Registration of jaw movements

Composite of several movements

Methods – palatal stylus tracing

<1900 – 2 degrees of freedom (xy) “Gothic arch”
Methods – pantograph

1950 - 2 degrees of freedom

Methods – Kinesiograph MKG

Jankelson, 1975 – 3 degrees of freedom

Methods – optical tracing

Selspot, 1975 - 3 degrees of freedom, contact free --- Qualisys, 1990
Methods – ultrasound

1990 - 3 degrees of freedom

Methods – magnet tracing

Sirognatograph 1995 - 3 degrees of freedom -> 6
1. Which jaw tracking systems have been used

<table>
<thead>
<tr>
<th>Method</th>
<th>(n reports)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selspot</td>
<td>(25)</td>
</tr>
<tr>
<td>Kinesiograph</td>
<td>(18)</td>
</tr>
<tr>
<td>Sirognathograph</td>
<td>(17)</td>
</tr>
<tr>
<td>Visiotrainer</td>
<td>(8)</td>
</tr>
<tr>
<td>other (e.g. 3DJaws)</td>
<td>(30)</td>
</tr>
</tbody>
</table>

22-degrees of freedom
33-degrees of freedom
66-degrees of freedom

2. Which functions have been evaluated in studies?

<table>
<thead>
<tr>
<th>Function</th>
<th>(n reports)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test food chewing</td>
<td>(72)</td>
</tr>
<tr>
<td>Chewing imitation</td>
<td>(11)</td>
</tr>
<tr>
<td>Opening-closing</td>
<td>(10)</td>
</tr>
<tr>
<td>Closing from PIOS</td>
<td>(6)</td>
</tr>
<tr>
<td>(Postural inter-occlusal space)</td>
<td></td>
</tr>
<tr>
<td>Border movements</td>
<td>(12)</td>
</tr>
</tbody>
</table>
Aims of studies
1. Basic research
   - Neurological mechanisms – age, gender, tooth loss, experiments, etc.
   - Chewing effectiveness
     - Diet – consistency, softness, size, weight, etc.
2. Therapy
   - Diagnostic purpose
     - Control patients vs. – TMD, malocclusion, prostheses, implant-ret.
     - Malocclusion
   - Interventions – results
     - TMD - splints, occlusal equilibration
     - Surgery – orthognathic, joint- & disectomies
     - Prosthodontics – prostheses, implants, FPDs
     - Pharmacology – Parkinson
3. Test of methodologies
   - Validity, reliability, repeatability, measurement error, CV

Should jaw tracking be used for diagnosing TMD patients?
Common signs & symptoms are
- limited opening,
- deviation on opening
- complaints about chewing ability
- The initial answer would initially appear to be positive.

TMD - Which parameters for jaw movement are the most relevant?
Which parameters?

1. Displacement

1. Displacement - reported criteria

- Spatial (-xyz) -Open, close (mm)
- Frontal/sagital/horisontal plane
  - Vertical location at turnpoint (mm)
  - Approach/departure angle -Open, close (degrees)
  - Open-close trajectory:
    - width (mm)
    - amplitude $S(x^2+y^2)$ (mm)
    - "core area" (mm$^2$)
    - areas relative to defined axis (mm$^2$)
    - envelope area (mm$^2$)
- Border limits relative to ICP (mm)
- Jaw location at max. velocity -Open, close (mm)
- Ratios: left-right (laterality index), vertical-horizontal, chewing location: border limits

Studies

- Max. vertical amplitude
  - * Feine&Lund95, Kuwahara ea, 94, ...
- Width of envelope
  - Kuwahara ea, 94
- Distance open phase*
- Distance close phase*
- Distance lateral*

* Jemt ea, 79, Jemt&Karlsson80, Jemt 81, Jemt&Hedegård82ab, Jemt ea, 82, Jemt&Karlsson82, Jemt ea 83, Jemt&Olsson84, Jemt ea, 85, Jemt&Stålblad,86, Karlsson&Carlsson89, Karlsson&Carlsson90, Killandis ea81, Karlsson&Jemt91, Tzakis ea, 92, Karlsson ea, 92ab, Book ea, 92, Jemt ea, 93, Kjellberg ea, 95
### Displacement

<table>
<thead>
<tr>
<th>Study aim</th>
<th>Significant differences (n)</th>
<th>No differences (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methodology</td>
<td>Spa- Fro- Sag- Hor</td>
<td>Spa- Fro- Sag- Hor</td>
</tr>
<tr>
<td></td>
<td>2  3  2  2</td>
<td>0  1  0  6</td>
</tr>
<tr>
<td>Food type</td>
<td>0  6  2  4</td>
<td>1  3  2  3</td>
</tr>
<tr>
<td>Basal mechanism</td>
<td>5  4  0  2</td>
<td>2  0  0  2</td>
</tr>
<tr>
<td>Diagnostic purpose</td>
<td>3  7  1  7</td>
<td>0  3  4  0</td>
</tr>
<tr>
<td>Treatment outcome</td>
<td>3  5  1  6</td>
<td>2  2  2  7</td>
</tr>
</tbody>
</table>

### Which parameters?

1. Displacement
2. Time

### 2. Time, full cycle, open-, close-, occlusion phases

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<th>No differences (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methodology</td>
<td>full open clos occl</td>
<td>full open clos occl</td>
</tr>
<tr>
<td></td>
<td>0  2  0  0</td>
<td>3  1  4  3</td>
</tr>
<tr>
<td>Basal mechanism</td>
<td>3  2  2  2</td>
<td>5  4  3  4</td>
</tr>
<tr>
<td>Food type</td>
<td>8  2  3  3</td>
<td>1  3  3  2</td>
</tr>
<tr>
<td>Diagnostic purpose</td>
<td>3  5  5  0</td>
<td>2  1  3  1</td>
</tr>
<tr>
<td>Treatment outcome</td>
<td>4  3  3  4</td>
<td>7  10  9  8</td>
</tr>
</tbody>
</table>
Which parameters?
1. Displacement
2. Time
3. Displacement/time, i.e. velocity

3. Velocity- reported criteria
- Opening - Closing phase
  - Mean, maximum
  - Ratio opening: closing phase
  - Maximum relative to:
    - turnpoint (%), (mm)
    - ICP (mm)
    - time
  - Decrease followed by increase < 3mm/s
- Patterns: "swing", uni/bimodal-flat, smooth/irregular

Velocity
<table>
<thead>
<tr>
<th>Significant differences</th>
<th>No differences</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(n)</strong></td>
<td><strong>(n)</strong></td>
</tr>
<tr>
<td>Study aim</td>
<td>open</td>
</tr>
<tr>
<td>Methodology</td>
<td>5</td>
</tr>
<tr>
<td>Food type</td>
<td>6</td>
</tr>
<tr>
<td>Basal mechanism</td>
<td>3</td>
</tr>
<tr>
<td>Diagnostic purpose</td>
<td>5</td>
</tr>
<tr>
<td>Treatment outcome</td>
<td>12</td>
</tr>
</tbody>
</table>
Hvilke parametre?

1. Displacement
2. Time
3. Displacement/time, i.e. velocity
4. Pattern recognition/classification, e.g. chewing

4. Pattern recognition

Patterns described in studies:

<table>
<thead>
<tr>
<th>2</th>
<th>3</th>
<th>4</th>
<th>6</th>
<th>7</th>
<th>12</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plane</td>
<td>Frontal:</td>
<td>7</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sagittal:</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal:</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*14open x 14close patterns grouped into 9 main groups

Jaw movement - TMD patients

- Amplitude of movement in vertical, horizontal, and anteroposterior directions
  - no chewing
  - Chewing
- Reproducibility or consistency of movement
  - no chewing
  - chewing (pattern)
- Velocity
  - no chewing
  - chewing
- Vertical freeway space

Other parameters?

1. Displacement
2. Time
3. Displacement/time, i.e. velocity
4. Pattern recognition/classification
5. Other:
   - Rotation (degrees)
   - Acceleration (mm/s²)
   - Closest speaking space (mm)
   - Postural inter-occlusal space (PIOS) (mm)
   - Chewing preference side (%)
   - Torque (degrees)

Conclusions-1

There is a great variation in choice of criteria to describe aspects of jaw movements, as well as different recording apparatus.

The variation in study designs complicates valid comparisons of reported values of jaw movement during function.

The duration of the full and phasic parts of the cycles is only affected by food type and under some experimental conditions.

The duration seems to be less influenced by experimental and demographic variables compared to the effects on displacement and velocity of the jaw.
Only recent studies present jaw movement data based on 6 degrees of freedom, i.e. the jaw posture during movements. There is a marked variation in reported significant effects of different demographic and experimental variables on chewing parameters. Both Type I (alpha) and Type II (Beta) errors are probably present among many studies reporting jaw movement.

Conclusions -2

Should jaw tracking be used for diagnosing TMD patients?

Common signs & symptoms are:
- limited opening,
- deviation on opening
- complaints about chewing ability

- The initial answer would appear to be positive.
- Does the dentist gain diagnostically additional relevant information from jaw tracking?
- This is an important question in view of the sparse and mostly unreplicated scientific evidence linking jaw motion to TMD diagnosis.