Soft-tissue based 3D reference frame for longitudinal facial growth in children

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Conventional cephalometric analysis

Athanasiou 1995
Clinical guide LHP superimposition

• Anterior cranial base reference structures
  
  *American Board of Orthodontics*
  *European Board of Orthodontics*
  *Angle Society*

• Basion-Nasion plane
  
  *Australian Board of Orthodontics*

• Sella-Nasion line
  
  *Dutch Orthodontic Society*
Research methods for 3D datasets

- Anterior cranial base rigid registration

- Landmark based reference frame

Cevidanes et al. 2009, Swennen et al. 2006
Research methods for 3D datasets

• Best fit of landmarks:

• Geometric morphometric:

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Form difference matrix (FDM).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euclidean distance</td>
<td>Ratio</td>
</tr>
<tr>
<td>Figure 2a</td>
<td>B–Gn 0.569</td>
</tr>
<tr>
<td></td>
<td>S–Ar 0.583</td>
</tr>
<tr>
<td></td>
<td>Gn–Go 0.589</td>
</tr>
<tr>
<td></td>
<td>N–ANS 0.591</td>
</tr>
</tbody>
</table>

Seager et al. 2009, McIntyre & Mossey 2003
Summary analytical techniques

<table>
<thead>
<tr>
<th>Technique</th>
<th>Landmarks required?</th>
<th>Size data</th>
<th>Shape data</th>
<th>Statistical treatment of data</th>
<th>Analysis of an individual case?</th>
<th>Analysis of groups of cephalograms?</th>
<th>Visual output</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCA</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Various univariate/multivariate methods</td>
<td>Yes</td>
<td>Yes</td>
<td>Poor, must be produced indirectly</td>
</tr>
<tr>
<td>Procrustes superimposition</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Principal component analysis</td>
<td>No</td>
<td>Yes</td>
<td>Good</td>
</tr>
</tbody>
</table>

COMBINE DIFFERENT TECHNIQUES!

McIntyre & Mossey 2003
Development of a method: The children’s reference frame
Material & Methods

• 39 stereophotographs in duplicate (N=78)
• Placement of reference frames (78 / observer)
  - 13 Caucasians patients (UCLP) age 3 months
  - 16 Caucasians controls age 3 months
  - 10 Caucasians controls age 12 months
• 3dMD stereophotogrammetry system
• 2 observers
• Maxillim software
Outcome parameters

Intra- and interobserver reproducibility:
• Mean distance = Measurement error
• Distance variability
• P95

Statistical analysis:
• Pearson’s correlation coefficient
• Student’s t-test
## Results: Measurement error

<table>
<thead>
<tr>
<th></th>
<th>Observer A Mean (SD)</th>
<th>Observer B Mean (SD)</th>
<th>Interobserver Mean (SD)</th>
<th>Correlation coefficient</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean distance (=measurement error)</td>
<td>0.40 (0.25)</td>
<td>0.37 (0.16)</td>
<td>0.52 (0.19)</td>
<td>-0.01</td>
<td>0.974</td>
</tr>
<tr>
<td>Distance variability</td>
<td>0.49 (0.19)</td>
<td>0.51 (0.12)</td>
<td>0.53 (0.09)</td>
<td>0.52</td>
<td>0.002</td>
</tr>
<tr>
<td>P95</td>
<td>0.80 (0.67)</td>
<td>0.75 (0.36)</td>
<td>1.10 (0.40)</td>
<td>0.01</td>
<td>0.949</td>
</tr>
</tbody>
</table>
Results: Factors of influence?

• Cleft vs non-cleft: \( p = 0.788 \)
• 3 months vs 12 months: \( p = 0.777 \)
• One ear vs two ears: \( p = 0.253 \)
Summary

- Children’s reference frame based on conventional cephalometric analysis
- Mean inter-observer measurement error 0.52 mm is acceptable
-Trimming of 3D model to decrease variability
- Presence of a cleft, age or missing data near one of the ears on the 3D model no effect on reproducibility
The children’s reference frame is a valid and reproducible method for 3D soft tissue facial growth analysis in children

…and should be used in concordance with other geometric morphometric techniques for research purposes…