The Effect of Bite Plane Use on Terminal Hinge Axis Location

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Orthodontic treatment is most often shown with plaster models depicting the ideal occlusal setup. If this occlusion is to function within a living organism, we must have a better gnathological basis for orthodontic concepts and treatment goals. Roth feels that equilibration for a treated orthodontic patient creates the greatest chance of stability if it is gnathologically principled.[1] Most occlusal adjustment should be preceded by a diagnostic equilibration on a properly programed, fully adjustable articulator. This diagnostic equilibration determines the feasibility of the procedure and provides a sequential list for the removal of prematurities.

To program a fully adjustable articulator the true terminal hinge axis of the patient must be determined. This axis occurs when the mandible is in centric relation and a pure rotational movement of the mandible is produced in the sagittal plane.[2] The use of the hinge axis makes it possible to relate the dental casts to the parts of the articulator in the same way the patient's jaws are related to the skull and glenoid fossae. Thus, any given point on the occlusal surface of the articulated mandibular cast has the same terminal arc of closure as the identical point in the patient's mouth and has identical spatial relations at any given vertical dimension. As a result, new centric relation records are not needed as the vertical dimension is changed during the diagnostic equilibration procedure.

A newer definition of centric jaw relation states that the mandibular condyles should be in their rearmost, uppermost, and midmost positions in their respective glenoid fossae.[2,7] This includes all three planes of space, allows an accurate description of the condylar position, and lends itself to the various hypothetical determinants of centric relation.

The muscles of mastication are considered to be a limiting factor in the posterior positioning of the mandible and help guide and determine the direction of mandibular movements. Normal muscle activity is under neural control and the proprioceptors located in the periodontal ligament, the temporomandibular joint, and the muscles of mastication inform the brain of mandibular spatial position.[4,8,9] When an occlusal interference is present, the neuromuscular reflex mechanism limits the force of contraction or causes a deviation in mandibular movement. The result of either action is a limitation of the traumatic force on the teeth. The range of individual accommodation determines the possibility of resulting pathologic sequelae.

The routine use of bite plane therapy has been suggested for patients with signs and symptoms of temporomandibular dysfunction.[2-5] Several authors have shown that occlusal interferences can affect neuromuscular activity.[10-14] Bite plane therapy allows normalization of the neuromuscular pattern, permit-

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ting a physiologic positioning of the mandible, and allowing inflamed temporomandibular tissues to recover. This permits the accurate determination of the true terminal hinge axis. Huffman and Regenos[2] believe that symptomatic relief usually occurs within three hours of the initiation of bite plane therapy. Therefore, the appliance can be an aid in differential diagnosis of migraine headache, tic douloureux, and other entities.

Terminology can be confusing, and the names given to bite-modification appliances are bewildering. Terms such as bite planes, bite guards, occlusal splints, mandibular repositioner, modified Hawley appliance, and Sved appliance have been applied. Ramfjord[8] uses the term bite plate for appliances which have only the anterior teeth occluding the acrylic. He feels the term "bite plane" should be used for those which present a flat surface against which all the teeth occlude. Bite planes made with all teeth in contact are preferable to those made with only the anterior or posterior segments occluding. With the relief of symptoms some patients may not return for adjustment and will continue to wear the appliance. If a bite-opening device is made which allows no posterior tooth contact, we may observe supraeruption of these teeth which will compound the dysfunction problem.

Since bite planes restore normal neuromuscular patterns they become an important aid in determining the true hinge axis. The purpose of this study was to compare the effects of a bite plane in locating the axis on Class I asymptomatic nontreated subjects and on those with TMJ problems.

Methods and Materials

The study was divided into two groups. The first consisted of twelve male dental students with no signs or symptoms of temporomandibular joint dysfunction. They had acceptable Class I occlusions which had not been treated orthodontically. This group was considered a normal sample. The second group consisted of fifteen females and two males ranging in age from fifteen to thirty-three years. Ten were Class I and seven were Class II. These subjects exhibited symptoms of TMJ dysfunction with pain in or around the TMJ or pain in the area of the muscles of mastication. Other symptoms of dysfunction could also be present, i.e., clicking, limited opening, locking of the joint, and headaches.

A maxillary full-coverage acrylic bite plane was made for each subject. A five inch square vinyl acrylic sheet 0.060 inch thick was heated and adapted to a stone model of the maxillary dentition by using a suction machine. The vinyl acrylic form was reduced until the plastic covered approximately three millimeters of buccal and labial tooth surface, extended over the occlusal and incisal surfaces, and covered about ten millimeters of palatal alveolar tissue.

A roll of self-curing acrylic was added to the occlusal surface of the bite plane form to establish the vertical dimension. With the subject's mandible in the most retruded position the teeth were closed into the soft acrylic until they nearly contacted the template. As the acrylic cured it was removed from the mouth, cooled under water, reseated in the subject's mouth, and the teeth lightly occluded into the material to check the relationships. The cooling and reseating was done repeatedly to limit any distortion which could occur as the heat of polymerization was emitted.

After the material was cured, the excess acrylic was removed until only a minimal impression of the buccal cusp tips and the incisal edges remained. The occlusion was perfected in the sub-

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ject's mouth until all mandibular teeth had buccal and incisal-edge centric stops on the bite plane.

The acrylic against which the mandibular anterior teeth occluded was adjusted to create a gradual cuspid rise which resulted in an immediate posterior disclusion. Therefore, all posterior working and balancing contacts were eliminated. The centric stops and the posterior eccentric disclusion were evaluated by using 0.0005 inch shim stock material. The pressure of all posterior centric stops was equalized; the shim stock could not be removed until the eccentric movement of the mandible was initiated. The interocclusal space was checked with the mandible in rest position to be sure the bite plane did not encroach upon this functional dimension.

Group I participants were instructed to wear their appliances for five days, twenty-four hours a day, except during meals. They were also requested to eat no solids for the meal just preceding their appointment for determination of the terminal hinge axis.

Using the principles as advocated by Guichet,[15] three separate axis location determinations were registered on each Group I subject. The maxillary bite planes were used prior to the first and third assessments while the second determination was done without the bite plane.

The first assessment of the hinge axis location had to be accurately and permanently recorded for direct comparison with subsequent determinations in terms of directional and linear change. The most accurate and acceptable method to clinically preserve this information was to make a tattoo by impregnating the subdermal layer of the subject's skin with India ink at the point of rotation. The subsequent hinge axis determinations could then be marked with nonpermanent ink and compared with the original.

During this procedure the subject was seated on a stool with his back self-supported in an erect posture. His head was positioned with the Frankfort plane parallel to the floor and the scalp and facial musculature relaxed; this position of the patient was used so the skin overlying the imaginary hinge axis would be in the same relative position for each subsequent marking allowing a more meaningful comparison of the locations. After recording the axis location from the initial period of bite plane utilization, the bite planes were stored in water to prevent any distortion due to dehydration of the acrylic.

A minimum period of seven days occurred between the first determination of the terminal hinge axis with bite plane use and the redetermination of the location without bite plane use. This waiting period was adequate for the original patterns and conditions to return since Jarabak found aberrant neuromuscular patterns returned after five minutes of function without bite planes.[11]

The determination of the axis without bite plane use was done in a manner similar to the initial one. This location was transferred and marked on the subject's skin with nonpermanent red ink in the manner described.

A second five to seven day course of bite plane utilization was begun after checking the bite planes for proper fit and function. This period of bite plane use ended with a third determination of the terminal hinge axis. The procedure was identical to the original except that the location was again marked with nonpermanent red ink on the surface of the subject's skin. This third procedure permitted a comparison of the reproducibility of the hinge axis following bite plane utilization.

The procedure for Group II differed slightly since they were symptomatic

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patients. Two hinge-axis determinations of each subject were made in exactly the same manner as Group I. However, the initial assessment was made prior to bite plane therapy and was tattooed with a pink dye of mercuric oxide and alcohol. The bite plane was then inserted and the patient instructed to wear it 24 hours per day except when eating. The subjects returned weekly for adjustment of the bite planes until symptoms of pain were absent. The second hinge axis was determined four weeks following the disappearance of symptoms and was marked with the black dye.

Recording of the Data

The center of the marks on the subject's skin which represented the true hinge axis location (black mark) was directly compared in millimeters and in direction of change to the marks determined without bite plane use. Any linear differences were transferred to the subject's record card using a bow divider with a central adjusting screw and recorded to the nearest 0.1 mm.

The directional change was recorded in terms of a clock face (Fig. 1). The center of the clock represented the determination without bite plane use, i.e., the pink dot. Each subject's determination of the location with bite plane use was marked on the clock face as to direction and distance from the center. Thus, a one millimeter change directly posterior to the center of the clock on the right side was described as being one millimeter at nine o'clock. A similar change on the left side was recorded as being one millimeter at three o'clock.

Method of Analysis

The directional change was analyzed in terms of both horizontal and vertical components, i.e., change in an upward and forward direction was depicted as a superior change for vertical analysis and an anterior change for horizontal analysis. It was observed that a linear

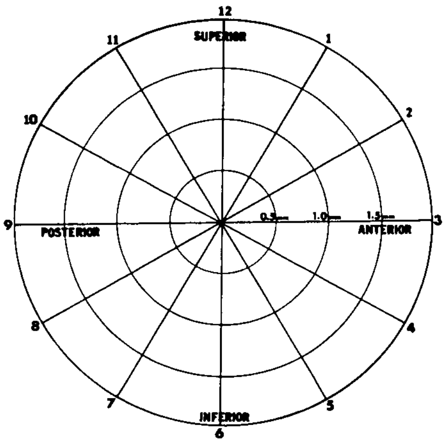

Fig. 1 Bulls-eye graph used in this study. The center represents the axis found without the use of a bite plane.

change could occur on one side with no change on the opposite. Therefore, the sides were considered to be independent and the samples for each group combined for statistical analysis. Chi-square analyses of the directional changes were done to determine the significance of change.

Findings

Group I

For all normal subjects the mean amount of change that occurred in the location of the terminal hinge axis with the use of bite planes compared with their absence equalled 1.14 mm on the right side and 0.87 mm on the left. The mean change was 1.0 mm with a range of 0.3-3.4 mm when the sides were combined. A change occurred on one side only in two subjects. Two other individuals demonstrated changes in opposite directions and in one subject both sides changed in the same direction. An obvious lack of hinge axis locations was apparent in the postero-inferior quadrant. Most of the marks following bite plane use were located in the anterosuperior portion.

The direction of change was analyzed in terms of horizontal and vertical components. Table I shows the vertical

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TABLE I
The distribution of vertical changes when bite plane use was compared with the absence of bite plane.

Direction	Right	Left	Combined
Inferior	3	4	7
No change	2	3	5
Superior	7	5	12

distribution of the location marks when the hinge axis locations determined with the use of bite planes are compared with those without. Five of the twenty-four locations determined with use of bite planes were unchanged and twelve were found in a superior direction ($P = 0.10$). This is not significant, but merely shows a tendency for a superior component of directional change when bite plane use precedes the hinge axis location.

Table II shows the horizontal distribution of the marks when the hinge axis locations determined with bite planes are compared with those without. There was either no change or a definite anterior directional change observed in twenty-two of the twenty-four hinge axis locations. Sixteen of these twenty-two locations showed an anterior directional change ($P = 0.001$). Therefore, when a bite plane was used, it resulted in a significant anterior directional change in the terminal hinge axis location.

Of course, when the horizontal and vertical components are combined, the hinge axis marks determined with a bite plane tended to be located anterosuperiorly from the reference mark. This gives the appearance of a possible dislocation of the mandibular condyles in a posteroinferior direction when the hinge axis was determined without a bite plane use.

Table III depicts the vertical distribution of the terminal hinge axis location marks when they were determined with the second use of the bite planes and compared with the original bite plane tattoo. When the two sides were combined, twelve of the twenty-two locations were vertically changed; four of these changed superiorly and eight changed inferiorly.

Table IV gives the horizontal distribution of the marks after the second use of bite plane when compared with the first. Twelve of the twenty-two hinge axis location marks were horizontally changed: five anteriorly, and seven posteriorly. When both sides were combined there was an obvious lack of significant directional change.

The mean change between the two bite plane determinations of axis locations equalled 1.09 mm on the right side and 0.65 mm on the left. When both sides are combined, the mean change was 0.87 mm and a range of 0.0-3 mm. When this is compared with the 1.0 mm change of the axis positions determined without bite planes, it appears that the accuracy of the bite plane-determined location is clinically similar to that determined without bite

TABLE III
The distribution of vertical changes when the second bite plane use was compared with original bite plane locations.

Direction	Right	Left	Combined
Inferior	6	2	8
No change	3	7	10
Superior	2	2	4

TABLE II
The distribution of horizontal changes when bite plane use was compared with its absence.

Direction	Right	Left	Combined
Posterior	1	1	2
No change	2	4	6
Anterior	9	7	16

TABLE IV
The distribution of horizontal changes when the second bite plane use was compared with the original locations.

Direction	Right	Left	Combined
Posterior	5	2	7
No change	5	5	10
Anterior	1	4	5

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plane utilization. However, it should be emphasized that this type patient is not one routinely in need of occlusal adjustment.

Group II

One subject never accomplished remission of pain symptoms and was therefore excluded from the study. The initial pink tattoo on a second individual became indiscernible and no comparison could be made. A third hinge axis changed 6.8 mm, was thought to be erroneous, and discarded from the statistical evaluations. Tables V and VI therefore indicate sixteen condyles on the right side and fourteen on the left.

Initially, all patients were classified as to the severity of their symptoms by a subjective analysis of the degree of pain presented. Thirteen of sixteen had pain in the right joint, while eleven of sixteen had pain in the left, and nine out of sixteen described pain in both joints. One subject did not have pain in either joint; his chief complaint was spasm and pain of the left anterior digrastic muscle and clicking of the left joint.

Subjective evaluation of pain to muscle palpation was also made by the patient. These tests revealed the medial and lateral pterygoid muscles had the greatest incidence of sensitivity. The right medial pterygoid was painful in sixteen of sixteen subjects; the right lateral pterygoid in fourteen of sixteen; the left lateral pterygoid in ten of sixteen, and the left medial pterygoid in twelve of sixteen subjects. Other muscles found painful in decreasing order were the masseter, temporalis, and digrastric. In this study the muscles on the patient's right side were found to be more sensitive than those on the left.

There was high incidence of joint clicking, bruxing, and headaches prior to bite plane therapy. There was also a difference between centric relation and centric occlusion in all of the sixteen subjects. This resulted in an occlusal slide from first tooth contact in centric relation to the full intercuspation position. The subjects became particularly aware of the slide immediately after removing the bite plane during the period of bite plane therapy; they did not close immediately into full intercuspation but rather to an occlusal position more distal for the lower teeth. The full intercuspation bite returned after a few minutes without the bite plane.

TABLE V

The distribution of vertical changes of the terminal hinge axis when bite plane use is compared with its absence.

Direction	Right	Left	Combined
Inferior	7	4	11
No change	5	2	7
Superior	4	8	12

TABLE VI

The distribution of horizontal changes of the hinge axis when bite plane use is compared with its absence.

Direction	Right	Left	Combined
Posterior	10	6	16
No change	4	4	8
Anterior	2	4	6

Fifteen out of sixteen subjects increased their maximum opening capabilities following bite plane therapy, while only one subject had a decrease. The range was from —6 mm (decrease of 6 mm after bite plane use) to + 14 mm with an average of 4.1 mm increased opening. Where the bite plane resulted in an increased vertical opening, the average increase was 4.73 mm. The duration of bite plane therapy ranged 4 to 16 weeks with an average of 10.4.

For fourteen subjects the distance from the position of the terminal hinge axis at the initial evaluation differed from the position of the terminal hinge axis at the end of bite plane therapy. This mean difference of both right and left sides was 1.46 mm. The mean difference on the right was 1.2 mm and

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1.65 on the left. The range of change in the position of the hinge axis was 0 to 3.3 mm excluding a 6.8 mm recording which was felt to be inaccurate. There was no significant ($P = 0.10$) difference in the amount of total movement between the right and left sides.

The direction of change was analyzed in terms of vertical and horizontal components (Tables V and VI). The difference between the vertical change on the right side and the vertical change on the left was not significant ($P = 0.23$). After combining the two sides nineteen out of thirty hinge axes were either vertically unchanged or located more superior. Twelve of these nineteen showed a superior directional change. The change in a vertical direction of the hinge axis locations after bite plane use was not significant ($P = 0.30$).

The difference between the horizontal change on the patients' right sides and the horizontal change on the left sides was not significant ($P = 0.50$). After combining the two sides, twenty-four of thirty axes were either unchanged or located in a posterior direction. Sixteen of these twenty-four showed a significant posterior directional change in the terminal hinge axis location ($P = 0.05$).

Discussion

Group I normals were found to produce an anterior superior change with the use of bite planes. This correlates with McMillen who indicated the importance of muscle tonicity in positioning the condyles in their superior-most relation.[16] He found the condyles dropped from this position when the subject was under general anesthesia and then administered succinylcholine. Vertical pressure applied to the angles of the mandible was insufficient to reposition the condyles in their original relations to the glenoid fossae. He also discussed the possibility of the temporomandibular ligaments serving as a fulcrum to permit the condyles to be seated in an anterosuperior direction. In the present study the lack of the bite plane could have allowed an aberrant neuromuscular pattern to remain and, therefore, a combination of aberrant muscle activity and ligamental limits may have resulted in the tendency for a posteroinferior displacement in the hinge axis location.

Patients with TMJ dysfunction exhibit abnormal muscular activity according to electromyographic studies.[10,11] A high or premature occlusal contact results in a constant partial contraction of various muscles of mastication causing these muscles to go into spasm.[9] Which muscle or muscles are involved varies according to the nature and location of the occlusal disharmony, e.g., if the lateral pterygoids were in spasm the condyles would be dislocated in an anterior direction. Thus, if the muscles were allowed to physiologically relax, the condyles would be positioned in a more posterior direction than when in spasm. If the lateral pterygoid on only one side were affected by spasm, then the right and left condyles could be positioned in different directions from each other. Since all the muscles of mastication interact with each other, there are various muscle combinations that could result in various condylar locational changes. Any condylar locational change would result in a hinge axis locational change for that condyle.

This could explain the variation in results of hinge axis locations after bite plane use with TMJ symptomatic patients. The pterygoid muscles were found to be tender to palpation more frequently than any other masticatory muscles. A higher incidence of lateral pterygoid spasm could explain the greater tendency for a more posterior

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axis location after bite plane use on symptomatic patients.

The mean change in hinge axis determined with a bite plane from that determined without a bite plane in Group I was 1.0 mm with a standard error of 0.16. The mean change in determination with and without a bite plane in Group II was 1.46 mm with a standard error of 0.18. The 0.46 mm greater average change in Group II when compared with Group I was borderline significant ($P = 0.06$). However, a variance in maxillomandibular tooth position could result from this amount of change. It has been shown clinically that as little as one mm change in condylar location will drastically affect the occlusal relationship of the mandibular teeth to the maxillary teeth.[17]

The reproducibility of axis locations following two different wearings of the bite plane in Group I should be noted (1.09 mm difference on the right side, .65 mm on the left). This is a clinically applicable finding since the true hinge axis is said to be the only one that is reproducible. With relaxed musculature it appears to be repeatable within the aforementioned limits.

If the one extreme change of 3 mm is removed from the sample, the range changes from 0.0-3.0 mm to 0.0-1.6 mm when comparing the two periods of bite plane wear.

Summary and Conclusions

The effect of bite plane therapy on the location of hinge axis was observed and compared in a sample of normal subjects and a group of individuals with TMJ dysfunction. The normal group displayed a mean change of 1.0 mm with a range of 0.3 mm to 3.4 mm between bite plane use and its absence. The direction of change with bite plane use was anterior with a tendency for a superior component. The same group utilized the bite plane a second time and the axis location was compared with the original determined with bite plane use. This procedure was done to test the reproducibility of hinge axis on normal subjects. The mean change between the two bite plane uses was .87 mm with a range of 0.0 mm to 3.0 mm.

The symptomatic patients changed a mean of 1.46 mm with a range of 0.0 to 3.3 mm. The direction of change was definitely posterior following therapy with a strong tendency for a superior component.

This study seems to emphasize the need for a relaxed and asymptomatic muscular pattern for individuals on whom occlusal adjustments are to be made. In the presence of erroneous maxillomandibular skeletal relationships inaccuracy is inherent for occlusal equilibration.

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REFERENCES

1. Roth, R. H.: Gnathologic concepts and orthodontic treatment goals, from *Technique and Treatment with Light Wire Edgewise Appliances*, 2nd edition, Jarabak and Fizzell, C. V. Mosby Co., St. Louis, 1972.
2. Huffman, R. W. and Regenos, J. W.: *Principles of Occlusion, Laboratory and Clinical Teaching Manual*, Ohio State University, 1967.
3. Dyer, E.: Dental articulation and occlusion, *J. Pros. Dent.*, 17:238-246, 1967.
4. Posselt, U.: *The Physiology of Occlusion and Rehabilitation*, Blackwell Scientific Publications, Oxford, Great Britain, 1962.
5. ———: Studies in the mobility of human mandible, *Acta Odont., Scand.*, Suppl. 10, 1952.
6. Boucher, L. J. and Jacoby, J.: Posterior border movements of the human mandible, *J. Pros. Dent.*, 11:836-841, 1961.
7. Dawson, P. E.: Temporomandibular joint pain-dysfunction problems can be solved, *J. Pros. Dent.*, 29:100-112, 1973.
8. Ramfjord, S. P. and Ash, M. M.: *Occlusion*, 2nd edition, W. B. Saunders Co., Philadelphia, 1970.
9. Sicher, H. and DuBrul, E.: *Oral Anatomy*, 5th edition, C. V. Mosby Co., St. Louis, 1965.
10. Jarabak, J. R.: An electromyographic analysis of muscular and temporomandibular joint disturbances due to imbalances in occlusion, *Angle Ortho.*, 26: 170-190, 1956.
11. ———: The adaptability of the temporal and masseter muscles: an electromyographic study, *Angle Ortho.*, 24:193-213, 1954.
12. Moyers, R. E.: Temporomandibular muscle contraction patterns in Angle Class II, Division 1 malocclusion: an electromyographic analysis, *Am. J. Ortho.*, 35:837-857, 1949.
13. Perry, H. T.: Functional electromyography of the temporal and masseter muscles in Class II, Division 1 malocclusion and excellent occlusion, *Angle Ortho.*, 25:179-188, 1955.
14. Pruzansky, S.: Application of electromyography to dental research, *Amer. J. Ortho.*, 44:49-58, 1952.
15. Guichet, N. F.: *Procedures for Occlusal Treatment*, a monograph, Denar Corp., Anaheim, California, 1969.
16. McMillen, L. B.: Border movements of the mandible, a thesis, *Ohio State Univ.*, 1970.
17. Huffman, R. W., Williamson, E. H.: unpublished clinical data, *The Ohio State Univ.*

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