Classic Article

An experimental study of the testing of occlusal patterns on the same denture bases

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Prosthodontia constitutes one of the most interesting and challenging phases of our profession; yet, it is a phase of our work which lends itself to violent disagreement and confusion, the effect of which is to produce bewilderment in the profession. Despite the labors of many individuals to seek fundamental knowledge, and exhaustive investigation in the many ramifications of prosthodontia, the result of our accomplishments still leaves us far from an adequate solution to its many problems.

For some reason, prosthodontia has the faculty of producing violent reactions in either the sponsor or followers of a certain technique or in the interpretation of a so-called basic concept. To illustrate, one will find extreme partisan reaction as to the type of impression to make and what material to use, and under what circumstances we should use this or that technique or material. Again, in occlusion we have the group which believes in the use of this or that articulator frame; those who use no articulator frame; those who set teeth on a flat plane or a curved plane or a reverse plane (Avery), or combinations thereof; those who use an anatomic or "cusp" tooth, or a nonanatomic tooth with the many and myriad variations of each general type. There is even disagreement as to what constitutes the masticatory cycle. Perhaps this is a normal situation which confronts us, or it may depend upon our range of vision when we make our evaluations. Our range of vision will color our thoughts, concepts, and our practice.

It is certain that no one procedure or technique can be applicable for use on all of our patients. Variations are a necessity if we are to render the highest possible type of service for each individual patient. It is possible that these necessary variations are among the causes for confusion.

One of our major difficulties in evaluating the truth or worth of a so-called basic concept or technique is the inherent difficulty of performing controlled experiments in prosthodontia. But wherever possible, this must be done if we are to evaluate without bias or prejudice which, though, sincere, may nevertheless be misguiding. As it is today, many of our concepts and techniques are based upon evaluation placed upon them by individuals who too frequently are in reality stating opinions and not facts. Who is to say what is correct and what is not?

The present experiment represents an attempt to set up a basis for a controlled study of occlusion. It is believed that by this means it is possible to study the various tooth patterns, concepts of occlusal planes, and to make comparisons in the use of fully adaptable, semiadaptable, and hinge articulating frames, and so forth.

To make this study, it was necessary that all factors except the one to be tested were made constant. Thus, one of the most important steps in the present experiment was to produce a base which could be made to serve as a common base for all occlusal changes. In this manner, the type of impression made, its extension, fullness, adaptation, retention, and so forth, would remain constant throughout the experiment. By having a single base, any changes which might be made in the base would produce a common factor of change throughout the experiment. Thus, if the change produced a harmful or undesirable result in the testing of one type of occlusion, the error would be constant for all other types tested. Construction of the base had to be made so that the entire artificial dentition could be placed in position or removed from the base with ease and accuracy.

The motivation for this study was received at the Houston meeting of the Academy of Denture Prosthesis in 1941, where McLean[1] presented his work on chewing efficiency tests. The work was as follows:

"The master casts were made from the original impressions, and mounted, with scored bases, on a Terrell articulator which was then adjusted by the House chew-in technique. The 45 degree cusp dentures were set up, tried in, and cured by a long, slow cure which would not disintegrate the casts. The case was returned to the articulator, to the [mounting] bases formed by the scored bases of the casts, for occlusal post-cure correction.

"Formation of subsequent casts was as follows: The upper 45 degree cusp denture was lightly lubricated

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and a new cast was poured into it. The upper cast was then mounted on the formed base on the upper bow of the articulator, in inter-cuspation with the lower denture, in centric relation.

"The lower denture and its cast were removed from the articulator. The lower cast was scored across its undersurface at the anterior end of the posterior outward flare just anterior to the heel and the piece was broken out. The rest of the cast could then be pried out of the denture. A new lower cast was poured in the lightly lubricated lower denture and mounted on the articulator base in centric inter-cuspation with the upper denture.

"This gave each new pair of casts the same orientation on the articulator as the master casts, and all eleven pairs of dentures could be mounted on the master casts in turn and put through the same mandibular movements on the articulator."

More recently, chewing tests were made by Payne[2] who constructed two sets of dentures for the same patient on duplicate casts but with different occlusal patterns. The experimental objective was, of course, to test tooth forms on identical bases. However, it is felt that both of these experimental procedures were not sufficiently accurate on two counts: (1) Pouring of the casts. Unless the water-powder ratio of the stone is kept constant, dimensional changes will occur. The presence or absence of air bubbles in the mix will also determine the density of the cast and may become an important factor in the curing process. (2) Adjustment of denture bases. This is probably the most serious objection to the use of duplicated denture bases. If it is found that a change must be made in the denture base (for example, the reduction of a slightly overextended periphery, peripheral width, and so forth), it would be impossible to correct the balance of the duplicate dentures exactly the same amount. If our experiment is to be scientifically acceptable, these possibilities of error must be eliminated.

Thompson,[3] in his very fine study, used a common base with a slotted arrangement for the posterior teeth so that the posterior teeth could be interchanged at will. While this adequately solved the problem of interchangeability of the posterior teeth on a common base, it had one serious drawback; it left the relationship of the anterior teeth fixed. Thus, whatever incisal guide angle was determined upon, it remained unchangeable throughout the experiment. This, it is felt, imposes a serious limitation on the scope of the studies which can be made.

A fixed incisal guide angle will immediately set this one controlling end factor of occlusion and, as a consequence, limit the degree of change which can be introduced in the setting up of posterior teeth. For example, if a steep incisal guide angle is deemed necessary during the testing of one type of setup, lack of freedom to change the degree of incisal guide angle will impose this condition on all subsequent setups which may be attempted. Since the angle is fixed permanently, no change can be made. An experimental comparison between cusp and noncusp teeth would be either impossible or seriously handicapped.

CONSTRUCTION OF BASES AND INTERCHANGEABLE DENTITION

Two methods were used to construct bases which would permit rapid and accurate interchange of the occlusal patterns:

Method 1

After recovery of the casts from the final impressions, the casts were surveyed for tissue undercuts and cast gold bases were constructed (Figs. 1 and 2, *B*). On the lower casting, to insure sufficient coverage and to permit a well-rounded periphery, the buccal, labial, and lingual extensions were completed in acrylic. Retention loops were thus constructed along the periphery of the gold casting below the finishing line to serve as a means for attachment of the acrylic base material (Fig. 1, *A*). To provide for positive insertion and retention of the occlusal segment, three rectangular posts were formed on the gold base. These posts were placed well to the lingual and situated so as to cause the least amount of interference during the setting up of the teeth (Fig. 1, *B*). Holes were drilled and tapped into these posts to receive Allen screws. Essentially the same procedure was used in making the upper casting. The palate portion was not cast in gold in an attempt to reduce the weight of the denture.

After numerous trials, it was found that the acrylic insert which carried the teeth could not be made to seat accurately on the gold base after the cured acrylic insert had once been removed. The inherent inaccuracy of our acrylic denture base material became quite apparent. Many methods of curing and many packing techniques were used in an attempt to overcome this dimensional change. Among the methods employed were: the long (six to nine hours) curing time, at 158°F and at 160°F and no boiling; three hours at 158°F and one-half hour of boiling; quick chilling; overnight bench cooling; pressure packing and flask closure; and acrylics made by various manufacturers. All methods produced sufficient change to make reseating inaccurate. It was finally decided to embed a rigid casting in the wax setup and then cure the acrylic. By this method, it was possible to produce acrylic inserts that seated accurately. The metal bar was formed in the shape of a loop with keys to fit onto the posts of the gold casting (Fig. 2). Holes were drilled and tapped into the keys so that the bar could be held rigidly to the post by means of the Allen screws. Vertical dimension, check bite records, facebow transfer, etc, were made, using the gold castings as bases. The casts were then mounted on a Hanau Model H articulator with split mounting plates attached.

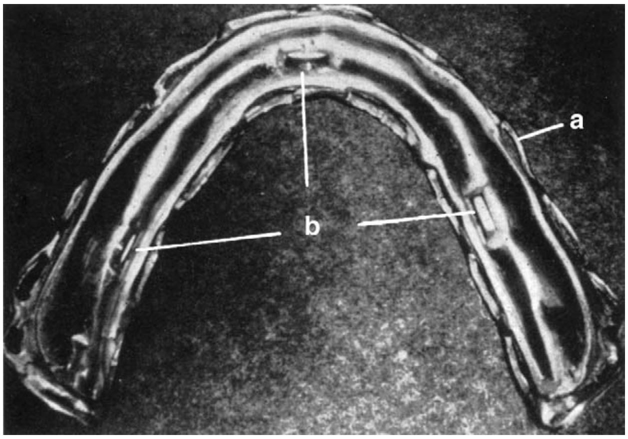

Fig. 1. Lower test cast gold base. **a,** Retention loops for attaching the plastic part of the base. **b,** Rectangular posts for the attachment of the interchangeable occlusal patterns.

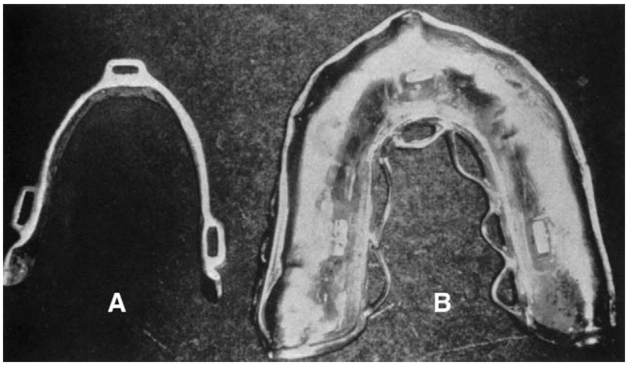

Fig. 2. A, Rigid gold bar to be embedded in an interchangeable acrylic insert. **B,** The upper test cast gold base, with the attachments on which the bar fits.

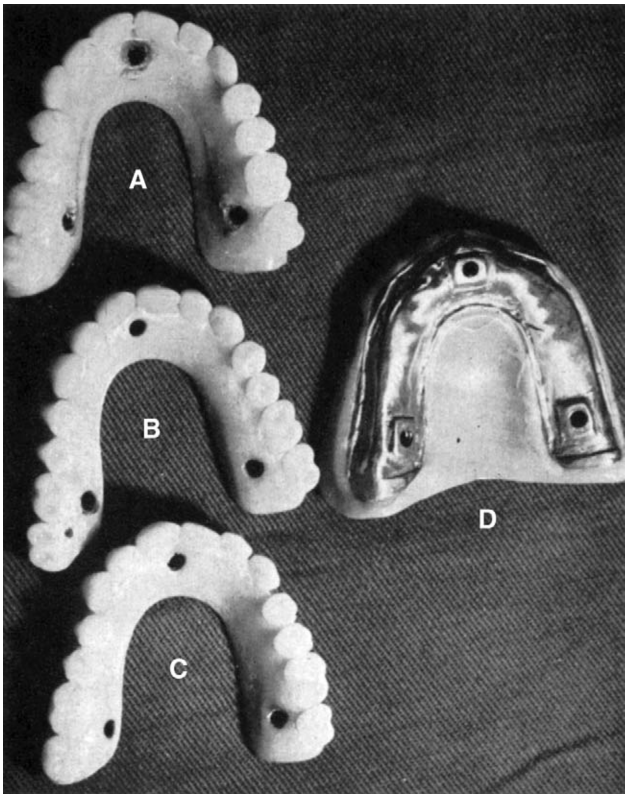

Fig. 3. A, Insert with DeVan teeth. **B,** Insert with Hall teeth. **C,** Insert with 20 degree teeth. **D,** The completed upper test base.

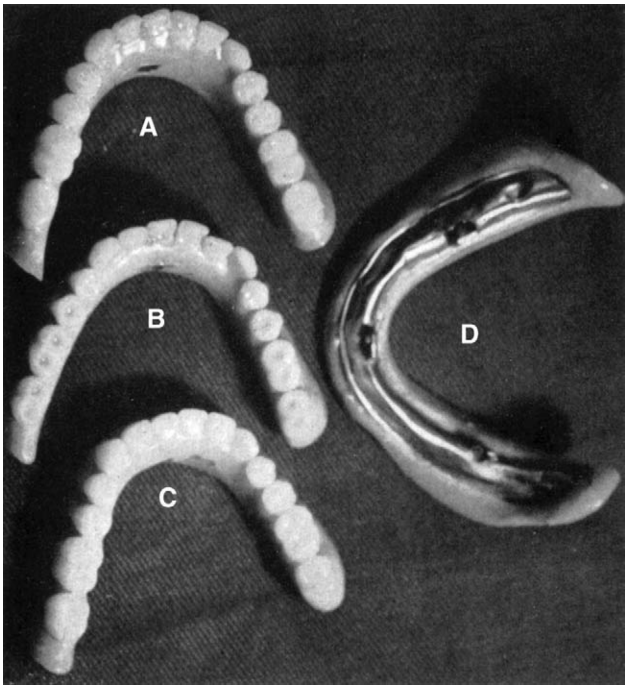

Fig. 4. A, Insert with DeVan teeth. **B,** Insert with Hall teeth. **C,** Insert with 20 degree teeth. **D,** The completed lower test base.

A tentative setup of teeth was made, and a recheck was made of vertical dimension and centric relation. Protrusive records were secured. Lateral condylar inclinations were set on the articulator in accordance with the Hanau formula.

In this first series of experiments, it was decided to test three different types of posterior teeth. They were (1) 20 degree, (2) Hall, and (3) DeVan posterior teeth. Further, it was decided to set up the 20 degree and Hall posterior teeth in accordance with the laws of articulation in order to secure bilateral balance within the limits of the articulator used. The buccolingual and the up-and-down position of the teeth was duplicated as carefully as possible. Mold 29M 20 degree posterior teeth and Mold 30SN Hall posterior teeth were used.

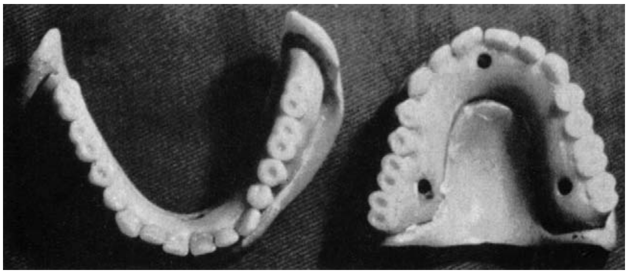

Fig. 5. The inserts with the Hall teeth in position on the bases, but without the Allen screws.

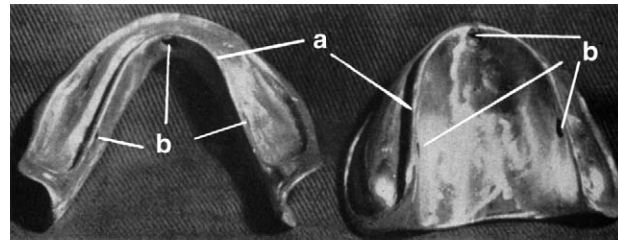

Fig. 6. Cast aluminum test bases. **a,** The raised flange. **b,** The holes drilled and tapped to receive Allen screws.

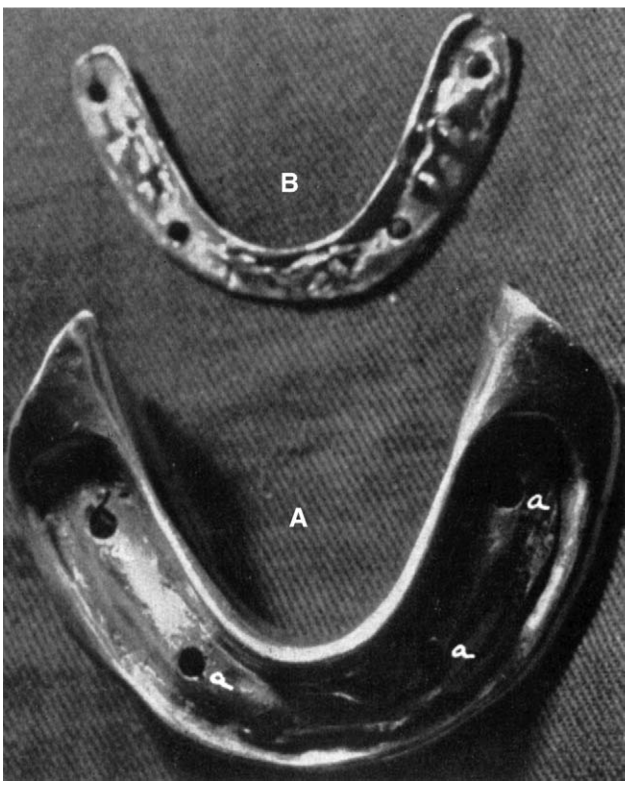

Fig. 7. **A,** Cast aluminum base with holes (**A**) for Allen screws which attach the insert to the base. **B,** Gold reinforcement for a plastic insert.

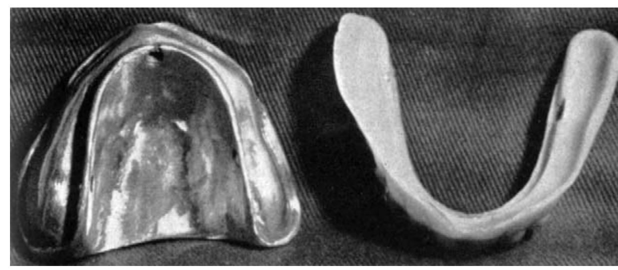

Fig. 8. The upper aluminum base and the base surface of one of the acrylic inserts which carry the teeth. Note that the gold reinforcement casting is embedded within the acrylic insert.

Fig. 9. The lower aluminum base and the base surface of an acrylic insert.

DeVan posterior teeth were set up on a flat plane and, of course, lacked bilateral balance on the articulator. The only mold available was used. It is slightly larger than either the 20 degree or Hall posterior teeth.

Each separate setup was cured and processed, removed from the gold bases, and the next setup made and cured. After the three setups were cured and processed, the peripheral borders of the maxillary and mandibular bases and palatal portion of the maxillary base were cured. The casts were returned to the articulator and reseated in their original mounting by means of the split remounting plates. Each set of the teeth was then placed in position on the gold bases, seated on the casts, and curing changes corrected by means of selective spot-grinding. Cusp angulation was reduced on both the 20 degree and Hall posterior teeth to harmonize with a flat incisal guide angle. With the DeVan posterior teeth, lingual to insure no interference during the set up of the teeh. The bases were corrected, and the anterior teeth were checked to be sure that there was no interference in either centric or eccentric positions (Figs. 3-5).

Method 2

Duplicate refractory casts were made of the casts which had been recovered from the final impressions. A wax of sufficient thickness to permit casting in

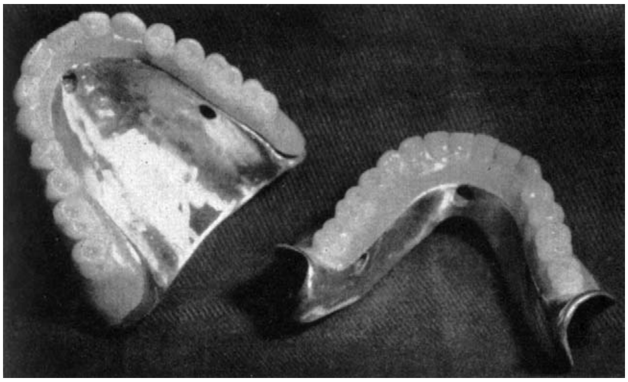

Fig. 10. The inserts with Hall Posterior teeth in position on the aluminum bases, but without the Allen screws.

aluminum was made (Fig. 6). A raised flange (Fig. 6, *A*) was made on the lingual of both the maxillary and mandibular bases, and placed far enough to the lingual to insure no interference during the set up of the teeth. The bases were then cast in aluminum. A rigid gold casting was made similar to the one previously described in Method 1. Holes were drilled and tapped in the flange and rigid gold bar to receive Allen screws (Fig. 6, *B*). A slight variation of this procedure is shown in Fig. 7, *A*. The holes are drilled and tapped through the bases (*A* in Fig. 7, *A*). Fig. 7, *B* shows the gold casting used to prevent change of the acrylic insert which will carry the teeth. After the aluminum bases and gold reinforcement bars are made, the procedure was essentially the same as that previously described (Figs. 8-11). The gold reinforcement castings are embedded in the acrylic inserts which carried the teeth.

The question arises whether to use experienced or inexperienced denture-wearing patients with whom to conduct the experiments. Both types of patients would present advantages and disadvantages. The inexperienced patient would be free of preconceived notions regarding the wearing of dentures and might, therefore, be able to approach the test with an unbiased opinion. Lack of experience would, however, be detrimental in that the patient would have to be permitted a varying length of time in order to learn the fundamentals of denture control with lips, cheeks and tongue, and to adjust the mental outlook toward the wearing of dentures. By this time, the patient could no longer be classified as inexperienced. It was therefore decided to conduct this first series of experiments on patients who had been wearing dentures for some years. Selection of patients was made on the basis of intelligence, dependability to follow instructions, and available inter-ridge space. All of the patients used in these experiments live at the Veterans Hospital at Bay Pines, Fla. Because the patients lived at the hospital, they were available at all times.

Forty-eight hour cycles for the wearing of each occlusal tooth pattern were established in order that the patient could better remember the experiences encountered in that length of time. To have increased the number of posterior patterns tested or increased the number of days between changes might have extended the testing beyond the memory range of the patient. The procedure was repeated twice before chewing tests were made.

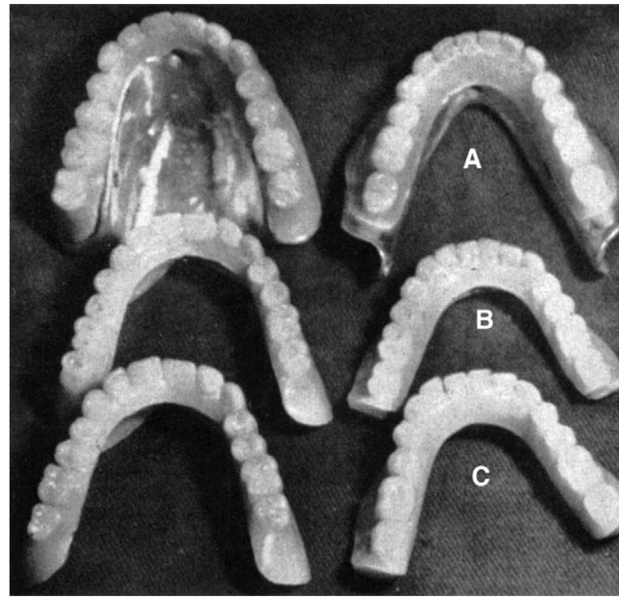

Fig. 11. The test bases with the three sets of acrylic inserts. **A,** With DeVan posterior teeth. **B,** Inserts with Hall posterior teeth. **C,** Inserts with 20 degree posterior teeth.

CHEWING TESTS

The chewing tests were made with fresh raw carrots and roasted peanuts. Carrots were selected because this vegetable does not readily disintegrate into extremely fine particles during mastication. The carrot does, however, absorb moisture (saliva) during mastication so that comparison of weights before and at the end of the chewing test have no correlation. The difference in weight would not represent the amount of material passing through a test sieve. The weight after mastication would also include the amount of moisture absorbed during mastication. The amount of moisture absorbed would vary depending upon the degree of the patient's salivation, length of time the bolus would remain in the mouth, and the degree of maceration that the particular patient would produce with any given set of teeth being tested. Because of the factor of coherence, the carrot makes an excellent food for observing particle size and was used for this purpose alone.

The roasted peanut, on the other hand, becomes easily macerated during mastication and as a consequence much of the material passes through a test sieve. The weight of the material passing through a sieve can be

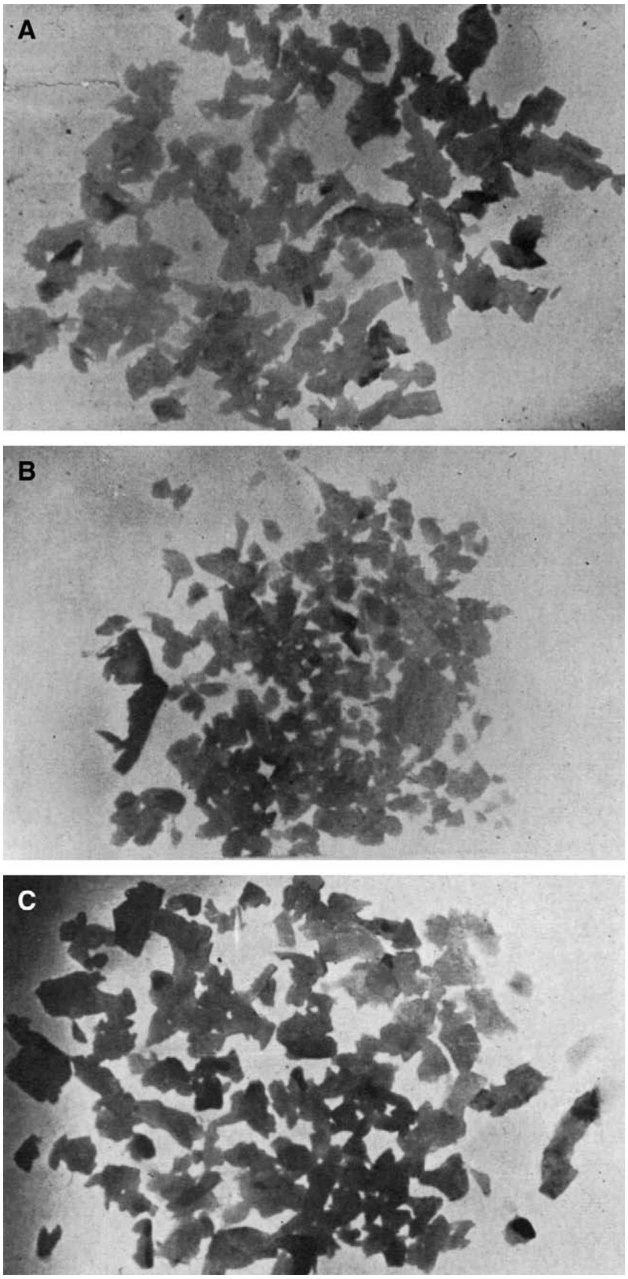

Fig. 12. The particle sizes of carrots in Case I M after twenty-five masticatory strokes. **A,** with DeVan posterior teeth; **B,** with Hall posterior teeth, and **C,** with 20 degree posterior teeth.

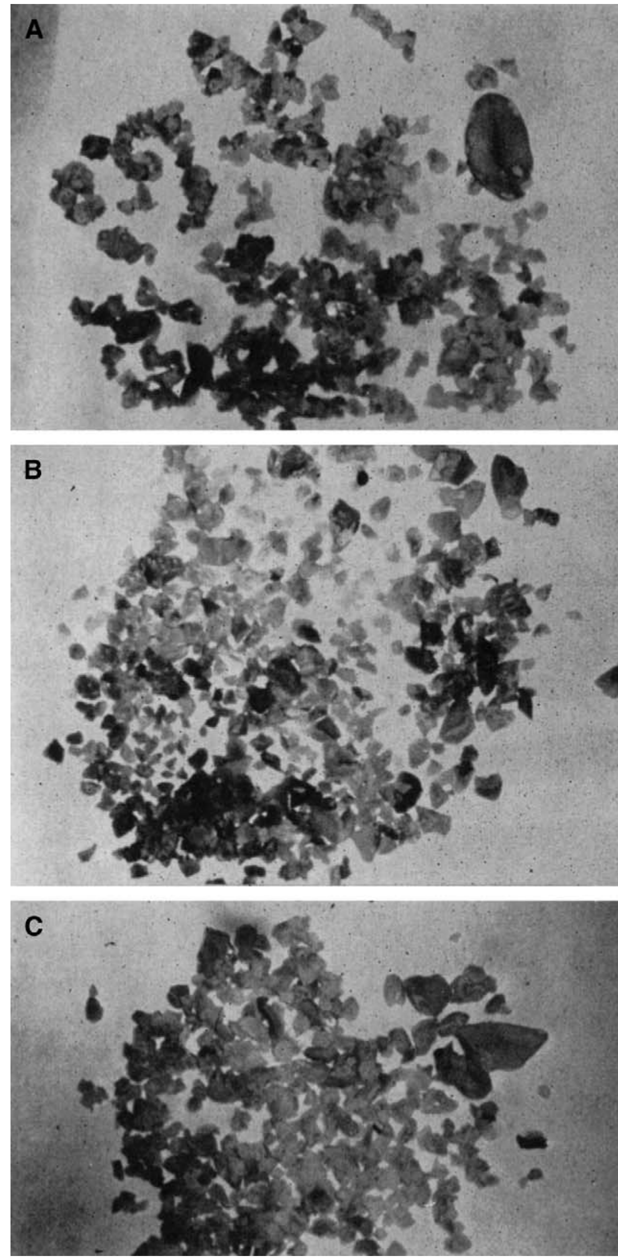

Fig. 13. The particle sizes of peanuts remaining in the 100-mesh screen in Case I M after twenty-five masticatory strokes. **A,** With DeVan posterior teeth; **B,** with Hall posterior teeth, and **C,** with 20 degree posterior teeth.

quite accurately determined, in the case of the peanut, because the particles remaining in the test sieve can be dried and the moisture absorbed during mastication can be eliminated. Peanuts also offer a fine opportunity for observation of particle size.

A 100-mesh screen was used for a sieve to study remaining particle size and weight changes in the test material after mastication in the tests.

The number of masticatory strokes the patient was permitted was first determined by allowing the patient to make a test chew. The number of strokes which the patient made, up to the time that deglutition started, was counted. In the cases cited, the patients were ready to swallow the bolus at thirty plus strokes. The testing was therefore limited to twenty-five masticatory strokes.

The carrots were cut into approximate 3/8 inch squares. No attempt was made to dictate to the patients the number of squares they were to attempt to chew at one time. Patients have their own idea of the size of food bulk which they feel they can handle during

Table I. Case I M

Tooth type	Wgt. peanuts chewed (Gm.)	Wgt. peanuts recovered (Gm.)	Wgt. peanuts passing through 100-mesh screen (Gm.)	% Passing through screen
DeVan	5.2	2.4	2.8	53.7
Hall	5.2	3.1	2.1	40.0
20 degree	5.2	1.4	3.8	72.5

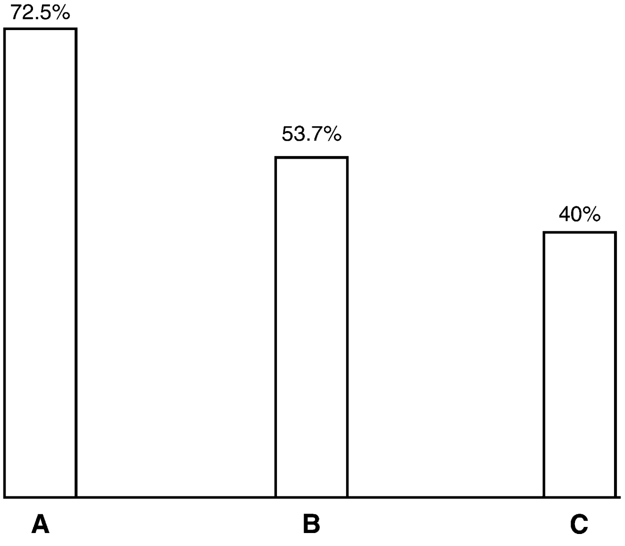

Fig. 14. Case I M. Per cent of bolus passing through 100-mesh screen. **A,** 20 degree posterior teeth; **B,** DeVan posterior teeth, and **C,** Hall posterior teeth.

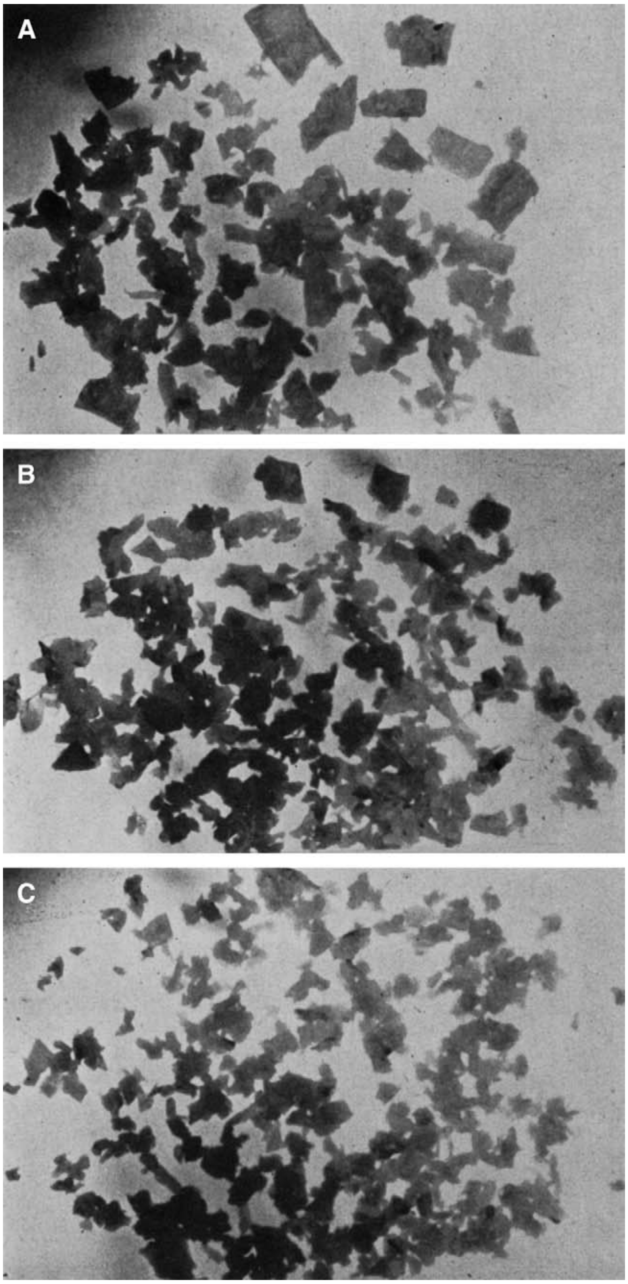

Fig. 15. Case II A. The particle sizes of carrots after twenty-five masticatory strokes. **A,** With DeVan posterior teeth, **B,** with Hall posterior teeth, and **C,** with 20 degree posterior teeth.

mastication and to interfere with this free selection *could* influence their chewing stroke. One patient did make a false start, that is, he took in a greater amount than he could handle. That bolus of food was discarded and a new start made.

It was suggested to the patients that they chew in any manner which was most comfortable to them, that is, on the right or left side, or both right and left sides at the same time. It was noted that all chewing was done on either the right or left side with little or no change from one side to the other. In other words, if chewing was started on the left side, it was completed on that side. None chewed on both sides *at the same time.*

Case I M

Results of chewing tests with carrots. About 5.2 grams of carrots were diced into approximately ⅜ inch squares. Twenty-five masticatory strokes were permitted for each mouthful. The particle size resulting from the use of the DeVan and 20 degree posterior teeth seemed to be relatively uniform and equal in size. The particle size resulting from the use of Hall posterior teeth seemed to be more finely ground (Fig. 12).

Table II. Case II A

Tooth type	Wgt. peanuts chewed (Gm.)	Wgt. peanuts recovered (Gm.)	Wgt. peanuts passing through 100-mesh screen (Gm.)	% Passing through screen
DeVan	5.2	3.66	1.54	29.4
Hall	5.2	3.5	1.7	36.2
20 degree	5.2	1.98	3.22	61.8

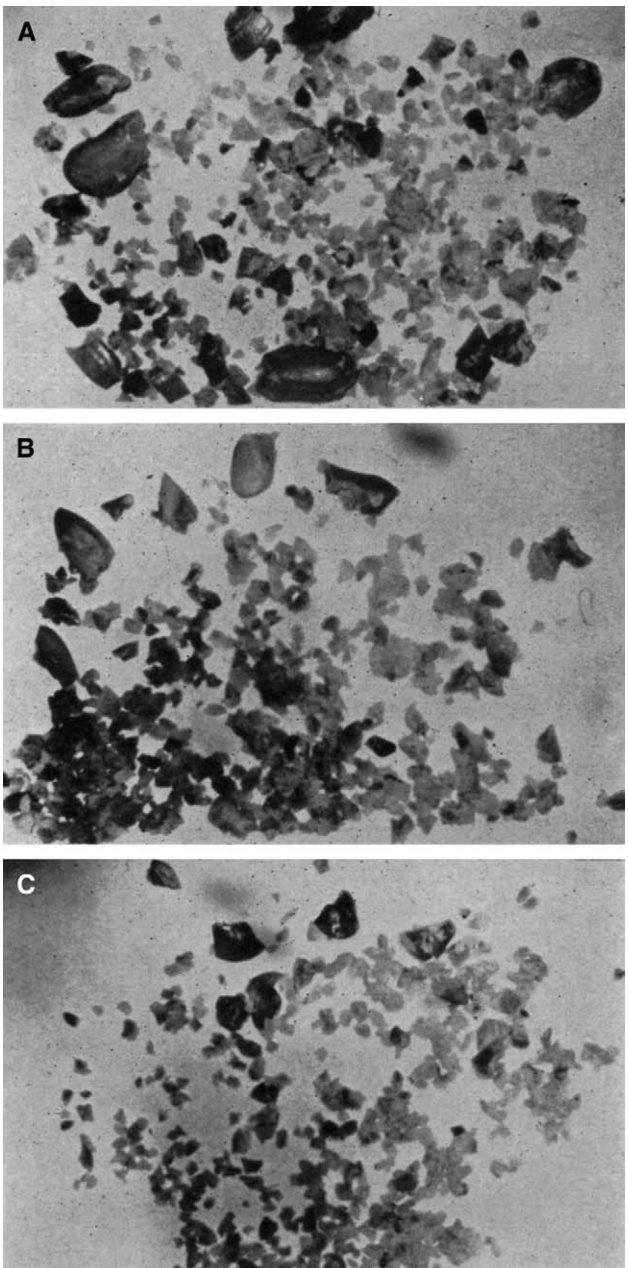

Fig. 16. Case II A. The particle sizes of peanuts remaining in the 100-mesh screen after twenty-five masticatory strokes. **A,** with DeVan posterior teeth; **B,** with Hall posterior teeth, and **C,** with 20 degree posterior teeth.

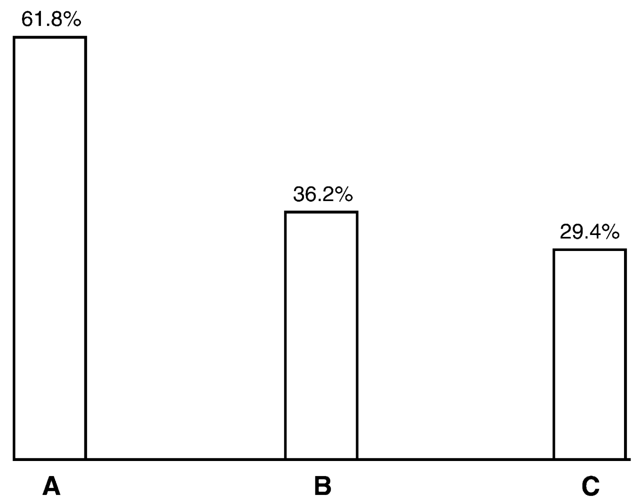

Fig. 17. Case II A. Per cent of bolus passing through 100-mesh screen. **A,** 20 degree posterior teeth; **B,** Hall posterior teeth, and **C,** DeVan posterior teeth.

Results of chewing tests with peanuts. Approximately 5.2 grams of shelled roasted peanuts were used to conduct these tests. As with the carrot, the patient was allowed twenty-five masticatory strokes for each mouthful.

As with the carrot, the particle size resulting from the use of the DeVan and 20 degree posterior teeth seemed to be relatively uniform and equal. Here again, the particle size resulting from the use of the Hall posterior teeth seemed to be more uniformly and finely ground (Fig. 13).

The masticated bolus of peanuts was weighed after screening with the results shown in Table I.

On the basis of the weight of the peanuts passing through the 100-mesh screen, the 20 degree posterior teeth were 18.8 per cent more efficient than the DeVan posterior teeth and 32.5 per cent more efficient than the Hall posterior teeth (Fig. 14).

Case II A

Results of chewing tests with carrots. About 5.2 grams were diced into approximately 3/8 inch squares. Twenty-five masticatory strokes were permitted for each mouthful. The particle size resulting from the use of the DeVan and Hall posterior teeth is about the same, while the particle size resulting from the use of the 20 degree posterior teeth is more uniformly and finely ground (Fig. 15).

Results of chewing tests with peanuts. Approximately 5.2 grams of shelled roasted peanuts were used to conduct these tests. As with the carrot the patient was allowed twenty-five masticatory strokes for each mouthful. (Fig. 16).

The masticated bolus of peanuts was weighed after screening with the results shown in Table II.

On the basis of weight checks the 20 degree posterior teeth were 32.4 per cent more efficient than the DeVan posterior teeth and 25.6 per cent more efficient than the Hall posterior teeth (Fig. 17).

It should be noted that the relative particle size which resulted in the chewing tests made on both patients remained rather constant for each patient. In Case I M the particle size for both carrots and peanuts was about the same when using the DeVan and 20 degree posterior teeth and somewhat more finely ground when using the Hall posterior teeth. In Case II A the particle size was about the same for carrots and peanuts when using the DeVan and Hall posterior teeth, and somewhat more uniformly and finely ground when using the 20 degree posterior teeth. In other words, the particle size remained relatively uniform for each type of food and type tooth used to masticate the food.

TISSUE REACTION AND PATIENT COMMENT

Case I M

During the first cycle ulceration of the lingual frenum occurred while wearing the DeVan posterior teeth.

The ulceration became greatly increased while wearing the Hall posterior teeth. Relief of the denture in this area seemed advisable. This was the only denture adjustment made. The patient was instructed not to wear the denture for twenty-four hours. At the end of this time the 20 degree posterior teeth were inserted. Progressive healing of the ulcerated area occurred.

During the second cycle when the DeVan posterior teeth were reinserted, there was a recurrence of the lingual frenum ulceration together with irritation on the right side along the mylohyoid ridge.

When the Hall posterior teeth were inserted, ulceration of the lingual frenum increased as did the soreness along the mylohyoid ridge. With the 20 degree posterior teeth in place, only very slight irritation of the lingual frenum persisted and it disappeared in the mylohyoid area.

Patient reaction and comment recorded at the end of each 48-hour period during both cycles was as follows:

During the first cycle with DeVan posterior teeth: Dentures tend to "dislodge" during mastication. "Have sensation of fullness" and "not able to eat."

Hall posterior teeth (first cycle): "Could not eat with the dentures because of soreness, but the sensation of fullness has disappeared."

Twenty-degree posterior teeth (first cycle): "Retention during mastication is improved." "Dentures have good feeling, are comfortable," and the patient is "relaxed."

During the second cycle with DeVan posterior teeth: "Teeth won't cut food." "Can't bite properly." "Can't wear the dentures at night" (Note that in the chewing tests, the particle size was about the same as that when using the 20 degree posterior teeth.)

Hall posterior teeth (second cycle): "Can't eat with them, but they are better than the last set" (DeVan posterior teeth). "Can wear dentures at night." (Note that in chewing tests particle size was more uniform and finely ground than with either DeVan or 20 degree posterior teeth.)

Twenty-degree posterior teeth (second cycle): "Over-all fee of the teeth is better than the others. Most satisfactory of any."

Case II A

While the patient wore the DeVan posterior teeth during the first cycle, ulceration occurred on the right side of the lower ridge lingually and buccally in the first bicuspid area about 2 mm. below the crest of the ridge.

No relief was made for this ulceration. The Hall posterior teeth were substituted, and it was found that the ulceration became much more marked. Without making a denture adjustment, the 20 degree posterior teeth were substituted for the Hall posterior teeth. Marked improvement of the ulcerated area was noted within forty-eight hours. When the cycle of tooth changing was repeated for the patient, the same pattern of ulceration started with the DeVan posterior teeth, became more accentuated with the Hall posterior teeth, and tended to disappear with the 20 degree posterior teeth.

As with Case I M, the patient reaction and comment was recorded at the end of each 48-hour period, during both cycles. Comment was quite generally the same. In regard to the DeVan posterior teeth, the patient stated that his mouth felt "too full of teeth" and that the "teeth rock around." In regard to the Hall posterior teeth he said, "Must chew too hard" and "have to fight them too hard." The 20 degree posterior teeth "were stable and can chew with them."

SUMMARY AND CONCLUSIONS

The main objective of this experiment was to determine the possibility of testing occlusal tooth pattens and occlusions by using a common base for all occlusal changes. The advisability and accuracy of this procedure has been demonstrated. Further studies by this technique will do much to clarify the possibilities offered by the use of various occlusal patterns, occlusal concepts, and the efficacy of different types of articulations. It is hoped that this study may serve as an incentive to others to carry on similar experiments with controlled bases.

In Case I M, the carrots were more finely ground with Hall posterior teeth than with DeVan and 20 degree posterior teeth, which were about the same.

In Case II A, the carrots were more finely ground with the 20 degree posterior teeth than with the DeVan and Hall posterior teeth, which were about the same.

In Case I M, the chewing tests with peanuts showed that the 20 degree posterior teeth were 18.8 per cent more efficient than the DeVan posterior teeth and 32.5 per cent more efficient than the Hall posterior teeth. In Case II A, they showed that 20 degree posterior teeth were 32.4 per cent more efficient than the DeVan posterior teeth and 25.6 per cent more efficient than the Hall posterior teeth.

The greatest amount of tissue ulceration was produced by the Hall posterior teeth. Less tissue ulceration was caused by the DeVan posterior teeth, and the least by the 20 degree posterior teeth. Both patients preferred the 20 degree posterior teeth. No conclusion should be drawn from this limited number of chewing tests.

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