletal Effects
and Treatment Timing for
Functional Appliances

Franchi L, Pavoni C, Faltin K Jr, McNamara JA Jr, Cozza P

Angle Orthod 2013;83:334-40

Samples
Groups N
Treated with Activator or Bionator 40
Untreated Class II 20

Timing of Tx: Prepubertal-Pubertal
Long-term observation: CS6 (18.6 ys)

Franchi et al., 2013
Long-term Changes
Mandibular Length (Co-Gn)

Difference FJO Untreated Cl II Controls
+3.6 mm

Franchi et al., 2013

Long-term Treatment Effects of the FR-2 Appliance: a prospective evaluation 7 years post-treatment

Angelieri F, Cevizdanes L, Franchi L, Goncalves JR, Benavides E, McNamara JA Jr

Eur J Orthod 2014;36:192-9

Samples
Groups N
Treated with FR-2 17
Untreated Class II 17

Timing of Tx: Prepubertal-Pubertal
Long-term observation: CS5-CS6 (19 ys)

Angeli et al., 2014

Long-term Changes
Mandibular Length (Co-Gn)

Difference FR-2 vs Untreated Cl II Controls
+3.7 mm

Angelli et al., 2014

Long-term Evaluations
Clinical studies

Freeman et al., 2009
Malta et al., 2010
Franchi et al., 2013
Angeli et al., 2014

Role of Timing on Long-Term Outcomes of Class II Treatment?
Long-term Dentoskeletal Effects and Treatment Timing for Functional Appliances

Franchi L, Pavoni C, Faltin K Jr, McNamara JA Jr, Cozza P
Angle Orthod 2013;83:334-40

Samples

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepeak Group (T1 CS 1; T2 CS 1-2)</td>
<td>20</td>
</tr>
<tr>
<td>Peak Group (T1 CS 3; T2 CS 4-5)</td>
<td>20</td>
</tr>
</tbody>
</table>

Long-term observation T3: CS6 (18.6ys)

Franchi et al., 2013

Long-term Changes

Mandibular Length (Co-Gn)

Difference Peak vs Prepeak Groups
+4.3 mm

Franchi et al., 2012

Long-term Evaluations

Franchi et al, 2013
FJO Treatment at Puberty

Long-term Changes

Advancement of the chin (Pog to Nperp)

NPerp

Difference Peak vs Prepeak Groups
+3.9 mm

Franchi et al., 2013

Long-term Changes

Advancement of the chin (Pog to Nperp)

FJO treatment completed
BEFORE the pubertal growth spurt
is NOT able to produce a significant advancement of the chin

Franchi et al., 2013
Long-term Changes
Advancement of the chin (Pog to Nperp)

Franchi et al., 2013

FJO treatment performed DURING the pubertal growth spurt is able to produce a significant advancement of the chin

Franchi et al., 2013

Difference Peak vs Prepeak Groups
+3.9 mm

Patients begin to perceive a change in the sagittal position of the chin only beyond an improvement ≥ 4 mm

Barroso et al., Prog Orthod, 2012:13:141-7

In Class II patients Tx timing can influence the effectiveness of treatment on mandibular growth: optimal timing is at puberty

Mandibular morphology should be evaluated to assess patient responsiveness: good responders have a small mandibular angle

Functional appliances are effective in altering mandibular length also in the long term