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THE TACTILE SENSIBILITY OF THE PARODONTIUM TO SLIGHT AXIAL LOADINGS OF THE TEETH

by

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The opening, closing and grinding movements of the mandible are fundamental components of the mastication process. They do not require conscious thought but generally occur automatically, guided by reflexes. The power exerted by the elevator muscles of the jaw is regulated by the sensory impulses discharged by the nerve endings of the parodontium. If the supporting tissues of a tooth are threatened by overloading, these impulses result in an inhibition of the elevators. We know that the parodontium is especially sensitive to the slightest tactile stimulus; *Münch & Schriever* (1947) report that pressure of as little as 1.5 g is detectable. Further, it may readily be verified that it is impossible to close the teeth without feeling it. In view of these facts the question naturally arises of how small a body between the biting surfaces of natural human teeth is capable of causing a tactile stimulus in the parodontium?

Only four studies dealing with this question could be found in the literature. In 1931, *Theil* in tests with 150 subjects reached the conclusion that the sensory threshold is between 20 and 100 μ. Thin pieces of platinum wire were used in these tests. Two years later *Hollstein* (1933), applying the same method with slight modifications on 125 subjects, obtained practically the same results. We were unable to find any subsequent studies directly concerning the sensory threshold between that time and the year

1962, when two papers on the subject appeared (*Kraft* and *G. Tryde et al.*). It would seem that the focussing of interest on the reflex actions in mastication has once again made it a subject of independent research in several quarters. As a result of his investigation *Kraft* reported that it is impossible to detect any body less than 20 μ in size between the occlusal surfaces of the teeth. Steel wires and perlon threads were used in the tests, but neither the method of investigation nor the material was described in detail. *Tryde et al.*, on the other hand, placed strips of silver foil between occluding teeth. These researchers reported their results as a 50 per cent sensory threshold in lieu of upper and lower threshold values; the values obtained varied between 10 and 35 μ.

Investigations along lines closely similar to those of the present study were carried out by *Manly et al.* (1952) and by *Kawamura & Watanabe* (1960), who sought to determine the threshold values of the ability of individuals to detect differences in the thickness of bodies situated between the occlusal surfaces of the teeth.

THE AIM OF THE PRESENT STUDY

The purpose of the original research plan was to compare the tactile sensibility of the mucous membrane underneath a denture with that of the parodontium. Since the available data on the sensitivity of the parodontium proved to be relatively scanty and the results of investigations varied, it was decided that, in order to create a basis for comparison, it would first be necessary to seek answers to the following questions; (1) How small a body can be detected between the occlusal surfaces of natural human teeth? (2) Do differences exist between different parts of the dentition with respect to tactile sensibility? (3) Do individual differences exist with respect to tactile sensibility? (4) How does local anaesthesia affect tactile sensibility?

METHODS

Bodies used in tests

In carrying out the tests, very thin metal foils were used. A piece of foil measuring a few square millimetres placed between the teeth has a much greater certainty of meeting the contact

surfaces than a stringlike body. One difficulty in selecting the material was the fact that two mutually incompatible properties were desired: the body ought to be as hard as possible but still capable of conforming to the surface of the contact area. Aluminium foil 8 μ thick and tin foil 10 and 30 μ thick were selected. The thicker tin foil was used in multiple layers as needed. The foil was cut into pieces measuring roughly 3×3 mm for testing in the region of the molars and into strips 3 mm wide for testing in the region of the incisors. The foils were factory-produced. Thicknesses were checked with a micrometer.

Performance of the tests

The subjects were placed in a dental chair in as comfortable an upright sitting position as possible. During the actual tests they were asked to keep their eyes shut in order to be able to concentrate better on the task of detecting the presence of foreign bodies between the teeth. The appropriate contact areas were ascertained with articulating paper for centric occlusion in the molar region and for the edge-to-edge bite in the incisor region. The piece of foil was placed with pincers on the lower contact facet chosen in the molar region after the traces of articulating paper had been removed, and the foil was then pressed against the tooth. Next the subject was asked to bite softly and to give a sign agreed upon in advance with his finger to indicate whether he felt anything between his teeth or not. When the front teeth were involved in the tests, the strip of foil was placed between the incisors while the investigator held on to one end with his fingers. The subject was told in advance only that the purpose was to carry out tests of tactile sensitivity with strips of foil of varying thickness, some of which might be too thin to be detected at all. The subject was asked to indicate immediately if he happened to feel the foil with his tongue or lips so that such results could be discarded. The cheek was lightly deflected from the teeth with a dental mirror during each of the tests in the molar regions.

The three least thicknesses (8, 10 and 30 μ) were each tested in a series of ten trials in random order in such a way that five times out of ten a piece of foil was placed between the teeth and five times the action of placing and pressing the foil was only

simulated. If even the thickest of the pieces was not detected without error in all trials, the test was continued in multiples of 30 μ until a completely certain result was achieved. The investigators took turns in placing the pieces of foil *in situ*. After the series of tests had been carried out without anaesthesia, they were repeated in the molar region following a mandibular block anaesthesia (1.8 ml 2 % Xylocain-Norexadrin). Thereafter the antagonist in the maxilla was anaesthetized by infiltration anaesthesia and the test series repeated.

SUBJECTS

The number of subjects was 36, of whom 34 were dental students (17 female and 17 male) and the remaining two were the investigators themselves (male). Twenty-nine of the subjects were included in the series involving local anaesthesia. The median age of the subjects was 24 years (mean age: 23.8 years). No clinically detectable deviation from a healthy condition could be observed in the parodontium or occlusion of any of the subjects. With two exceptions the teeth between which the pieces of foil were placed had no root filling and were accordingly considered vital. The subjects were deliberately selected because the investigators wished to carry out their study with a sufficiently intelligent group, capable of comprehending the purpose of the tests.

SOURCES OF ERROR

With a view to diminishing the influence of the sources of error involved in the tests, the following measures were taken:

Since the detection of the pieces of foil used in the tests occurs near the threshold of sensibility, other, stronger irritants acting on the same or other senses are apt to have a disturbing effect. Accordingly, the tests were conducted in a peaceful room, with the subjects seated in a comfortable dental chair, with eyes closed and giving their responses simply by lifting a finger.

The experimental situation also includes psychological factors liable to produce errors. Although the honesty of the subjects need not be doubted, it is conceivable that in a situation where his sensory apparatus is put to the test a person might unconsciously strive to extend the range of his senses beyond their native

capacity. Under such circumstances, he is apt to indicate, quite honestly, that he feels something between the teeth — because he believes it, although the body might, in reality, be too tiny to be detected. The experiment was therefore so conducted as to allow an estimation of the reliability of each subject. Without the subject being aware of it, in each series of ten trials no foil was placed between his teeth half the times. In such cases either the subject had to indicate that he could detect nothing or he would betray his unreliability as an observer by indicating a positive perception. The more often a subject claimed to detect something that in reality was not there, the greater was the reason to suspect that he was guessing even when he happened to make a correct indication. The number of errors proved to be small; 19 of the subjects made no errors while the total percentage of error of the rest of the group (17) in the series involving no anaesthesia was under 10 %. Therefore it was considered legitimate to estimate the effect of the errors in the case of each subject by having each error simply cancel out one correct perception. Thus the effect of the errors is concentrated on the detection of the lesser thicknesses, which involved more errors. This procedure undoubtedly takes the effect of an error sufficiently into account, perhaps a trifle too much so; for an examination of the scores of the group making no errors and of the one with errors (Table 1) shows that in those trials where the foil had actually been placed between the teeth there is no significant difference between the groups with respect to the number of failures (Wilcoxon's test). If more errors than correct perceptions occurred, the final result was not recorded as negative, however, but as a zero.

Among possible sources of error, the effect of the sense of hearing should be taken into consideration. The slightest sound from the mouth is easily heard, being conducted by the intervening tissues directly to the inner ear. Any change in the sound of the teeth touching each other is apt to betray the presence of a foreign substance. The aluminium foil sometimes gave off a rustling sound because of its hardness. Efforts were made to prevent this by placing the foil appropriately. In addition, a separate control test was carried out with three persons (two credited with no errors and one who had made many). The entire series of tests was repeated while a loud rustling noise was conducted to the

Table 1

	Unperceived	8 μ		10 μ		30 μ		60 μ		90 μ		120 μ		150 μ		180 μ	
		N	E	N	E	N	E	N	E	N	E	N	E	N	E	N	E
I	0	2	3	6	5	15	9	15	12								
	1	5	1	3	2	—	1	—	—								
	2	—	1	2	1	—	2	—	—								
	3	4	4	—	1	—	—	—	—								
	4	—	1	3	3	—	—	—	—								
	5	4	2	1	—	—	—	—	—								
M	0	2	—	2	2	14	8	16	13								
	1	3	1	4	—	2	3	—	—								
	2	3	5	4	3	—	—	—	—								
	3	1	3	2	4	—	1	—	—								
	4	5	2	1	—	—	1	—	—								
	5	2	2	3	4	—	—	—	—								
MA_1	0	1	—	1	—	8	4	14	11	16	12						
	1	3	2	3	1	4	3	1	2	—	1						
	2	6	2	5	1	2	4	1	—	—	—						
	3	1	3	1	3	1	1	—	—	—	—						
	4	2	3	2	3	—	—	—	—	—	—						
	5	3	3	4	5	1	1	—	—	—	—						
MA_2	0	—	—	—	—	3	1	12	3	14	7	15	9	15	11	16	13
	1	—	—	—	—	3	—	1	2	—	3	—	1	—	1	—	—
	2	2	—	3	3	5	4	—	5	1	—	—	—	—	—	—	—
	3	3	2	1	1	1	4	2	—	—	1	—	2	—	—	—	—
	4	4	3	2	1	2	2	—	2	—	2	—	1	—	—	—	—
	5	7	8	10	8	2	2	1	1	1	—	1	—	1	1	—	—

The distribution of the subjects making errors (=E) and those making none (=N) in the control series, estimated according to the number of times the presence of foil between the teeth remained undetected out of a total of five tests. 0 = foil invariably perceived, 1 = unperceived once, etc. Explanations of symbols I, M, MA_1 and MA_2 are given in Fig. 1. No significant difference between the groups can be observed in the light of Wilcoxon's test.

subjects' ears from an audioanalgesia apparatus. The previous experimental results did not change, however, suggesting that the sense of hearing did not fundamentally aid perception.

The metallic foil was apt to induce an electrical discharge at the instant of contact in the case of subjects with metal fillings at the site of contact. This could be prevented by keeping the dental region tested dry or by selecting a different contact area. In the region of the incisors, of course, no trouble of this kind occurred.

In test series carried out under anaesthesia, an uncertain factor is the depth and extent of the latter. The amount of anaesthetic administered for each anaesthetization was 1.8 ml. The sensation of numbness is as a subjective experience as that of pain. Therefore the subjects' own judgement was considered the main yardstick. They had to feel a strong sensation of numbness. However, certain measures were taken to control the efficacy of the anaesthesia. Controls were carried out with two subjects, the effectiveness of the anaesthetization being checked with a vitalometer. No changes were observed in comparison with the uncontrolled series of the same subjects. The omission of anaesthetizing the maxillary palatinal and mandibular buccal mucosa might be supposed to affect the results, although no innervation is known to occur from these parts to the parodontium. They were actually anaesthetized in three subjects without any effect on the results. In the case of five subjects not only were the opposite halves of the jaws anaesthetized but also the upper jaw on the opposite side, and in one case both jaws on both sides. The results were not affected.

The procedure followed in the tests may therefore be judged to ensure that the possible sources of error will not, at least not materially, distort the results.

RESULTS

After the errors of the empty trials had been deducted, the corrected results were classified as follows: (1) No or one perception out of five possible = deficient perceptiveness, (2) Two or three perceptions out of five possible = uncertain perceptiveness, (3) Four or five perceptions = certain perceptiveness. Figure 1

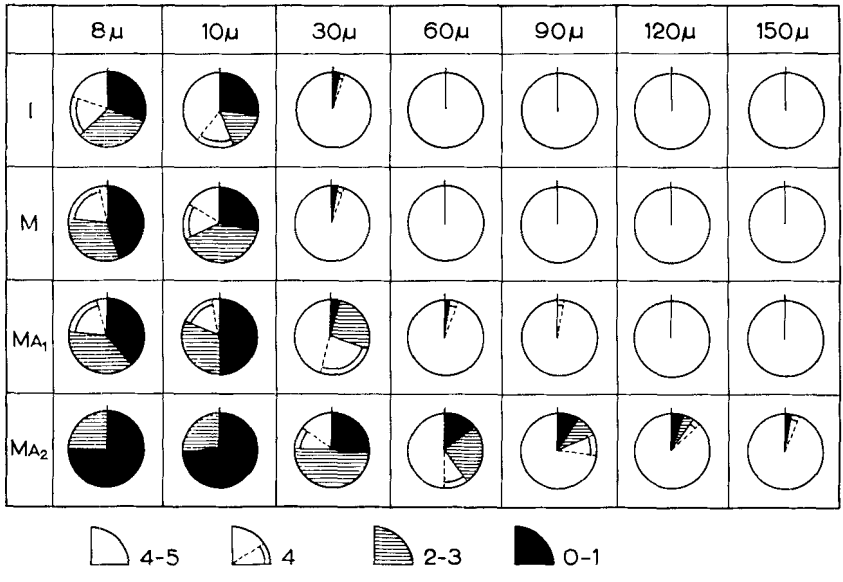

Fig. 1.

Distribution of subjects (36) according to perceptiveness: 0—1 perceptions out of five possible = deficient perceptiveness, 2—3 perceptions = uncertain perceptiveness, 4—5 = sure perceptiveness.

I = foil between incisors
M = „ „ molars
MA_1 = „ „ „ mandibular block anaesthesia
MA_2 = „ „ „ preceding anaesthetization + anaesthetization of upper molar.

shows the results: one-third of all the subjects unmistakably perceived the presence of foil 8 μ thick between the incisors, while almost a quarter of the subjects could also detect it between the molars both when no anaesthetic was used and after anaesthetization of the lower antagonist, and uncertainly even after both antagonists had been anaesthetized. When foil 10 μ thick was used, the number of subjects capable of perceiving its presence was slightly larger when no anaesthetic was administered. All but three of the subjects unmistakably perceived the presence of foil 30 μ thick between the edges of the incisors as well as between the molars when no anaesthetic was administered. After anaesthetization of the lower antagonist, about two-thirds of the group perceived the 30 μ foil unmistakably; and after anaesthetization of both, perception was still retained with one-quarter. More than

three-quarters of the subjects unmistakably perceived the 90 μ foil after anaesthetization of both antagonists; foil 150 μ thick escaped detection by only two subjects, who, however, could detect a thickness of 180 μ.

The women's perceptiveness was not significantly greater than that of the men, although the results do indicate a slight tendency in this direction.

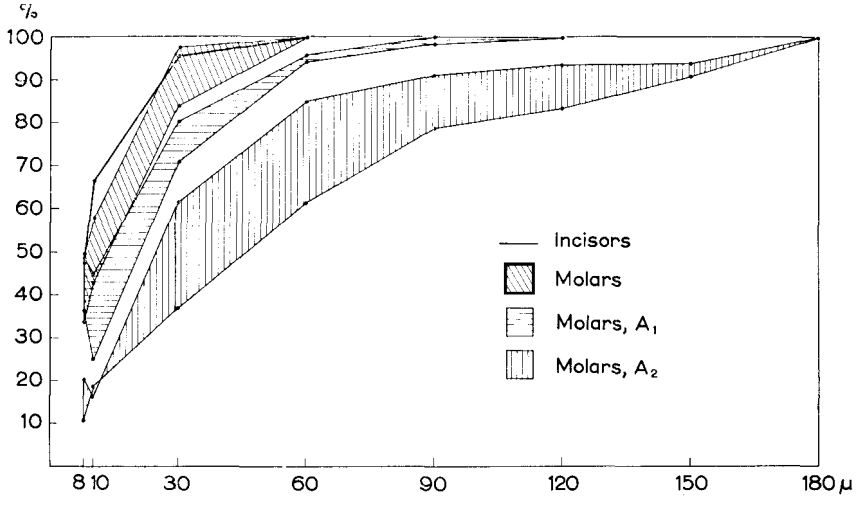

Fig. 2.

Mean perceptive accuracy of unerring (upper line of shaded area) and erring subjects (lower line) represented in percentages of completely correct test series.

The women's perceptiveness was not significantly greater than that of the men, although the results do indicate a slight tendency in this direction.

If the whole group of subjects is divided into two on the basis of the errors made — viz., (1) subjects responding unerringly (19) and (2) subjects making errors (17) — it will be observed (Fig. 2) that the accuracy of the group of subjects making errors, expressed as a mean percentage of the completely correct series of perceptions, is poorer in the light of the sign test than that of the group scoring no errors. The difference increases with the difficulty of the perception tests, and is greatest when both jaws

are anaesthetized. The difference between the groups appears greater than it is in reality, however, for the manner in which the errors were estimated tends to exaggerate them somewhat (Table 1).

In Fig. 3 the total numbers of errors are presented as percentages of the maximum numbers of errors compared with the means of the perceptive capacity of the entire group. At all points,

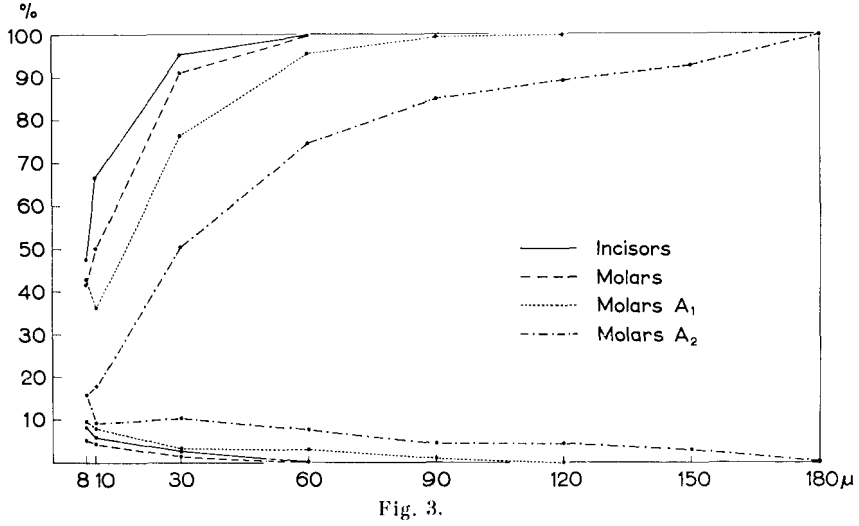

Fig. 3.

Numbers of errors (lower 4 lines) as percentages, as compared with the average perceptiveness of the whole group.

excepting the 8 μ and 10 μ values of two anaesthetizations (A_2), the effect of the errors is so slight that the results are statistically highly significant (χ^2 test).

DISCUSSION AND CONCLUSIONS

(1) It is possible to perceive a hard body 8—10 μ in thickness between the occluding teeth in both the incisor and molar regions. If unmistakable perception is regarded as the criterion, one-quarter of the subjects tested had the capacity for this. If uncertain perceptions are also taken into account, then two-thirds of the total group would qualify. The result does not conform to

previous data (*Kraft*, 1962) according to which it was impossible to detect any body less than 20 μ thick between the teeth. The difference in these results may be due to differences in the form and hardness of the bodies used in the tests. Kraft used stringlike bodies, some of which were of perlon. On the other hand, the present results agree well with those obtained by *Tryde et al.* (1962). The thickness of 8 μ does not represent any absolute threshold value; for lack of suitable material to use in carrying out tests, it has not yet been possible to determine the ultimate threshold.

(2) The sensibility of the incisors was not significantly greater than that of the molars, although a tendency in that direction does exist.

(3) Individual differences in the perceptive accuracy of the tactile sense were noted among the subjects. The minimum thicknesses unmistakably perceived varied between 8 and 60 μ, though 30 μ was exceeded by only three persons. When anaesthetization was used, the individual differences were greater: the minimum thicknesses perceived varied between 30 and 180 μ.

(4) The desensitizing effect of local anaesthesia on tactile sensibility is surprisingly slight. Compared with the minimum thickness of foil unmistakably felt between the teeth, the corresponding thickness perceived under a local anaesthetic was only double expressed as a median value (mean value: 3.7 fold), the lowest value being the same in both cases and the highest 18 times as high. This may be due to the fact that the sensory receptors are not completely desensitized even after the sense of pain has been lost — or else the mechanism involved is a deep-seated sense which transmits tactile sensations, as we might suppose, by a hydraulic process in the intra- and extracellular liquids beyond the region affected by anaesthetization. Even if the quantity of anaesthetic agents used were assumed to have been insufficient to produce total anaesthesia, in any case the effect of local anaesthesia, experienced subjectively as total loss of sensation in the teeth, proved to be unexpectedly slight.

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SUMMARY

The purpose of the present study is to determine how small a foreign body between the occlusal surfaces of natural human teeth is capable of causing sufficient pressure on the parodontium to make detection of the body possible. The sensitivity of the molars and the incisors were investigated separately, and one or both antagonistic molars were locally anaesthetized.

The foreign bodies used in the experiment were aluminium foil 8 μ thick and tin foil between 10 and 180 μ thick cut into pieces measuring 3×3 mm. Examination of each thickness of foil was carried out in a series of ten observations, including five control observations without foil.

One-third of the subjects were unmistakably aware of the presence of 8 and 10μ thickness of foil between unanaesthetized teeth; pieces 30 μ thick were felt by all but three of the subjects while the thickness of 60 μ was felt without exception.

Anaesthetization of the molar antagonist in the lower jaw diminished sensitivity; even so, two-thirds of the subjects were capable of detecting a 30 μ foil, and the entire group with but two exceptions perceived a 60 μ foil unmistakably. After anaesthetization of the other antagonist, three-quarters of the subjects detected a 90 μ foil unerringly, while only two failed to detect a 150 μ foil. The two exceptions were capable of sensing a piece of foil 180 μ thick (Fig. 1).

There was no significant statistical difference in tactile sensitivity between the sexes or between the incisors and molars.

RÉSUMÉ

SENSIBILITÉ TACTILE DU PARODONTE À L'APPLICATION DE CHARGES AXIALES LÉGÈRES SUR LES DENTS

La présente étude a pour but de déterminer l'épaisseur minimum que doit avoir un corps étranger placé entre les faces oc-

clusales de dents naturelles chez l'homme pour pouvoir causer sur le parodonte une pression suffisante pour permettre la détection du corps étranger. La sensibilité des molaires et celle des incisives ont été étudiées séparément, et une anesthésie locale a été donnée soit aux deux molaires antagonistes, soit à l'une d'elles seulement.

Les corps étrangers utilisés dans cette expérience étaient des morceaux de 3 mm sur 3 découpés dans de la feuille d'aluminium de 8 μ d'épaisseur, et dans de la feuille d'étain de 10 à 180 μ d'épaisseur. L'étude de chaque épaisseur de feuille métallique a été faite sur une série de 10 observations comprenant 5 observations de contrôle sans feuille.

Un tiers des sujets étaient nettement conscients de la présence de feuilles de 8 μ et de 10 μ d'épaisseur entre les dents non anesthésiées; les morceaux de 30 μ d'épaisseur étaient perçus par tous les sujets sauf trois, tandis que tous sans exception percevaient une épaisseur de 60 μ.

L'anesthésie de la molaire antagoniste inférieure diminuait la sensibilité, mais même dans ce cas, deux tiers des sujets étaient capables de déceler une feuille de 30 μ, et à deux exceptions près, le groupe entier percevait nettement une feuille de 60 μ. Après anesthésie de l'autre antagoniste, les trois quarts des sujets ont décelé sans erreur une feuille de 90 μ, tandis que deux sujets seulement ont été incapables de déceler une feuille de 150 μ. Ces deux exceptions ont été capables de percevoir un morceau de feuille de 180 μ d'épaisseur. (Fig. 1).

Il n'existait pas de différence significative du point de vue statistique entre la sensibilité tactile suivant le sexe ou entre celle des incisives et celle des molaires.

ZUSAMMENFASSUNG

BERÜHRUNGSEMPFINDLICHKEIT IM PARODONTIUM BEI LEICHTER AXIALBELASTUNG DER ZÄHNE

Durch diese Untersuchung sollte festgestellt werden, wie klein ein zwischen die Kauflächen natürlicher Menschenzähne hineingelangter Fremdkörper sein kann, um gross genug zu sein, einen zur Entdeckung des Fremdkörpers ausreichenden Druck auf dem Parodontium hervorzurufen. Die Molaren und die

Schneidezähne wurden gesondert auf ihre Empfindlichkeit geprüft, und einer oder beide Molarantagonisten wurden mit Lokalanästhesie behandelt.

Als Fremdkörper dienten für die Untersuchung Aluminiumfolie von 8 μ und Zinnfolie von 10 bis 180 μ, in Stücke von 3×3 mm ausgeschnitten. Versuche mit jeder Foliestärke wurden in Serien von 10 Observationen einschliesslich 5 Kontrollobservationen ohne Folie durchgeführt.

Ein Drittel der Versuchspersonen konnte mit Sicherheit das Vorhandensein von 8 und 10 μ dicker Folie zwischen nichtanästhesierten Zähnen merken. Stücke von 30 μ Dicke wurden von allen Versuchspersonen ausser 3 gefühlt, während die Dicke von 60 μ von sämtlichen gefühlt wurden.

Anästhesie der Molarantagonisten im Unterkiefer verminderte die Empfindlichkeit, aber dennoch waren zwei Drittel der Versuchspersonen imstande, eine 30 μ Folie zu entdecken, und die ganze Gruppe bis auf zwei Ausnahmen spürte mit Sicherheit eine 60 μ Folie. Nach Anästhesie des zweiten Antagonisten entdeckten drei Viertel der Versuchspersonen fehlerfrei eine 90 μ Folie, während nur zwei nicht imstande waren, eine 150 μ Folie zu spüren. Die beiden Ausnahmen waren in der Lage, ein Stück Folie von 180 μ zu entdecken (Abb. 1).

Hinsichtlich der Berührungsempfindlichkeit konnte kein statistisch signifikanter Unterschied zwischen den Geschlechtern oder zwischen Schneidezähnen und Molaren festgestellt werden.

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