Measurement of lateral loads exerted on the maxillofacial region by habitual postures

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INTRODUCTION

Bone morphology is influenced by repetitive mechanical stress. Remodeling with bone resorption and formation may result in skeletal imbalance or deformity. In the maxillofacial region, pressure above a certain magnitude applied for an extended period of time is considered to influence morphology and relationship of the jaws. Indeed, many patients with a diagnosis of jaw deformity who undergo orthognathic surgery to correct facial asymmetry have postural and other habits. This study was conducted to measure lateral loads exerted by habitual postures and to evaluate their possible effects on the maxillofacial complex.
SUBJECTS AND METHODS

1. Methods

Pressure measurements were taken with a small, highly sensitive pressure sensor (PSL-A type, Kyowa Co.) connected to a desktop dynamic strain gauge (DPM-600, Kyowa Co.), and recorded with an oscillographic recorder (PDM-100A, Kyowa Co.). A vinyl chloride resin bag was filled with 50 g of a viscous, plastic heavy-body silicon impression material with a low elasticity. The pressure sensor was embedded into the center of the silicon material and secured with a bonding agent. The lead wire from the sensor in the vinyl bag (hereinafter referred to as measuring bag) was connected to the dynamic strain gauge (Fig. 1). The pressure sensor was capable of measuring up to 49.03 kPa with a measurement error within 1%.

1) Preliminary study: A 1 kg weight was placed on the measuring bag. Once stability of the reading was reached, the weight was increased to 2 kg, 3 kg, etc. to obtain a graphic record of the measurements with the oscillographic recorder. The measurement of each weight was repeated 3 times under the same conditions. The measured values were averaged and utilized to derive a conversion formula for load calculation.

2) Main study: The subjects were asked to lie down on a couch and sit at a desk for pressure measurement. They lay (1) face down, (2) prone with the face turned to one side and rested on the arm on a pillow, and (4) prone with the face turned to one side and rested directly on a pillow. In sitting positions, the subjects sat at a desk (5) resting one side of the face on the arm, and (6) resting one side of the chin on the hand. Three facial sites were selected for measurement: the cheekbone, gonial angle, and lateral part of the chin. Measurements were taken in 12 combinations of postures and sites. The measurement was repeated three times in each combination to calculate a mean value.

2. Subjects

The study included 20 male volunteer staff members and students of the orthodontic department at Tokyo Dental College who had healthy oral function without systemic or occlusal abnormalities or temporomandibular dysfunction. Their mean age, body height, and weight were 24.0 years, 173 cm, and 68 kg, respectively.

RESULTS

1. Preliminary study

The measured values increased in proportion to the weights. The reading returned to zero upon weight removal (Fig. 2). The following proportional constant \( a = 5.21 \) and conversion formula were derived from the results:

\[
Y = 5.21 \cdot X + 0.13
\]

\( X: \text{weight (kg)}, Y: \text{measured value (kPa)} \)

The formula allowed load calculation from the measured value.

2. Main study

The lateral part of the chin was subjected to the highest load of 43.7N when the subjects lay face down (Table 1). In the prone position with the face turned to one side on a pillow, the mean lateral load of 33.7N was applied on the gonial angle with the arm placed between the face and pillow, about twice as large as
15.0N without the arm in between. Nearly 30N of lateral load was exerted in the prone position with the face turned to one side without a pillow, 25N in the sitting position with the face on the arm, and 20N in the sitting position with the chin on the hand. The lateral load varied little by site of measurement.

DISCUSSION

A survey on habitual postures was conducted in actual patients. Fifteen orthognathic surgery cases (6 males and 9 females) with 7mm (Fig. 3) or greater lateral shift of Me (menton) based on their frontal cephalograms were selected from patients visiting the orthodontic department of Tokyo Dental College Chiba Hospital (Table 2). At the initial examination, they had been asked about habitual postures, particularly those that are likely to exert lateral pressures on the face such as resting the chin on the hand and lying prone with the face turned to one side, unilateral chewing, and other oral habits. Five patients with mandibular shift to the left were found to have the habit of resting the right side of the chin on the right hand, and one patient with mandibular shift to the right had the habit of resting the left side of the chin on the left hand. The mandible was deviated opposite to the side that rested on the hand in all of these patients. Two patients with mandibular shift to the right had the habit of lying prone with the face turned to the right, while three with mandibular shift to the left had the habit of lying prone with the face turned to the left. The mandibular lateral shifts noted in these patients were categorized as follows:
1) Lateral shift of Me
2) Unequal right and/or left ramus lengths
3) Deformity extending to the maxilla
4) Lateral inclination of occlusal plane in a frontal view

<table>
<thead>
<tr>
<th>Posture</th>
<th>Area and measured value</th>
<th>Lateral loads (Average) (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cheekbone</td>
</tr>
<tr>
<td>Lying</td>
<td></td>
<td>—</td>
</tr>
<tr>
<td>Face down</td>
<td></td>
<td>—</td>
</tr>
<tr>
<td>Prone with face turned to one side</td>
<td>30.3</td>
<td>28.5</td>
</tr>
<tr>
<td>Prone with face on pillow; with arm</td>
<td>—</td>
<td>33.7</td>
</tr>
<tr>
<td>Prone with face on pillow; without arm</td>
<td>—</td>
<td>15.0</td>
</tr>
<tr>
<td>Sitting</td>
<td></td>
<td>—</td>
</tr>
<tr>
<td>Prone with face turned to one side</td>
<td>25.9</td>
<td>25.7</td>
</tr>
<tr>
<td>Chin on hand</td>
<td>20.7</td>
<td>19.6</td>
</tr>
</tbody>
</table>

Fig. 2 Measurement volumes by preliminary study
Table 2  15 cases with habitual posture and lateral shift of Me

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Sex</th>
<th>Age</th>
<th>Habitual posture</th>
<th>Lateral shift of Me</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Face down</td>
<td>Chin on hand</td>
</tr>
<tr>
<td>1</td>
<td>M</td>
<td>17y 1m</td>
<td>○</td>
<td>R ○</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>29 1</td>
<td>R ○</td>
<td>R ○</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>22 9</td>
<td>R ○</td>
<td>R ○</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>18 10</td>
<td>R ○</td>
<td>R ○</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>14 2</td>
<td>○</td>
<td>R ○</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>18 4</td>
<td>R ○</td>
<td>R ○</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
<td>25 7</td>
<td>○</td>
<td>R ○</td>
</tr>
<tr>
<td>8</td>
<td>F</td>
<td>20 10</td>
<td>○</td>
<td>R ○</td>
</tr>
<tr>
<td>9</td>
<td>F</td>
<td>30 8</td>
<td>R ○</td>
<td>R ○</td>
</tr>
<tr>
<td>10</td>
<td>M</td>
<td>24 2</td>
<td>L ○</td>
<td>R ○</td>
</tr>
<tr>
<td>11</td>
<td>F</td>
<td>19 3</td>
<td>R ○</td>
<td>R ○</td>
</tr>
<tr>
<td>12</td>
<td>M</td>
<td>17 5</td>
<td>R ○</td>
<td>R ○</td>
</tr>
<tr>
<td>13</td>
<td>F</td>
<td>21 2</td>
<td>○</td>
<td>R ○</td>
</tr>
<tr>
<td>14</td>
<td>F</td>
<td>20 11</td>
<td>R ○</td>
<td>R ○</td>
</tr>
<tr>
<td>15</td>
<td>M</td>
<td>25 0</td>
<td>L ○</td>
<td>L ○</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>5</td>
<td>R:5, L:1</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td>12.4</td>
<td>2.9</td>
</tr>
</tbody>
</table>

R: right  L: left

Fig. 3  Landmarks and lines of P-A cephalogram

1) ZR: Zygomatic frontal right
2) ZL: Zygomatic frontal left
3) AZ: Zygomatic arch right
4) ZA: Zygomatic arch left
5) CG: Crista gali
6) ANS: Anterior nasal spine
7) ME: Menton
8) GA: Antegonial protuberance right
9) AG: Antegonial protuberance left
5) Laterally or mesio-distally tipped incisors (L1, U1)

Post-surgical changes in mandibular position can be evaluated with changes in Me before and after surgery. However, mandibular shift may occur postoperatively as seen in the case shown in Fig. 4. The preoperative mandibular shift of 13.0 mm to the left was corrected surgically to achieve coincidence of the upper and lower dental midlines and a favorable jaw relationship. The lateral shift observed postoperatively seems to be attributable to deformity and asymmetry of the mandible itself.

The lateral pressures exerted on the maxillofacial region by resting the lateral part of the chin on the hand and by lying prone with the face turned sideways without a pillow were as high as 20N (about 2.04 kg) and 30N (about 3.06 kg), respectively. These pressures, exerted habitually or several times a day, will accumulate to a large work load. Generally, the orthodontic forces used for tooth movement range from 20 to 100 g and orthopedic forces from 400 to 700 g. The lateral forces generated in the habitual postures are far greater than these forces. Repetitive application of such forces every day for several years to the jaw bones, particularly the mandible, in a growing child may cause deformity or asymmetry of the jaws.

Some of the lateral loads exerted by habitual postures can be as large as 43.7N or 4.5 kg. The habitual postures may be assumed several times for several hours every day. Some children acquire these habits in primary, middle, or high school. Once acquired, the habits may be retained for several years. The children themselves and those around them pay less and less attention to the habits as they grow older. However, this part of childhood is a critical period for jaw growth, which may be adversely affected by postural and other habits resulting in deviation or deformity of the jaws.

One of the major challenges in orthodontics for many years has been to maintain occlusal stability after treatment, which requires a thorough investigation into the cause of the malocclusion to prevent its post-orthodontic relapse. In this regard, it is important to have a clear grasp of each patient’s habitual posture and provide appropriate guidance on lifestyle habits.

REFERENCES


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