Functional Genioplasty in growing patients

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Scenario

Baseline

Progress

Final

Unfavourable vertical growth
Symphysis hypoplasia
Vertical excess of LAFH
Lip incompetency

How many of you would recommend a genioplasty?
What would happen if you advance the chin in this 13 years old boy?
What would happen if you do not?
Inferior Border Osteotomy

• Isolated procedure or in combination with other maxillo-mandibular osteotomies
  - Most common for AP deficiency or vertical excess
    - Simultaneous advancement & vertical reduction
  - Set back (usually not as successful because of aesthetic problems)

Motorine & RF  Wire Fixation  Rigid Fixation

Functional Genioplasty

• Defined by Precious and Delaire
• Provide beneficial change in the lip function
• Helps to obtain lip competency at repose
• Tends to reduce lip pressure against the lower incisors

Alloplastic Chin Augmentation

- Alloplastic material does not integrate with bone
- May drift off the chin
- Muscle and soft tissue → pressure → bone resorption underneath
- Do not permit vertical reduction
- May cause ptosis of the lower lip
- Poor aesthetic and functional outcome

Indication

- Vertical excess of the lower anterior facial height
- Lip incompetence at rest when incisor showing is normal
- Elevation of mental soft tissues in order to obtain lip closure

Problems with Strain on Lip Closure

- Flattening of anterior surface of the chin due to active contraction of labiamental muscles to achieve lip closure
- Periosteal tension. Absence of muscular balance
- Alveolar bone thinning → root prominence → gingival recession!
Growth consideration

- Anterior face above the symphysis is a resorptive zone
- Inferior border is an apposition zone
- Dentoalveolar growth balance the growth at the condyle

When ortho treatment has created md incisor protrusion
- Improving relationship between the chin and mandibular incisor
  - Thought to improve the chance of incisor stability
  - Might be beneficial for some mucogingival problem
• Helpful when improvement in occlusion was achieved by tooth movement with minimal or unfavourable md growth

Additional benefits

• Facial appearance can be a serious psychosocial handicap, even early in life
• Functional genioplasty
  + Means to improve facial aesthetics
  + Function
  + Stability in conjunction with orthodontic treatment


Rationale for the study

• Number of publications
• Only a few have data for this procedure in adolescents
• No good recent data on bone remodeling following genioplasty in growing and non-growing patients
• None include follow-up of a control group who were evaluated as potentially benefiting from genio but rejected it
• Optimum age has been somewhat controversial
Positive Psychosocial Reaction

- Improved facial appearance would suggest earlier treatment for severely affected patient
- Concerns about possible negative effects on growth and decreased stability would be the major reason for waiting until little or no growth remained

Osseous remodeling after IBO

- Better regeneration in the symphysis thickness in patient younger than age 15 than in older non-growing individuals
  - 75% regeneration of the interalveolar gap
  - 93% regeneration of symphysis width
  - Martinez et al, JOMS 1999

Impact of genioplasty on mandibular growth during puberty

  - Early genioplasty could improve mandibular growth direction
  - Might increase nasal breathing because of improved lip function

Weakness:
  - Sample too small and diverse for broad generalization
  - No control group + changes pregenio and immediate postgenio not evaluated
Isolated lower Border Osteotomy

- Requires general anesthesia, but not overnight hospitalization
- Day-op procedure

Usually part of a larger orthognathic surgery plan because medical insurance almost never cover the cost in an isolated procedure

Medical coverage is provided

Aim of the study

- Clarify the optimal time for functional genioplasty from evaluation of
  - The pattern of bone remodeling at the chin
  - The pattern of postsurgical stability in growing and non-growing patients

Methodology
Cephalometric Analysis Time

- **Experimental Group**
  - T1: 2-3 months prior to genioplasty (10.11 ± 13.82 weeks)
  - T2: 1 month post surgery (4.57 ± 3.82 weeks)
  - T3: 2 years post surgery (111.04 ± 29.91 weeks)

- **Control Group**
  - T2: End of orthodontic treatment
  - T3: 2 years follow-up (117.42 ± 27.34 weeks after T1)

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Sample Characteristics

- **Patient Sample**
  - Retrospective data from 54 patients who underwent isolated advancement genioplasty to achieve lip competency as an adjunct to orthodontic treatment

- **Control**
  - 23 patients with similar morphology who were offered genioplasty in conjunction with their treatment but declined it.

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Sample Characteristics

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>% female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gr 1</td>
<td>28</td>
<td>32 %</td>
</tr>
<tr>
<td>Gr 2</td>
<td>16</td>
<td>44 %</td>
</tr>
<tr>
<td>Gr 3</td>
<td>10</td>
<td>40 %</td>
</tr>
<tr>
<td>Control</td>
<td>23</td>
<td>39 %</td>
</tr>
</tbody>
</table>

- Experimental groups are similar relative to genial advancement, vertical reduction and % of females
- Changes of control growth express horizontal and vertical growth in 2 years (T3T2)
Sample Characteristics

- Groups are similar and comparable regarding FMA and symphysis thickness

Surgical Procedure

- General anesthesia, H. E.-j.
- Technique:
  - Describe by Precious, Armstrong & Morais
  - Anterior and superior repositioning, slide into its new position
  - Slice of bone might be removed prn to increase vertical reduction
  - Wire osteosynthesis: 3 transosseous double strand 28 gauge SS
  - (Only 5 had screw fixation, none were removed)

Cephalometric Data

- AGP= anterior genio point: antero superior edge of the distal segment
- PGP = posterior genio point: pin point of the notch left on the inferior border after advancement
- ACP= anterior concavity point
- PCP= posterior convexity point
- ACP & PCP are measured 4 mm below lower incisors apex
- Symphysis thickness = ACP to PCP
Cephalometric Data

- A-P chin deficiency
  - Assessed by N-A-Pg angle (males 3.9° ± 6.4; females 2.6° ± 5.1)
    - 70% of the pre-surgical and sample patients had an angle > 10°
- Vertical excess
  - Assessed by mandibular dental height (male 39.9 ± 2.7; female 38.9 ± 2.4 mm)
    - 70% of pre-surgical and controls patients, this distance was > 43 mm

Statistical Analysis

- Distribution of the sample was evaluated and judged close enough to normal to use mean, s-d, and range as descriptive statistics
- Repeated-measure factorial ANOVA to compare data and changes between group, gender and time points
  - Gender did not contribute to the differences and was eliminated from the analysis

Statistical Analysis

- One-sample T tests: evaluate the chance that data for each sample point was different from 0
- Pairwise comparisons with Bonferroni adjustments for multiple comparison was use to evaluate the change between time points
  - IBM SPSS Statistics version 21
Method error

- 15 cephalograms re-digitized (5 patients X 3 ceph)
- 41 variables X 3 time points X 5 patients = 615
- **Coefficient of fidelity = 0.99968**
- Symphysis thickness and PGP
- **Coefficient of fidelity = 0.92306**
- No significant difference between initial and re-digitized tracing
- SAS 9.4 (SAS Institute Inc.)

Results

Change at Surgery

- Typical change after functional genioplasty
Change at Surgery

Horizontal Change at Pg

Vertical Change at Me

- The changes were highly significant (< .0001)
- No significant differences between the 3 groups
- Mean advancement 6.1 ± 2.2 mm; vertical reduction 3.3 ± 2.5 mm

Gr 1 (<15 y)  Gr 2 (15-19 y)  Gr 3 (>19 y)

Symphysis Thickness Changes

- Significant increase for the 3 groups
- Slight significant decrease for Controls
- T1-T3
  - Gr 1 = 3.44 ± 2.51 (p < .001)
  - Gr 2 = 2.15 ± 1.88 (p < .001)
  - Gr 3 = 1.04 ± 1.16 (p = .027)
  - Gr 4 = -0.44 ± 0.67 (p = .004)
- Pairwise comparison (bonf. adjust.) Gr 1 ≠ Gr 3 (p = .024)
  (Gr 2 = Gr 1 or Gr 3)
- Youngest group
  - 39% = 2 to 4 mm increase
- Two-thirds
  - 29% = >4 mm increase
  - 2 to >4: Gr 1 ≠ Gr 3 (p=.011)
- Gr 2
  - 37% = > 2 mm increase
- Gr 3
  - 20% > 2 mm increase
- Gr 4 Controls:
  - 30% = > -1 mm decrease (and 39% = -1 to 0)

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**Change in Coordinate Position**

- T2-T3
  - Significant change from 0
    - Gr 1 & Gr 4
  - But change Gr 1 ≠ Gr 4
  - Non Sig. for Gr 2 & Gr 3

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**Change in Coordinate Position**

- T2-T3
  - Vertical growth of Gr 1 similar to Gr 4
  - Significant change from 0
    - Gr 1, Gr 2, Gr 4 (Controls)
  - Non Sig. change for Gr 3
Change in Coordinate Position

- T2-T3
  - Significant change from 0
    - Gr 1, Gr 2, Gr 3, Gr 4
  - Change of Gr 1 ≠ Gr 2 & Gr 3
  - Vertical change at Me was balanced by posterior facial growth
  - FMA change is non Sig. for any group

Correlations

- 3 Variables significantly correlated to postsurgical change in symphysis thickness
  - Genial advancement (T1-T2)  \( r = 0.264; p = 0.028 \)
  - Vertical dentoalveolar growth (ΔADH)  \( r = 0.316; p = 0.011 \)
  - Age at surgery  \( r = -0.396; p = 0.002 \)

**Significantly correlated to the outcome of symphysis thickness at T3**
- But \( R^2 \) is low (7%, 10% and 16%)

Regression:
Dependent variable: Symphysis thickness

- If the predictor variable change of 1 standard deviation, the dependent variable increase of the Coefficient Beta (s.d.)

- Ranking the predictor variable
  - Genial advancement (ΔPg horiz) Sc. co. \( b = 0.264; p = 0.057 \)
  - Vertical dentoalveolar growth (Δ ADH) Sc. co. \( b = 0.272; p = 0.049 \)
  - Age at surgery Sc. co. \( b = -0.332; p = 0.032 \)

- The younger the age at surgery and the better the dentoalveolar growth, the more the symphysis will increase in thickness due to bone apposition
Remodeling Changes

- Remodeling of the symphysis involves
  - Bone apposition above the repositioned chin, changes leading up to and beyond B point
  - Removal of bone adjacent to the notch in the lower border

Typical Remodeling Pattern
Young Patients

- T2-T3
  - Significant change for Gr 1 & Gr 2
  - Non Sig. change for Gr 3 & Controls
Correlation:
Dependent variable: PGP_MP at T3

- Δ ADH_change T3T2 \( r = 0.311; p = 0.012 \)
- Δ PGP_change T3T2 \( r = 0.322; p = 0.009 \)
- Age at surgery \( r = -0.331; p = 0.008 \)

★ Significant correlation to the outcome of inferior border remodeling at T3
★ But \( R^2 \) is low (≈10%)

Regression:
Dependent variable: PGP_MP at T3

- Predictor variable
  - Dentoalveolar growth change (Δ ADH) 
    - St. co. \( r = 0.272; p = 0.049 \)
    - Change of 1 standard deviation of the dentoalveolar growth will change the dependent variable of 0.272 standard deviation.
  - The greater the dentoalveolar growth, the more the notch on the inferior border will be remodelled
  - The decreased incisors eruption after genioplasty in older adolescent and adults is the primary reason for better remodeling in young patients
  - Genial advancement (ΔPg) and Age at surgery are not significant predictor of the outcome PGP_MP at T3

Therefore

- The age at genioplasty, which affects the amount of incisor eruption afterward, does make a difference in the extent of both bone apposition and remodeling
- More apposition and remodeling in patients under age 15, less in late adolescents and still less in adults
Stability of the Surgical repositioning

- Postsurgical changes due to
  - Combination of mandibular growth & surface remodeling near the chin
- Gr 1 vs Gr control
  - Mean AP change after genio of Gr 1 is less than Controls (i.e. slightly more stable) but the difference is small and non sig. (p = 0.09)
  - Vertical change is similar Gr 1 vs Controls

Therefore

- Forward and downward growth at the chin was not significantly affected by genioplasty
- Changes in chin position were maintained in growing patients

Discussion
Growth issues

- Normal growth
  - Chin more prominent by resorption above Pg extending upward toward + above B point

- Data from our Control group
  - Lip incompetency persist
  - Resorption at B point (0.36± 0.38 mm; p = .007 )
  - Symphysis thickness decrease (0.44 ± 0.67 mm; p = .004)

- Change, or lack of it, in typical control patient

Follow-up 10 years

- Change, or lack of it, in typical control patient
**Growth Issues**

- No evidence support a negative effect on mandibular growth from IBO
  - Whether done early or late adolescence
- FMA decrease during normal growth
  - Same as in younger genioplasty patients and controls
- Once lower canines are erupted (~ 12-13 y)
  - No problem to do a genioplasty

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**Stability / Remodeling Issues**

- Previous study reported it is the most stable orthognathic surgery procedure
  - Tulane, using different surgical procedure, reported greater relapse (40%) in younger patient
  - Martinez et al reported greater relapse (16%) but not clinically nor statistically sig.

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**Stability / Remodeling Issues**

- Relapse at Pg can be estimated by Pg to N perp-FH
  - Gr 1 -0.48 mm (7%);
  - Gr 2 -0.86 mm (14.7%);
  - Gr 3 -1.04 mm (4.7%)
- Relapse T2T3 is not significant for any group (p > .235 Anova Gr * Time)
- Relapse is similar between group, (p > .176 Anova Time * Gr)
Stability / Remodeling Issues

- Our findings do not support greater relapse at Pg for younger growing patients
- 91% had wire fixation
- Better post-surgical stability with more costly bone screws may not be a consideration

Previous DS, Gordon AM, Curtis EC. Bone remodeling at the inferior border of the proximal segment between the distal point of the osteotomy cut and the advanced distal segment
Gr 1 and Gr 2:
  - Significant reduction of this notch (1.2 ± 1.3 mm; 0.6 ± 0.9 mm)
Gr 3:
  - Modest non-significant reduction 0.3 ± 1.0 mm

Stability / Remodeling Issues

- Our study supports other findings
  - Bone remodeling at the inferior border of the proximal segment between the distal point of the osteotomy cut and the advanced distal segment
  - Gr 1 and Gr 2:
    - Significant reduction of this notch (1.2 ± 1.3 mm; 0.6 ± 0.9 mm)
  - Gr 3:
    - Modest non-significant reduction 0.3 ± 1.0 mm

Stability / Remodeling Issues

- Control group has significant resorption at B point (0.4 ± 0.6 mm)
  - Consistent with usual pattern of growth at the chin in adolescence
- All 3 age groups had similar bone apposition at B point (0.7 to 1.0 mm)
- Bony angles above repositioned chin became rounded, rough edge became smooth.
Stability / Remodeling Issues

- Bone apposition at B point (0.7 to 1.0 mm)
- May help preventing mucogingival problems buccal to lower incisors

Control

End of ortho  Follow-up 2 years  Follow-up 10 years
End of ortho
Gr 1 (< 15y)  Follow-up 2 years  Follow-up 15 years
Post Genio

On average adults shows,
- Significant increase of symphysis thickness: $1.11 \pm 1.02$ mm ($p = .011$)
- Significant bone apposition at B
  - $\Delta$ B horizontal: $1.9 \pm 1.42$ ($p = .004$)
  - $\Delta$ Bp to Mp: $0.69 \pm 1.00$ (n.s)
- A few if any bone remodeling at the inferior border
Stability / Remodeling Issues

- Shaughnessy et al suggested to place autogenous bone grafts from the iliac crest to be place above the repositioned distal segment.
- None of our patients received a graft.
- All had significant apposition at B point.
- Bone grafting is questionable particularly form a donor site like iliac crest that requires invasive surgery.

Further study

- Soft tissue changes relative to hard tissue changes.
- Stability of lower incisor to MP using the reference measurement FMIA rather than IMPA.
- Long term change and stability.
  - Patients are currently recalled to obtain at least 20 patients at T4 (4 to 10 years post genio).
Benefits of Genioplasty

- Improved facial proportions
- Improved smile aesthetics and display of the incisors
- Lip competency in function and repose
- Decrease muscular periosteal tension above the chin that may improve incisor stability

Functional Genioplasty

- When indications for such a genioplasty are recognized
  - Early surgical correction (< age 15)) produces a better outcome in terms of bone remodeling
  - This is related to greater vertical growth of the dentoalveolar process in younger patients
  - There is no difference in post-surgical stability in younger and older patients

Thank you
Extra slide.

Bone remodeling

- Symphysis thickness increase for the 3 groups
- Gr 1 increase 3 times the thickness increase of Gr 3
- Bone apposition occurred at B point
- Bone apposition occurred at the posterior interface between the mandible and the advanced chin (PGP flattened and the notch almost disappear in the younger groups)

Support Shaughnessy et al. Martinez et al

Why I don't like rigid fixation for a genioplasty

- Poor contact between distal & proximal segment
- Screw in the resorptive zone
- Note bone formation over superior portion of fixation device and resorption in area of inferior portion of fixation device
Why do I prefer osteosynthesis?

Growing individual

- What would happen if you do not recommend and perform a genioplasty?
  - Occlusal plane relationship (Wits) is likely to be maintained
  - Lip incompetency and regional muscle disequilibrium is likely to persist up to maturity
  - Thinning of the alveolar bone (cross section of symphysis) is likely to occur

Like in this control case

- Occlusal plane relationship is maintained
- Symphysis thickness has a tendency to decrease \( (p = .034) \)
- Lip incompetency persist
But if you do recommend a genioplasty
- Adult will benefit from...

- Class I
- Bimaxillary protrusion
- Lip incompetency

- 3 months post genio
- Improved facial aesthetics
Adult

- 2 y post genio
- Some bone apposition at the B
- Inferior border notch remain

Adult

- 7 y post genio
- T3 vs T4
- Inferior border notch remain

On average adults shows,

- Slight increase of symphysis thickness
- Slight bone apposition at B
- A few if any bone remodeling at the inferior border
- Δ Symphysis Thickness = 1.11 ± 1.02 mm (p = .011)
Younger adult
- More bone apposition at B
- Better bone remodeling at the inferior border

Summary

Adults

- Adults don't have vertical dentoalveolar growth
- Therefore certain changes are limited:
  - bone apposition at B point
  - symphysis thickness
  - bone remodeling at the inferior border

If you do recommend a genioplasty to an old adolescent
- He will benefit from...
Gr 2 Adolescent 15-19y

- On average
  - ∆ Symphysis thickness: 2.06 ± 1.24, p = .000
  - Bone apposition at B greater, although n.s. different, than adult
  - Good remodeling of the inferior border

- Improved aesthetics
- Lip competency at repose
Summary

Gr 2 15-19 y

- Older adolescents have some vertical dentoalveolar growth
- However bone remodeling is favourable
- Δ Symphysis thickness (p < .001)

- Class II div I
- Bimaxillary protrusion
- Lip incompetency at repose
• Class I occlusion achieved
• Lip strain persist
• Chin projection deficient
• LFH slightly excessive

• Genioplasty
• 29 days post surgery
• Lip competency achieved

• Complete symphysis regeneration & remodeling
• Bone apposition at B
• Increased symphysis thickness
• Bone apposition at the inferior border
• How many cases have you finished with such a profile?
• Isn’t this a better outcome?

• And the benefit long-term?

Summary
Gr I (<15)

• Vertical dentoalveolar growth helps:
  ✦ Generate bone apposition at B point
  ✦ Increase symphysis thickness
  ✦ Remodeling at the inferior border
Symphysis changes are likely explained by vertical dentoalveolar growth.