Masseter Muscle Bite Force in First Bicuspid and Collapsed Occlusion Cases

By Martha E. Rich, DMD, FAGD, FAACP

Abstract: The masseter muscle is the primary bite force generator for chewing and swallowing. Masseter muscle strength was recorded on 89 subjects using electromyography. Subject groups were separated into 4-bicuspid extraction cases, collapsed occlusions, and controls. Data was averaged and analyzed. The control group displayed the greatest strength.

Introduction

The maxilla and mandible articulate through the temporomandibular joints and the occlusion of the individual teeth. The force of articulation, however, must be supplied by the elevator muscles of mastication, chiefly the temporalis and masseter muscles. Ideal occlusion allows maximal force to be exerted by the muscles of mastication while all of the teeth are in even contact and the temporomandibular joints are properly aligned. Proper alignment of the temporomandibular joints places the condyles in the superanterior position as stated by Okeson.\(^1\) In order for the maximal force of the muscles to be obtained, the occlusion of the teeth must be in such an alignment that most of the individual muscle fibers contract along their individual long axis. Thus the occlusion, the muscles of mastication, and the temporomandibular joints should all function harmoniously. This should be the goal of all temporomandibular joint treatments, oral reconstruction, and orthodontic treatment.

The temporalis muscle is the posturing muscle for the mandible. It brings the mandible close to actual occlusion. When initial tooth contact occurs, the masseter muscle (and the medial pterygoid which forms a sling around the mandible with the masseter muscle) then takes over as the main muscular component of chewing and swallowing (Figure 1). These powerful muscles can exert more than 200 lbs. of pressure on the molars. When chewing hard foods, heavy masseter function bilaterally coincides with contraction of the temporalis muscles. The loss of teeth radically alters such muscle activity and chewing patterns. When only anterior teeth are present, the facial and circumoral muscles become very active in mastication and there is minimal masseter activity.\(^2\)

In addition to chewing, the masseter muscles are a very important aid in swallowing. Swallowing or deglutition is a very complicated process utilizing numerous muscles in the head and throat. In the normal adult swallow, the mandible is stabilized by tooth contacts. This allows the musculature of the infrahyoid and suprahyoid areas to control the movements of the hyoid bone for swallowing.
As with all skeletal muscles, the fibers of the masseter generally extend the entire length of the muscle. In order for a muscle to do “work,” the individual muscle fibers contract along their long axis. The long axis of the superficial masseter, which is the larger part of the muscle, is aligned anteriorly while the smaller deep masseter fibers are aligned a bit more vertically. When the chewing or swallowing cycles begin, the temporalis muscle brings the mandible into closer proximity. When the first tooth contact is reached, the masseter begins to forcefully bring the teeth together. The muscles seek maximum intercuspation. The teeth guide the muscles and temporomandibular joints into position. The exquisite proprioceptive sensitivity of the teeth ensures that the muscles become programmed to allow only certain movement patterns that will result in maximum tooth contact.

The masseter muscle, then, is the force generator of chewing, swallowing, and bite force. Since this muscle is so important to the overall function of the stomatognathic system, including the functional health of the masseter muscle it is absolutely critical to proper function. Therefore, it must be taken into consideration during diagnosis and treatment planning.

This study was undertaken to determine the forces generated by the masseter muscle in three population groups: first, dysfunctional patients who had undergone four bicuspid extractions for orthodontic treatment; second, dysfunctional patients who had collapsed and mutilated occlusions; and third, a control group. The term dysfunctional includes pain, a perceived inability to chew well, or a perceived uneven occlusion. The subjects were not separated based upon internal derangements within the joints. Those subjects placed in the category of collapsed occlusion displayed missing teeth other than the first bicuspids, a class II malocclusion, a deep curve of spee, a class I malocclusion with lingually tipped maxillary incisors, a deep overbite, and/or severe wear. Many subjects displayed a significant bicuspid drop-off. None of the subjects had multiple missing molars in one quadrant and none had partial or full dentures. In other words, they all displayed four quadrants of teeth.

### Materials and Methods

Twenty-five subjects, 22 females and 3 males, who had experienced first bicuspid extractions were recruited from the private practice of the author. Each subject was experiencing temporomandibular joint and/or facial pain. In the collapsed occlusion category, 41 subjects were recruited, which included 31 women and 10 men. The control group consisted of 10 women and 13 men (Table 1).

As Okeson and many other authors have stated, upwards of 70% of the general population may have signs and symptoms of temporomandibular joint dysfunction. To find controls with no missing teeth except third molars, no signs and symptoms of TM disorders, a class I occlusion, and are willing to have electrodes placed on their face is difficult. Most of the control subjects were dental students attending Oregon Health Sciences University.

Functional forces were analyzed using the EM2 electromyography unit from Myo-Tronics, Inc. in Seattle, Washington. The electrode sites were scrubbed with rubbing alcohol and bipolar self-jelled surface electrodes were placed over the body of the masseter muscle in alignment from the angle of the mandible to the zygomatic arch. This would parallel the long axis of the muscle. This collects the highest electrical activity. Data was simultaneously recorded from the function test from both the temporalis and masseter muscles. However, for the purposes of this study, only the functional levels of the masseters were reported.

Subjects were seated in a straight, upright chair with the feet flat on the floor. They were asked to sit as straight as possible. Initial resting readings were taken while the subjects lightly closed their eyes and were asked to relax as much as possible. The subjects were then asked “to relax, relax, then clench as hard and as evenly as possible on both sides.” During the clench, the author kept repeating “clench, clench, clench” in an attempt to truly obtain the strongest biting force as more fibers were recruited. For purposes of this paper, the peak values were used for the dysfunctional subjects and the five highest values were averaged into a single value for the controls. This was done because the dysfunctional subjects were usually unable to sustain the clench. If averaged values had been used here, the author believes the discrepancies between the controls and dysfunctional subjects would have been even greater.

#### Table 1 - Subject Demographics

<table>
<thead>
<tr>
<th>Condition</th>
<th>Male</th>
<th>Female</th>
<th>Age Mean (Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Bicuspid Extraction</td>
<td>3</td>
<td>22</td>
<td>33.2 (19.2-60.5)</td>
</tr>
<tr>
<td>(n=25)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collapsed Occlusion</td>
<td>10</td>
<td>31</td>
<td>37.2 (24.1-49.7)</td>
</tr>
<tr>
<td>(n=41)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>13</td>
<td>10</td>
<td>41.5 (19.6-75.4)</td>
</tr>
<tr>
<td>(n=23)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>26</td>
<td>63</td>
<td>38.7 (19.2-75.4)</td>
</tr>
<tr>
<td>(n=89)</td>
<td></td>
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</table>
For most subjects, two readings were taken. The subjects were first asked to clench on their natural dentition. Following this, cotton rolls were placed between the teeth, and they were asked to clench as hard as they could again. Some of the subjects were not asked to clench on the cotton as they were too uncomfortable. The cotton rolls uncouple the occlusion, and therefore, additional fibers can be recruited without processing proprioceptively noxious stimuli in an uncomfortable occlusion. Only one control subject was asked to clench on the cotton rolls. The functional levels for most control subjects were thought to be strong enough without the additional step. The cotton roll clench was added in as a separate event. Table 2 shows the actual sample demographics with the cotton roll samples added in. The means of the individual events were calculated along with the standard deviations. These figures were still separated by gender as shown in Table 3. New means and standard deviations were then calculated without gender separation as shown in Table 4. Finally, an analysis of variance was performed to determine if there were significant differences using the no-cotton measurements and controlling for gender and age. These calculations were performed by an independent observer.

### Results

In the 1st bicuspid extraction condition, the females could clench harder than the males. However, the males were strongest when the cotton was added. The number of males in this sample is very small and the analysis of variance (ANOVA) showed that gender is not a significant predictor. Age was also not a significant predictor of strength for any of the events.

In the collapsed occlusion sample, the females were again able to clench harder than the males. The results here of clenching on the cotton were mixed. In all cases, clenching on the cotton produced more strength than clenching on the natural dentition. In the 1st bicuspid extraction subjects and the collapsed occlusion subjects, the right masseter was slightly stronger than the left when biting in the natural dentition, but this condition was reversed when cotton was used. No explanation is apparent for this observation. The control figures were more equal when the right side was compared with the left side, except in the one case where cotton was used.
The ANOVA yielded a significant main effect by condition for the left masseter muscle, \( F(4,84) = 12.87 \) \( p<.0001 \) and for the right masseter muscle, \( F(4,84) = 12.81, p<.0001 \). Planned comparisons showed that values obtained for the 1st bicuspid extraction were significantly lower than the control for both the left masseter (\( t = -4.76, p<.0001 \)) and the right masseter (\( t = -4.51, p<.0001 \)). The collapsed occlusion condition was also significantly lower than the control condition for the left masseter (\( t = -4.36, p<.0001 \)) and the right masseter (\( t = -4.62, p<.0001 \)). No significant differences were observed between the collapsed occlusion cases versus those with the 1st bicuspid extractions.

**DISCUSSION**

The masseter muscle is, under normal conditions, a very powerful, forceful muscle for both mastication and stabilization during degluttion. The temporomandibular joints provide the fulcrum against which the masseter and other muscles of mastication can perform work. When we consider the exquisite proprioception of the teeth and the neural pathways that exist to guide the muscles into maximum intercuspation (centric occlusion), it follows that occlusal disharmony sets up conditions that do not allow the muscles of mastication to function ideally. This, then, is recorded electromyographically as decreased function. When the cotton rolls were used, the noxious stimuli were interrupted from the occlusion and increased function resulted as Jankelson has suggested. Cooper also showed that masseter muscle function was increased in dysfunctional subjects with the use of a neuromuscular orthotic. Other studies have shown similar results.

When muscles are not used ideally over a period of time, the result is weakness and disuse atrophy. In disuse atrophy, the contractile proteins decay more rapidly than they are replaced. The muscle withers away. This is evident in subjects with dentures even with different occlusal schemes as stated by Caloss. Atrophy can also produce increased tension that will, in time, produce tension syndromes including active trigger points as stated by Travell. Masseter muscle function can be checked clinically, even before performing electromyography, by asking the subject to clench while palpating the muscle. In many of the 1st bicuspid extraction and collapsed occlusion cases documented above, the masseter muscle can barely be felt. This in and of itself should alert the clinician to probe more deeply into the state of the occlusion. In the absence of a central nervous system defect or other neuropsychological problem, this should not be the case for a muscle that is supposed to be so strong and powerful. If the teeth are not in the correct alignment to allow the masseter to perform its work, it may indicate that the temporomandibular joint is misaligned also.

In the cases of 1st bicuspid extraction, generally the maxillary anterior segment has been retracted, which in turn retracts the mandible. Due to the strong input of proprioception from the teeth, particularly nociceptive stimuli from the anterior teeth, the muscles no longer function well and bite forces are significantly decreased. This same phenomenon is present in the cases of collapsed occlusion. When posterior vertical dimension is lost, the muscles can no longer function at their proper length for maximum strength or the mandible retracts. The occlusion is no longer aligned to allow the masseter to function well. However, the muscle strength can increase with the gradual advancement of the mandible as stated by Du and others.

At the time of the electromyographic investigation of the 1st bicuspid extraction cases, it was almost universally impossible to palpate the masseter muscle. The muscles were atrophied from disuse. The body of the muscles were unable to contract due to the dental alignments. Profitt states that there was a widespread reintroduction of bicuspid extractions during the 1930s. Profitt also states that in the 21st century there is more emphasis on dental and facial esthetics in orthodontics and less emphasis on occlusion. During the investigation of a number of other orthodontic textbooks, it was found that there was little or no mention made of the muscles of mastication or the masseter muscle in particular. This seems incredible when the muscles are such an integral part of the proper function of the entire stomatognathic system. When muscles are mentioned, they are generally those of the tongue or the lips.

A recent study published in the *Journal of Oral Rehabilitation* states that in healthy subjects, maximum function was obtained “for occlusions with bilateral posterior contacts and the mandible in a stable centric position.” As clinicians it behooves us to treat our patients to the most stable and functional position possible. Masseter muscle function and temporomandibular joint alignment must be considered while we are planning to restore the occlusion, lost vertical dimension, or align the teeth esthetically. Our patients deserve stability and harmony of the stomatognathic system and the best functional position possible.

**CONCLUSION**

Twenty-five first bicuspid extraction subjects, forty-one collapsed occlusion subjects, and twenty-three controls were recruited for electromyographic studies of masseter muscle bite force. The control subjects displayed the highest bite force. The functional masticatory muscular status should be taken into consideration during orthodontic and prosthodontic treatment planning. Further research should be conducted.
References


Martha E. Rich, D.M.D. obtained her BS degree from Boise State University in 1978 and her DMD degree from Oregon Health Sciences University in 1981. She was an associate professor of Fixed Prosthodontics at OHSU from 1984 to 1991. She has also maintained a private practice in Portland, Oregon, since 1981 where she focuses on general dentistry, temporomandibular joint and craniofacial pain disorders, sleep apnea, and orthodontics. She is a member of the International Association of Orthodontics and the American Academy of Dental Sleep Medicine. She holds a fellowship from the Academy of General Dentistry and the American Academy of Craniofacial Pain.