Analysis of Occlusal Parameters and of the Jaw Jerk in Healthy Subjects and in Patients Affected by TMJ Pain-Dysfunction Syndrome

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Temporomandibular joint (TMJ) pain-dysfunction syndrome is considered a multifactorial pathology and many researchers have attempted to elucidate possible causes of occlusion that contribute to this pathology. Many authors have observed that there are abnormalities in the masticatory patterns of TMJ patients, but because current investigative methods lack standardization we cannot yet explain the physiopathologic mechanism of such differences. Bird showed in an animal study that the speed of the opening-and-closing phase changes continually and not only in the occlusal phase. Many investigation methods have been proposed including radiographic examination, magnetic resonance analysis, pantographic examination, axiographs of functional traces, and kinesiographic research using electrognathograph. All these methods have technical limits that have been analyzed and discussed at length by various authors. Electrognathography has the advantage of reducing the intraoral disturbances to a minimum, but has the limitation of not reproducing mandibular torsion. Our aim was to analyze certain occlusal parameters and correlate them with the biomechanical and neuromuscular systems in order to construct a hypothesis on the possible physiopathologic mechanisms.

Materials and Methods

Two groups of subjects were examined. One group comprised 10 healthy subjects aged 20 to 30 years (mean = 24) free of disturbances and facial pain. A second group, referred to here as the "patients," ranged in age from 25 to 50 years (mean = 35) and were affected by TMJ dysfunction, having unilateral cranio-mandibular pain, mainly in the temporal muscle region and the TMJ. They were therefore classified under the algic side. Healthy subjects were classified according to the preferential mastication side. All subjects were asked to masticate biscuits (crackers) unilaterally and then proceed through the whole mastication cycle as far as deglutition. Ten mastication tests were carried out, and the occlusal parameters were determined using a Siemens Sirognathograph (Germany). The traces were recorded on a floppy disk and analyzed with the help of a computer program (Columbia System, Ing. E. Fabbris, Pordenone, Italy). The jaw jerk analysis was carried out by means of an electromyograph (Ote Biomedica, Florence, Italy) and the surface electrodes were applied to the masseter muscles. The sensitivity was 100 to 500 μV/cm, while the filter band was 50-2KHZ.

A software for evoked potentials was used to average the muscular responses. The amplitude was calculated at the positive and negative peaks (microvolt) with the mandible in rest and occlusal positions.

The following occlusal parameters were analyzed.
1. (FP) Masticatory cycle on the frontal plane. The angle considered was formed by the initial phase of the opening trace and the final phase of the closing trace (Figs 1 and 2).
2. (SP) Masticatory cycle on the sagittal plane. The angle considered was formed between the opening trace, which is initially anterior, and the slightly posterior closing trace (Figs 1 and 2).
3. (HP) Masticatory cycle on the horizontal plane. The angle considered was formed between the final
Figs 1 and 2  Kinesiographic traces in healthy subjects. In the traces on the frontal plane the subject chews on the right and left sides. The apex of the masticatory cycle (muscular-centric point) coincides with the intercuspal position (occlusion-centric point). This means that the functional and structural traces virtually coincide, with very little phase of the opening trace, which is posterior, and the initial phase of the lateral trace (lateral movement) at a distance of 2 mm (Figs 1 and 2).

4. (SS) Lateral shift in intercuspal position on frontal plane. Before going through the masticatory cycle, the healthy subjects were asked to carry out dental contact repeatedly in intercuspal position so that the computer could record the final mandibular position and automatically determine the distance, in millimeters, between the latter and the apex of the functional masticatory cycle.

Muscular centric point and occlusion-centric point (Figs 1 and 2):

5. (OCP) The mean temporal calculations, measured in milliseconds, of the whole masticatory cycle difference (0.6 mm). The frontal plane angle is formed between the opening and the final closing phase. In the sagittal plane the intraincisal angle is limited to between the opening and closing phase. With the final opening phase, the initial closing phase determines the laterotrusive angle in the horizontal plane.

established by the opening and closing phases. (Table 1).

6. (SCP) The mean temporal calculations, measured in milliseconds, of the closing semicycle time (Table 1).

7. (FOP) The mean temporal calculations in, milliseconds, of the final occlusal phase of the masticatory cycles with dental contact until the next opening phase (Table 1).

8. (SCP) The relative time, expressed as a percentage, of the closing phase compared with the whole cycle, when the patients chewed on the symptomatic versus asymptomatic side.

9. (FOP) The relative time, expressed as a percentage, of the semicycle of the final occlusal phase compared with the whole cycle (Table 2), when the
patients chewed on the symptomatic versus asymptomatic side.

10. (JJRP) Jaw Jerk, analyzed with the mandible in rest position. The peak-to-peak amplitude was measured in microvolts.

11. (JJOP) Jaw jerk, analyzed with the mandible in occlusal position.

For both groups the descriptive data were expressed (Table 1) as mean (± SD). The intraindividual differences were estimated by Student's t test for paired data.

Results

The mean shift in centric position for the right and left sides in the healthy subjects was 0.6 mm. In closing, all patients deviated toward the affected side (Figs 3 and 4). Statistical analysis was therefore carried out to assess the deviation when the subject masticated on both the symptomatic and asymptomatic sides. The mean deviation was 1.5 mm and the difference for the paired data (−0.6 mm) was statistically significant (P = .03) (Table 3). The centric shift toward the affected side was, in fact, 0.6 mm less when the patient masticated on the symptomatic side.

The absolute time value for carrying out a complete opening and closing cycle was 615 msec for the healthy subjects and 627 msec for either group (Table 1). The closing semicycle was 319 msec for the healthy subjects and 309 msec for TMJ patients; in the final closing phase the necessary absolute temporal values were 131 and 128 msec, respectively.

The difference between the two sides for the relative time of the occlusal phase compared with the whole cycle in the patients was 6.6% (P = .0004) (Table 3).

The amplitudes of the jaw jerk, in mandibular rest and occlusal positions, respectively, were 1138 and 1423 µV in the healthy subjects and 970 and 1450 µV in the TMJ patients.

The asymmetry between sides was statistically significant only for the symptomatic side, with the mandible in occlusal position (−969 µV) (P = .002) (Table 3).

Discussion

Many authors have attempted to record the substantial difference of the masticatory function in healthy subjects as compared to patients affected by TMJ dysfunction. The functional and occlusal
Figs 3 and 4  The masticatory cycle of a patient with TMJ dysfunction. This patient is affected by deviation toward the right side (affected side) in intercuspal position (occlusal-centric point) and shows a click on this TMJ when he chews only on the right side. Frontal plane: When he chews on the left side, the translation toward the affected side (right side) is apparent; the first part of this opening phase produces an increase in the angle in the frontal plane. Sagittal plane: When the same patient chews on the affected side, the angle on the sagittal plane disappears. Horizontal plane: The laterotrusive angle in the horizontal plane remains 90 degrees even when the patient chews on the affected side.

Table 3  Analysis of the difference in the occlusal parameters and jaw jerk between the symptomatic and asymptomatic sides, in the patients affected by craniomandibular disorders.

<table>
<thead>
<tr>
<th>Parameters*</th>
<th>TMJ patients</th>
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<tbody>
<tr>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>FP (degrees)</td>
<td>4.2</td>
</tr>
<tr>
<td>SP (degrees)</td>
<td>-2.1</td>
</tr>
<tr>
<td>HP (degrees)</td>
<td>10.8</td>
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<tr>
<td>SS (mm)</td>
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<tr>
<td>SCP (%)</td>
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<tr>
<td>FOP (%)</td>
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<tr>
<td>JJRP (µV)</td>
<td>-276</td>
</tr>
<tr>
<td>JJOP (µV)</td>
<td>-969</td>
</tr>
</tbody>
</table>

* See Table 1 for explanation.
The masticatory cycles of a patient with TMJ dysfunction. This patient feels pain in the left temporal region and has a click on the left side. Frontal plane: The traces of the masticatory cycle recorded show a shift toward the left side in intercuspal position (occlusal-centric point) when the patient chews on the right or left side. Sagittal plane: The masticatory traces in the sagittal plane show an increased angle when the patient chews on the affected side; this increased angle must be considered together with the results of the horizontal plane. Horizontal plane: The laterotrusive angle increases on the affected side and exceeds 90 degrees. These results for the sagittal and horizontal planes show that the temporomandibular ligament is damaged, probably with loss of the retentive function.

The functional limit of the mandibular retraction in masticatory cycles is mainly represented by the mandibular temporal ligament, while the anterior dental obstacle decreases the intrincisal free space (Fig 3).

The angle on the horizontal plane increased 10 degrees on the symptomatic side. The TMJ patients chewed mainly on the affected side, and the continual rotation of the working condyle could determine a loading on the temporal mandibular ligament. This could allow the condyle greater rotation, reflecting on the incisal point as a laterotrusive trace (Fig 6).

The centric shift of the incisal point must be considered together with the medial and superior shift of the working condyle in the occlusal phase. The range of this condyle displacement in healthy subjects seems to be 0.20 mm medially and 0.33 mm anteriorly. In the TMJ patients this shift toward the symptomatic side was 1.5 mm and was 0.6 mm greater during mastication on the asymptomatic side (Figs 3 to 6).

The difference in the final occlusal phase for healthy subjects was not statistically significant (Table 2), while for the patients it was greater (6.6%) during mastication on the affected side. This result cannot be explained only in terms of biomechanical considerations: by considering a longer centric shift on the asymptomatic side of mastication, one would expect it to take longer to complete the occlusal phase in intercuspal position on this side.

The amplitude asymmetry of the jaw jerk was more evident when the patient maintained occlusal position, while in rest position this asymmetry was not
**Fig 7** The amplitude of the jaw jerk in a patient affected by TMJ dysfunction, mandible in rest position.

**Fig 8** The evident asymmetry between side of the jaw jerk in the same patient, mandible in occlusal position.
It is possible that in rest position the mandible recovers centricity and that all muscles are the same length. In this situation the spindles are excited symmetrically; however, in occlusal position the mandible deviates toward the symptomatic side, determining muscular elongation of the contralateral side, since the spindles in the asymptomatic side are in passive facilitation.

It is also possible that the central drive determines active facilitation on the gamma circuitry, especially on the muscles deputated to deviate the mandible. In this case, the masseter muscle on the asymptomatic side deviates the mandible on the symptomatic side, since it is more facilitated (active facilitation).

Another possibility is that when the mandible deviates toward the symptomatic side, the mediotrusive precontact often arises and an excitatory mechanism loop could be produced by pressoreceptors and periodontal stimulation.15-17

When the patients chew on the asymptomatic side, the mandible deviates toward the symptomatic side more than when they chew on the contralateral side, while the relative time in the final occlusal phase decreases (see Table 3). This acceleration can be explained by a neuromuscular excitatory response on the asymptomatic side (active facilitation).

However, the present research shows that the most evident occlusal parameters for classifying a patient as TMJ dysfunctional, are (1) centric shift, (2) the relative time of the final occlusal phase compared with the whole cycle, and (3) amplitude of the jaw jerk, with the mandible in rest and occlusal positions.

The physiopathologic mechanism considered could be the integration of the biomechanical and neuromuscular systems, but other research is necessary to understand the physiopathologic mechanisms of the stomatognathic system, especially in patients affected by TMJ dysfunction.

References

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