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An Evaluation of Occlusal Force Discrimination by Denture Wearers

Fred James Pacer
Loyola University Chicago

AN EVALUATION

OF OCCLUSAL FORCE DISCRIMINATION

BY DENTURE WEARERS

BY

FRED JAMES PACER

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LIFE

Fred James Pacer was born in Chicago, Illinois, on July 25, 1934.

After his graduation from Gage Park High School in 1952, he completed two years of pre-dental studies at Northwestern University, Evanston. He entered Loyola University School of Dentistry, Chicago, in 1954 and received the degree of Doctor of Dental Surgery in June 1958.

Following graduation he joined the Dental School's prosthodontic faculty on a part-time basis for three years. In July 1961 he became a full-time faculty member and was named Assistant Professor of Prosthodontics. From 1961 to 1969 he also served as Director of Continuing Education for the Dental School.

In 1969 he took a leave of absence to begin full time graduate studies in oral biology at Loyola University and to pursue a two-year residency in prosthodontics at the Edward Hines Veterans Administration Hospital in Hines, Illinois.

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CHAPTER I

INTRODUCTION AND STATEMENT OF THE PROBLEM

In recent years several investigators have studied the proprioceptive ability of the natural dentition under various conditions. Very few studies have been undertaken concerning the sensory function of edentulous patients wearing artificial dentures.

Within the last few years the use of the overlay type denture has come into some prominence in the dental literature and in clinical usage.

The purpose of this study is to measure and evaluate the ability of subjects wearing conventional and overlay type dentures to discriminate between varying force stimuli.

CHAPTER II

REVIEW OF THE LITERATURE

1. Measurement of Discriminatory Ability

It was pointed out by Weber in 1850 that subjects did not really perceive the difference between two objects, but rather the ratio of this difference to the magnitude of the objects compared. He called this change in stimulus the "just noticeable difference." This difference was found to be a constant proportion.

Fechner (1854) studied perceptible differences in weights placed on the palm of the hand (from Woolworth and Schlosberg, 1958). From his observations Fechner noted that the subjects adjusted intensity of a stimulus until it appeared twice or half as great as the standard. Combining his findings with those of Weber, he formulated what is known as Weber's Law: The size of the difference of a threshold is a constant proportion of the intensity level at which it is measured. The mathematical expression would be:

$$C = dI/I$$

where I is the stimulus, dI is the change in intensity of the stimulus, and C is the constant. He further stated this as the Psychophysical Law:

$$S = A \log I + K$$

where S is the intensity of the stimulus perceived, I is the intensity of the stimulus, and A and K are constants.

Stevens (1957) criticized the Fechner Psychophysical Law. He showed that the apparent subjective magnitudes grow as a power function of stimulus intensity. In his experiment he arrived at a range for power function exponents of 0.3 for loudness to 3.5 for electric shock to the finger.

Treisman (1964) pointed out a problem in methods used, stating that a difficulty lies in the fact that an assumption is made that a 1/1 relation exists between the sensation and the response. He concluded, however, that the Weber Law would apply validly only to the middle range of stimulus intensities.

Many investigators such as Hecht (1924), Kawamura and Watanabe (1960), Bowman and Nakfoor (1968), Bonaguro, Dusza and Bowman (1969), Soltis (1968), and Toso (1969) have worked with Weber Ratios and have found them valid for the middle range of intensities of the stimulus.

2. Proprioceptive Function of the Periodontal Ligament, Gingival Mucosa and Temporomandibular Joint

Peaslee (1857) stated that pressures can be detected and localized by the teeth and stated further that this was a function of the pulp. Black (1887), however, believed that pressure sensation was the function of the periodontal ligament. Then Stewart (1927) applied forces to teeth from which the pulp had been removed and found that there was no alteration in tactile ability.

Sensory nerve endings were described in the periodontal ligament by Noyes (1921), Van der Sprenkel (1936), and later by Kizior, Cuozzo and Bowman (1968). Lewinsky and Stewart (1936) described two types of fibers

in the periodontal ligament and stated that each was responsible for different types of impulses--thick fibers from special end-organs for tactile sensations and fine fibers for pain sensation. Adler (1948) applied a light force of 1.5 grams to both vital and pulpless teeth and the results indicated that the pulpless teeth were just as sensitive.

Sherrington defined proprioceptors as sensory receptors in muscles and tendons which transmit information of muscle conditions to the central nervous system. Matthews (1933) indicated three types of stretch-sensitive receptors. Two are in the muscle spindles: the A1 or flower spray receptors which are for quick opening moves and are fast adapting, and the A2 annulo-spiral receptors for long sustained stretch. The third type are simple receptors found throughout the connective tissue of muscle. These are known as the Golgi tendon organs or B type receptors. They are for quick opening and are fast adapting.

Corbin and Harrison (1940) stated that fibers of the caudal half of the mesencephalic root of the trigeminal nerve mediated deep pressure impulses from the homolateral maxillary teeth, hard palate and masticatory muscles.

Dixon (1963), in his study of oral nerve plexuses, noted a great density of plexus formation from tongue, hard palate and gingiva (particularly from the anterior part of the mouth). His findings supported the view that sensory discrimination depends on a complex pattern of nerve impulses reaching higher centers. The arrangements of nerve fibers beneath the oral epithelium closely resemble those of the cutaneous plexus.

Orban (1953) listed the gingival nerve endings as: Meissner corpuscles, end bulbs, loops or fine fibers.

Gairns and Aitchison (1950) called attention to the fact that the human gingiva was very well innervated and similar in fashion to the innervation of the skin.

In 1956 Gairns described the free nerve endings as being extremely profuse and said they may arise from either myelinated or non-myelinated nerve fibers. The organized endings are either encapsulated or non-encapsulated. He also stated that the so called ultraterminals are fine fibrils found only in moist mucosa.

Kawamura (1964) reported on the reception of touch and pain sensation through the periodontal ligament, stating that the sensory feedback is actually the same for the pulp and periodontal ligament. This would also be true for the receptors of the tongue, lips and oral mucosa as well as the temporomandibular joint receptors. He implied here that one could take over the function for another if one pathway was lost.

3. The Overlay Type Denture

Brill (1955) described the overlay type denture as a "hybrid-prosthesis" because it incorporates qualities of two species--the removable full denture and removable partial denture. He cited some of the characteristics of this type of prosthesis which have been described since 1952 by such men as Rehm, Biaggi, Dolder and Krogh-Poulsen. Brill's enthusiasm centered principally around the advantage of added denture retention due to the retained teeth.

The use of roots of suitable teeth retained as support for a full denture was advocated by Miller (1958). He felt that roots of teeth would be a better medium for support of a denture than the mucoperiosteum. Miller described these retained roots as "biologic stabilizers" for dentures.

Prince (1965) advocated the conservation of the supportive mechanism by the retention of teeth and the subsequent coverage of these teeth with a full denture.

Dolder (1961) reported on many cases where teeth had been retained and used in conjunction with a bar and sleeve type retaining mechanism. He stated that these were worn with great acceptance by many patients for as long as eight years.

Lord and Teel (1969) defined the overdenture as a complete denture fabricated over retained teeth and the residual ridge. Usually the remaining teeth--cuspids or bicuspids-- are reduced in length to within 2 to 3 mm. of the gingiva and covered with cast gold copings. The removable denture is then fabricated over these copings and teeth. Some of the advantages listed in favor of this type of complete denture are: less pressure on the residual ridge, psychological advantage to the patient, and an improved crown to root ratio which favors the health of the periodontal ligament. Preiskel (1968) described the retention and overlaying of these teeth as a kind of "safety valve" rather than for primary retention of the prosthesis.

Morrow, Feldman and Rudd (1969) described tooth-supported dentures as an approach to "preventive prosthodontics." They listed several indications and contraindications to the construction of such dentures.

Morrow, Powell, Jameson, et al. (1969) supported the use of overlay type dentures by utilizing the periodontometer to evaluate two parameters of the retained teeth--pocket depth and tooth mobility. The evidence indicated the periodontium of such retained teeth remained in excellent health.

It has been suggested by Crum, Loiselle and Hayes (unpublished paper) that the retention of these roots under a complete denture effect a "physiologic implant" which preserves some of the proprioceptive function or discriminatory ability usually lost to the denture wearer.

4. Investigations Related to This Study

Sensory thresholds of persons with natural and artificial teeth were studied by Manley, Pfaffman, Lathrop and Keyser in 1952. Using boilable lucite rods of different thickness they measured the tactile sensibility of natural dentition versus artificial. They reported that denture wearers showed slightly impaired sensory acuteness and also that the ability of denture patients to distinguish between different grades of hardness was not affected by the application of topical anesthetic to the tissue underlying the denture.

An often quoted study by Kawamura and Watanabe (1960) attempted to examine the sensory functions of persons with natural and artificial

dentitions. Their experiment studied the physiologic function of the teeth to judge size of material. The least perceptible difference in thickness of two wires was tested first in persons with natural dentition; then thresholds for the discrimination of thickness of two wires were compared among denture wearers. Three persons with normal dentition and three with artificial dentition were selected. Each person was asked to indicate the least perceptible difference in thickness of wires ranging in size between 0.5 mm. and 5 mm. Weber Ratios were established for natural dentition, but the investigators reported that Weber Ratios did not apply to the artificial dentition--leading to the conclusion that the periodontal ligament in both upper and lower teeth is important to achieve the right judgment of size of materials.

Langer and Michman (1968) investigated the ability of denture wearers to discriminate differences in hardness of rubber sticks. They came to no conclusions as to absolute values, but found that experienced denture wearers could better perceive and distinguish these differences than could inexperienced denture wearers.

Vinton and Manly (1955) studied the masticatory efficiency of denture wearers during the adjustment period. They found that denture wearers swallowed foods independently of the number of chews when the food reached a certain degree of pulverization. Thirty-eight patients were followed and found to exhibit no marked change in efficiency, measured by strokes. The conclusion was that adjustment to a denture is subjective rather than functional.

Ringel, Burk and Scott (1970) reported on their work with stereognosis or the ability to recognize forms with oral sense of touch. This ability to differentiate was significantly less for people with articulatory problems than for the normal speaking persons studied.

Kapur and Collister (1970) refuted the concept that periodontal receptors play a primary role in the salivary reflex. They studied two matched age groups of natural versus artificial dentitions, finding that denture wearers have about the same amount of saliva under every condition. They also proposed the question: Is the loss of textural judgment due to the absence of the periodontal receptors or because the denture does not transmit and confine pressure in the same manner as natural teeth? The suggestion was made that low sensitivity in judging texture may be responsible for certain food preferences, as well as lack of chewing efficiency and gratification from eating--factors frequently associated with dentures.

Brill, Schubeler and Tryde (1962) used thin silver strips of various thickness to study certain aspects of occlusal sensation. They reported that dentulous patients could determine differences as small as 0.02 mm. and denture wearers, differences of 0.06 mm. They concluded that exteroceptors of the oral mucosa take over the sensory functions of the teeth and periodontium.

Bowman and Nakfoor (1968), working with direct application of force upon natural dentition, confirmed the fact that the "just noticeable difference" is nearly constant only in the middle range of stimulus

activity. They found Weber Ratios of 10-15 percent of the standard for a range of 50 to 500 gram forces. Weber Ratios were found to be 0.10 to 0.15 for a 70 percent discrimination of forces. They also showed that the power function equation:

$$dS = kI^{x}$$

best expressed the formula. Their study also showed that there was no greater directional sensitivity along the long axis of a tooth than at 90° to the long axis. The proprioceptors in humans, therefore, differ from reports on proprioceptors of other animals.

Soltis (1968) evaluated the proprioceptive discrimination of the human periodontal ligament over a long period of time. The study was conducted before and after orthodontic treatment. It was found that the ability to discriminate well returned to normal as the effects of the orthodontic appliance diminished. This work also confirmed the validity of the Weber Ratios and the Psychophysical Law for the middle range of standard force values.

Dusza (1968) also used a torque wrench assembly to study the effects of orthodontic forces on the discriminatory ability of natural teeth. He found that four days after placement of the orthodontic appliance, the ability to discriminate between similar forces improved. The range used was 200 to 500 grams and the Weber Ratios ranged between 0.06 and 0.15 of the standard force values for a 70 percent discrimination. Dusza found that the differential threshold was best expressed by the Stevens formula.

CHAPTER III

METHODS AND MATERIALS

1. Introduction

The subjects (aged 29 to 81 years) used in this study were selected from patients presenting for treatment at the Dental Clinic of Loyola University School of Dentistry, Maywood, Illinois, and the Dental Clinic of Edward Hines Veterans Administration Hospital, Hines, Illinois.

Each patient was either completely or partially edentulous and in need of a denture prosthesis to restore masticatory function. Of the fourteen patients used in this study, eight had been treated with a conventional type mandibular denture. That is to say, the maxillary and mandibular ridges had been completely edentulated, a period of healing had taken place, and the well-healed ridges were fitted with dentures. These dentures were constructed according to the generally accepted methods and technics used in the prosthodontic departments of both institutions. The completed dentures were worn by the patients and an adjustment period had elapsed in which time any sore spots on the underlying denture bearing tissue had been eliminated.

Each subject had become accustomed to the dentures and stated that he or she was satisfied with them. The dentures and underlying tissues were separately evaluated by this investigator and found to be "average" and satisfactory, with no evidence of tissue irritation or pathology.

The second group used in this study consisted of six patients chosen from the same two sources--Loyola and Hines. In these patients, however, the mandibular arches had not been totally edentulated. Instead, at least two teeth had been retained and endodontic root canal therapy had been completed. The crown portions of the teeth were reduced and a denture was constructed around these remaining tooth stumps. In these cases the denture received some support and retention from these retained teeth with their intact periodontium. At the time of study, each of these patients stated that he or she was satisfied and functioning well with the dentures. The denture bearing tissue was found to be "normal" in each case, as evaluated by this investigator.

2. Apparatus

The instruments used in this study consisted of a series of torque wrenches, an adjustable arm assembly attached to a base, and a dental chair.

The torque wrenches were designed for a study by Kizior, Cuozzo and Bowman (1968) and were manufactured in 1966 by the P. A. Sturtevant Company of Elmhurst, Illinois.

A torque wrench has been defined as a device used to measure resistance to a turning force (Figure 1). The components are:

a) Drive square

b) A flexible beam

c) Handle

d) Scale

e) Force indicator

FIGURE I

TORQUE WRENCHES

Flexing the beam by application of force on the handle produces torque at the drive square end. The magnitude of torque can be computed by the mathematical expression T = F x D, the Torque Law. T expresses torque, F designates force, and D is the distance through which force is applied, or the beam length.

The Torque Law, fundamentally the Law of the Lever, governs the use of a torque wrench. The Law states that the moment or torque about a point equals the force multiplied by the distance. The lever length refers to the distance from the point on the handle where the pulling or pushing force is concentrated to the center of the drive square. This is always measured 90° to the direction of the force.

A torque wrench must always function upon another object to measure torque, which is resistance to turning. A specific task can be accomplished by modifying torque wrench engaging devices.

Variability in the angle at which force could be applied to the denture was achieved by adapting a bearing and drive shaft assembly to the torque wrench. This modification allowed nearly frictionless movement and the ability to rotate 360°. This rotating drive shaft was coupled to a twelve inch lever arm with a plastic point designed to apply the force to the denture. The other end of the arm had an adjustable counter balance weight.

To insure that the force application was perpendicular with the torque wrench beam and to standardize the procedure, all forces were applied by using the index finger and thumb of the right hand of the examiner.

The force was applied by pulling the disk or handle which was centered to concentrate all the force at one point. The use of the thumb and index finger to apply the needed force insured that the force would be 90° to the beam. If any additional force was required, as when applying 1000 grams or more, the left hand was used to push the right wrist, thus applying the additional force through the centered handle.

All torque wrench calibrations were certified by the manufacturer with a maximal allowable error that did not exceed two percent of the full scale readings.

Three torque wrenches were used in this experiment. They were calibrated as follows:

a) 0-350 grams calibrated in 10 gram increments

b) 0-1500 grams calibrated in 50 gram increments

c) 0-3000 grams calibrated in 100 gram increments

The above figures were the range of forces which would be delivered to the denture, depending upon deflection, through the twelve inch lever extension from the drive shaft. The direct force readings can be explained by solving the Torque Law, $T = F \times D$, for F which reads $F = T/D$.

The torque force is produced at the drive square and transmitted through the drive shaft and ball bearing assembly. The resulting torque force is called the "compressive" force and was delivered to the denture through a plastic point 1 cm. long and 1.5 mm. in diameter. The force varied indirectly with the length of the lever arm. That is to say, a fifty inch gram torque wrench exhibits 50 grams "compressive" force

one inch from the center of the drive shaft. At twelve inches from the center of the drive shaft, a fifty inch gram torque wrench would exhibit 1/12 "compressive" force or 4.15 grams.

The calibrated scales were engraved to give direct readings of the "compressive" force expressed in grams when the twelve inch lever arm was used. The length of the lever arm remained constant throughout the experiment.

In order to direct the force against the denture from an occlusal direction, a flat metal plate from a Hight Tracing Device* was attached to the denture by means of Sticky Wax** placed at the midline and at each of the second molars (Figure 2).

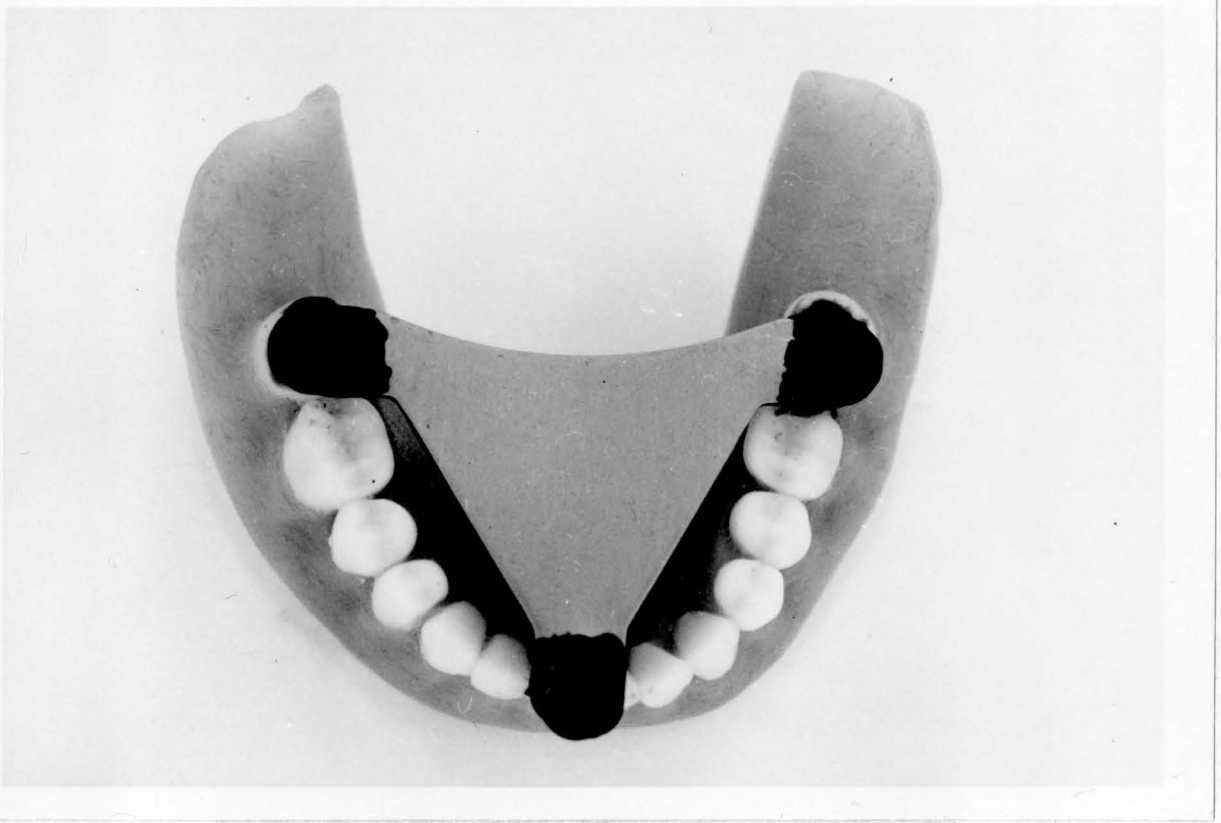
The torque wrench was suspended from an assembly which allowed additional versatility (Figure 3). The iron base measured forty-eight inches by eighteen inches and weighed approximately 300 pounds. Centrally located on the rear of this base was an adjustable iron pipe which projected upward 90° to the base and measured forty-eight inches. A conventional dental headrest was attached to a post and was used to support the head.

An extension arm, forty-eight inches high, paralleled the fixed post. Two right-angled arms braced the extension arm to the fixed post. One arm was an iron extension and the second was welded. Both were adjustable in a horizontal direction. The bottom brace was also adjustable in the vertical direction.

* Hanau Engineering Company, Inc., Buffalo, New York.

** Kerr Manufacturing Company, Detroit, Michigan.

FIGURE 2



DENTURE WITH METAL PLATE ATTACHED

FIGURE 3

DENTAL CHAIR AND TORQUE WRENCH ASSEMBLY

A thirty-six inch adjustable vertical arm ran perpendicular to the extension arm. The torque wrench assembly was securely fastened to this vertical arm.

The major horizontal and vertical adjustments were accomplished by a perpendicular adjustable assembly holding these arms. This was a welded couple with set screws to secure the desired position.

The great versatility of the torque wrench assembly and the numerous horizontal and vertical adjustments allowed the apparatus to accommodate any size patient in the most desirable position.

3. Experimental Procedure

The study was conducted in a small isolated room in the Physiology Department of Loyola University School of Dentistry. The room was air conditioned, well lighted, ventilated, and free from surrounding distractions. The examiner was seated on a firm stool to the left of the subject.

The subject was seated in the dental chair and the headrest and back of chair were adjusted to a favorable position. Each was asked if he would be willing to help the examiner find out something about his ability to tell the differences between two forces applied to his denture. He was assured that the procedure would not be painful.

The shoulder of the subject was then used to demonstrate the application of two forces, one obviously greater than the other. He was asked: "Which is greater, this ... or this?" It was explained that two different forces would be applied to his denture and he was to identify

the greater force by signaling with one or two fingers which was the greater. It was suggested that during the experiment he should close his eyes, concentrate on each pair of forces applied, and indicate his choice quickly and without any concern as to being right or wrong or giving incorrect answers. The subject was requested simply to answer to the best of his ability.

Prior to collecting the actual data to be used in the study, a pilot study was conducted on two selected denture patients for the purpose of becoming familiar with the instrument, standardizing the technique, and establishing threshold value ranges for the standard force values. With this information a data sheet was compiled, listing the standard force values versus the variations from 5 to 50 percent.

The standard force values used in the study were 50, 100, 200, 500, 1000 and 2000 grams. The differential threshold was established for each of these force ranges for each subject. This was accomplished by first using a differential of 10 percent of the standard value and then increasing or decreasing these forces as necessary for the individual. The validity of the differential threshold was established by having the subject identify correctly the heavier of two forces at least eight out of ten times.

If the subject could not correctly identify the heavier force 80 percent of the time, it was considered too low and was then increased. If the subject identified the heavier force ten times out of ten, the differential threshold was considered too high.

The forces were administered in random order. The subjects' replies were immediately recorded on the data sheet.

4. Miscellaneous

A definite effort was made to develop a rhythm of nearly uniform duration for the stimulus and recovery time.

All subjects cooperated willingly and showed no signs of apprehension.

The point at which the force was transmitted to the metal plate was balanced to maintain just the slightest contact. The point was directed at the very center of a triangular plate which contacted the dentition at the anterior midline and posterior second molar areas. This insured that the force was placed as closely as possible to the dynamic center of the occlusal table of the denture. This force placement resulted in equal distribution to the entire denture bearing tissue without introducing any tipping or dislodging factors.

CHAPTER IV

FINDINGS

The standard force values used in this experiment were 100, 200, 500, 1000 and 2000 grams. Of the eight conventional type denture patients tested, only two had a threshold within 50 percent of the 50 gram level. Three of the six overlay type denture patients, however, exhibited a threshold at this 50 percent of 50 gram level.

Bowman and Makfoor (1968), Soltis (1968), and Bonaguro, Dusza and Bowman (1969) worked with natural dentition and a similar method of force application. Each found a significant level of discrimination around the 50 gram level.

In their studies the upper limit of the force range was between 2400 and 2600 grams, because at this level each patient experienced discomfort and dislodgment of the denture. This phenomenon was true for both conventional and overlay type denture wearers.

All data were recorded as percentage differentials of the standard force values used, and all figures represent percent values (Tables 1 and 2).

A statistical comparison was made between the discriminatory ability of the conventional and overlay denture wearers. The means and probability are shown in Table 3. The conventional denture wearers showed lower mean threshold values at the 100, 200 and 500 gram force levels.

TABLE 1

DISCRIMINATORY ABILITY OF CONVENTIONAL TYPE DENTURE WEARERS

SUBJECT	STANDARD FORCE VALUES					
	50 grams	100 grams	200 grams	500 grams	1000 grams	2000 grams
1	.50	.10	.10	.10	.10	.30
2	*	.30	.20	.20	.05	.05
3	.50	.20	.20	.05	.05	.10
4	*	.10	.10	.10	.10	.20
5	*	.05	.10	.05	.10	.20
6	*	.30	.30	.10	.10	.05
7	*	.05	.05	.05	.10	.05
8	*	.05	.05	.05	.05	.10
Mean		.14	.14	.09	.08	.13
Standard Deviation		.11	.09	.05	.03	.09

TABLE 2

DISCRIMINATORY ABILITY OF OVERLAY TYPE DENTURE WEARERS

SUBJECT	STANDARD FORCE VALUES					
	50 grams	100 grams	200 grams	500 grams	1000 grams	2000 grams
1	*	.05	.10	.05	.05	.10
2	*	.20	.20	.20	.10	.05
3	*	.50	.40	.20	.30	.20
4	.50	.20	.05	.05	.05	.05
5	.50	.20	.05	.10	.05	.05
6	.05	.05	.10	.20	.05	.05
Mean		.20	.15	.13	.10	.08
Standard Deviation		.16	.13	.08	.10	.06

* Threshold not measurable at this force.

TABLE 3

STATISTICAL COMPARISON BETWEEN DISCRIMINATORY ABILITY OF CONVENTIONAL AND OVERLAY DENTURE WEARERS
(Studentized "t" Test)

Standard Force Value	Mean for Conventional Denture Wearers	Mean for Overlay Denture Wearers	Probability
100 grams	.14	.20	$.05 > P > .01$
200 grams	.14	.15	$P > .50$
500 grams	.09	.13	$P < .01$
1000 grams	.08	.10	$0.50 > P > .10$
2000 grams	.13	.08	$P < .01$

At the 2000 gram force level the mean threshold values for the overlay type denture wearers are less, to a statistically significant degree.

Fechner (1854) expressed the Psychophysical Law as the formula:

$$S = A \log I + K$$

If this relationship is valid, a semi-logarithmic plotting of the mean discernible force against the logarithm of the force should approach a straight line.

Stevens (1957) said the law was best expressed by the power function formula represented by the equation: $ds = KI^X$ or the logarithmic plotting of the mean discernible force versus the logarithmic plotting of force values.

The mean discernible difference for each force used was plotted against the logarithm of the force (Figure 4), and the logarithm of the mean discernible difference was plotted against the logarithm of the force (Figure 5).

The graphs show a close linear relationship between the force values for the overlay denture wearers by the semi-log and log-log plottings. The conventional denture wearers, however, do not follow either the Fechner or the Stevens power formula.

FIGURE 4

SEMI-LOGARITHMIC GRAPH OF MEAN DIFFERENTIAL THRESHOLDS PLOTTED AGAINST THE GRAM FORCE STIMULI

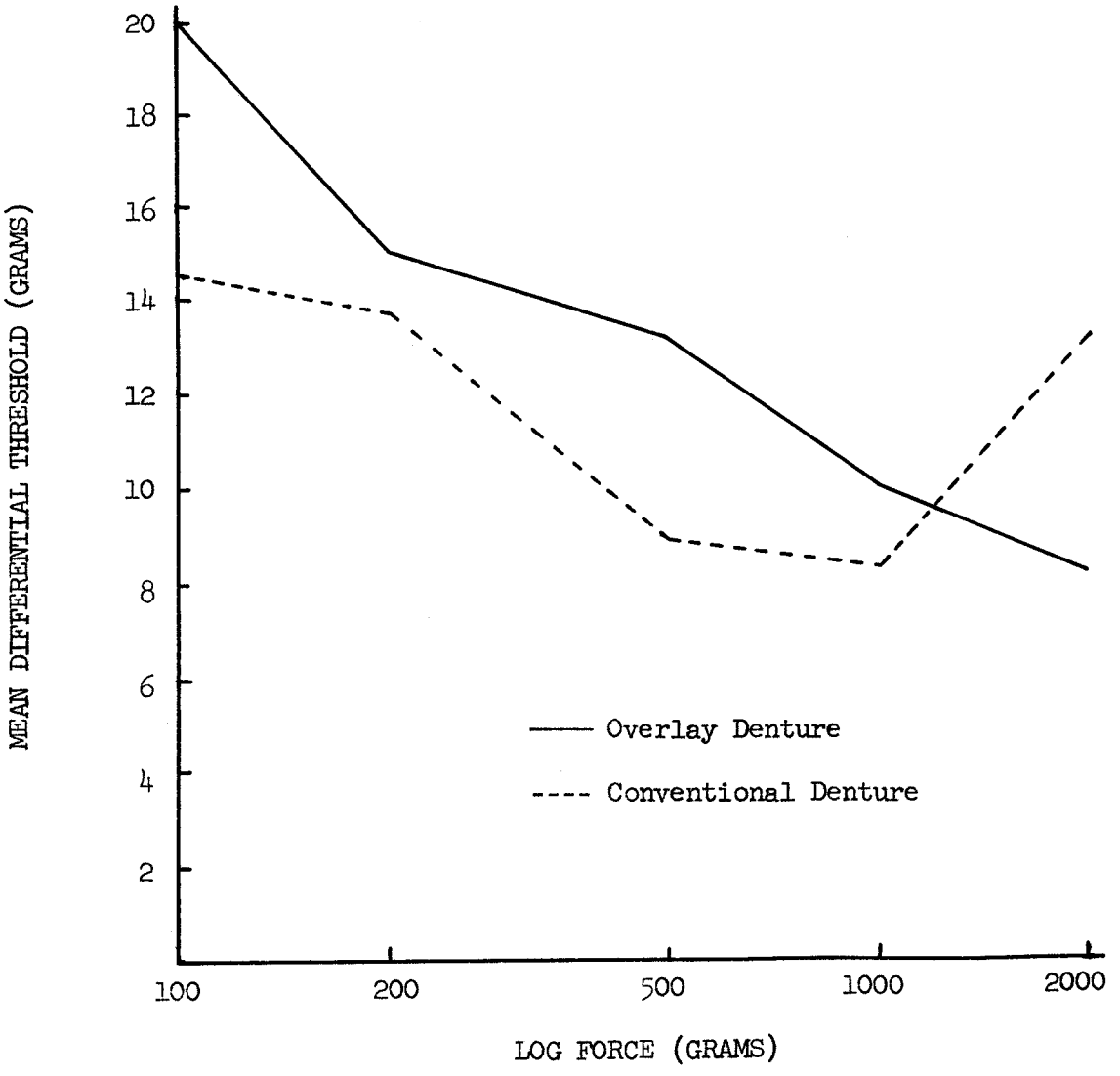
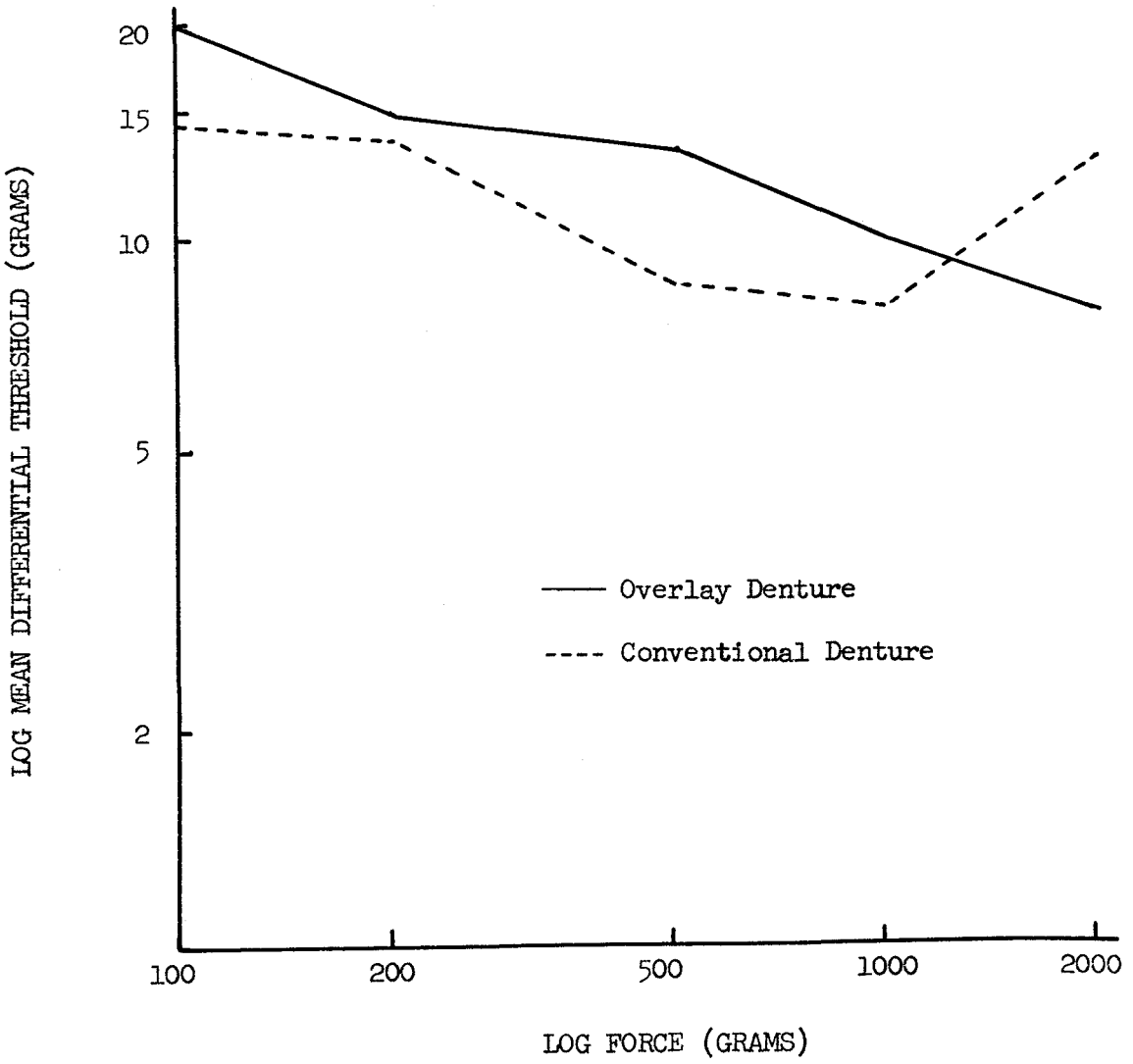


FIGURE 5

LOGARITHMIC-LOGARITHMIC GRAPH OF MEAN DIFFERENTIAL THRESHOLDS PLOTTED AGAINST THE GRAM FORCE STIMULI



CHAPTER V

DISCUSSION

The wearers of conventional and overlay type dentures in this study were found to do nearly as well as persons with natural dentition in regard to discrimination of forces when compared with reports of Bowman and Makfoor (1968), Soltis (1968), and Bonaguro, Dusza and Bowman (1969). The studies on natural teeth represented results of proprioceptive ability tests conducted on single teeth, not the total dentition or even a functioning group of teeth.

In contrast, this study concerned itself with the mandibular full denture. Forces were placed in the center of the occlusal table of the denture and thus distributed by means of the artificial teeth and denture base material to the total denture bearing area of the oral mucosa. This force distribution is similar to the functional force distribution when a denture wearer is masticating a bolus of food.

Threshold values for discrimination were found to be low ($.08 \pm .03$ to $.20 \pm .16$) for the middle range of forces (100 to 2000 grams) for all denture wearers tested. This is in contrast with the report of Kawamura and Watanabe (1960) which stated that the periodontal ligament receptors were necessary to make correct judgments.

In their study, however, Kawamura and Watanabe (1960) tested only three subjects with artificial dentition by the technique of

identification of metal rods of varying thickness. Only one of these subjects had full maxillary and mandibular dentures; one had a full maxillary denture opposing natural mandibular dentition; and the third had a fixed prosthesis on the maxillary opposing natural mandibular dentition. On the basis of these patients it is difficult to arrive at any general statements regarding denture wearers because two of the three subjects had natural mandibular dentition with all of the influence of the periodontal ligament receptors of the natural teeth.

Manley, Pfaffman, Lathrop and Keyser (1952) used boilable lucite rods of varying thickness to test the tactile sensibility of persons with natural dentition and denture wearers. Similar judgments were reported by the two groups, but with some impaired sensory acuteness in the denture wearers. In such a study voluntary biting on rods limits the amount of force the denture wearer will apply, because of the tendency of this type of force application to dislodge the denture. The wearer would have learned to guard habitually against a force of the magnitude necessary to cause this dislodgment.

of the eight conventional denture wearers tested in this study, only two had a discriminatory threshold within 50 percent of the 50 gram level, while three of the six overlay type denture wearers exhibited a threshold lower than 50 percent at this level. This would indicate that at the lower force level, denture wearers do not discriminate force difference as well as reported for natural dentitions. The slightly better response of the overlay type denture wearer, however, suggests

that this type of denture more closely approaches the response of persons with natural dentition.

Conventional denture wearers demonstrated lower discriminatory thresholds at the 100, 200 and 500 gram force levels, but at the higher force level--2000 grams--there was a significant difference in the threshold values between those persons having conventional and overlay type dentures, the overlay denture wearer exhibiting lower threshold values. The lower thresholds indicate that the overlay denture wearer is better able to discriminate occlusal forces at this level. At the higher force level the denture base is more firmly in contact with the denture bearing tissue, thus approaching maximum response from the mucosal receptors. Due to the resilient effect of the underlying tissue, the portion of the denture base overlaying the retained teeth is probably in light or no contact with these teeth at rest or during light occlusal force application.

With the application of heavier occlusal force, however, the contact of the denture and the retained teeth is made firm, thus enlisting the response of the proprioceptors of the periodontal ligaments of these teeth. The combination of greater sensory response from the tissue receptors under the denture base and the response of the periodontal ligament receptors probably accounts for the improved discriminatory ability of overlay type denture wearers at higher occlusal force values.

The linearity of the graphs (Figures 4 and 5) of the mean differential thresholds of the overlay type denture wearers demonstrates

that this type of denture more closely follows the Fechner and Stevens formulae for the expression of the Psychophysical Law than does the conventional denture. This indicates that the overlay denture more closely approaches the results observed for natural dentition regarding sensory function. The retained teeth and periodontal ligament receptors thus enable the overlay denture to respond more like natural dentition to occlusal forces.

The advantages of denture retention and stability of the overlay type denture have been proposed by such investigators as Brill (1955), Miller (1958) and Dolder (1961). The added advantage of sensory function--improved over the conventional denture and more closely related to natural dentition--would indicate that overlay dentures are more "physiological" and as a result should be more acceptable, functional and generally satisfying to the wearer.

CHAPTER VI

SUMMARY AND CONCLUSIONS

A previously described method of applying force and testing a subject's ability to distinguish between two forces was utilized in this experiment.

Fourteen patients, each wearing full dentures, were randomly selected for this study--eight with conventional lower dentures and six with overlay type lower dentures. Perpendicular forces were applied to the dynamic center of the occlusal table of the mandibular denture in each case, and the forces were thus distributed equally over the entire denture bearing tissue area. Each subject's ability to distinguish differences in force values was observed and recorded. Forces used ranged from 100 to 2000 grams.

All denture wearers tested showed sensory threshold values close to those reported for natural dentition, but the overlay denture wearers exhibited better perception at the lower and higher extremes of the force range.

A graphic plotting showed that the overlay type denture wearer responded more closely to the Psychophysical Law expressed as a power function by Stevens. Since this phenomenon holds true for natural teeth, the overlay type denture more closely resembles natural dentition in sensory function than does the conventional prosthesis.

In addition to recognized advantages of denture retention and

stability, this study shows that the overlay type mandibular denture also provides better sensory function than the conventional denture. The recognition of this advantage should further motivate dentist and patient to consider the retention and utilization of at least two suitable mandibular teeth in an overlay type denture service.

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APPROVAL SHEET

The thesis submitted by Dr. Fred James Pacer has been read and approved by members of the Department of Oral Biology.

The final copies have been examined by the Director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the thesis is now given final approval with reference to content, form, and mechanical accuracy.

The thesis is therefore accepted in partial fulfillment of the requirements for the Degree of Master of Science.

Date

Signature of Advisor