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# DENTAL SENSITIVITY TO ELECTRICAL EXCITATION

## THRESHOLD VALUES OF CARIES-FREE NON-FILLED TEETH

*by*

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### INTRODUCTION

Determining the sensitivity of teeth to electrical current is a part of the clinical evaluation of the pulp and periapical tissues. Essential information can be obtained by this means. It is necessary to point out that only in combination with anamnestic data, and other clinical methods including roentgenographic examination can definite conclusions be drawn concerning the vitality of the tissues. For successful use of an electrical stimulator, judicious evaluation based partly on knowledge of the limitations of the method, and partly on the reliability of the apparatus is necessary (*Mumford & Björn*, 1962).

Since *Björn* in 1946 succeeded in adapting modern neurophysiological experiences to the determination of the state of the tooth by studying its sensitivity to electrical excitation, this method of examination has been used more and more widely within different fields both of clinical practice and research (*Mårtensson*, 1950; *Huldt*, 1953; *Berling*, 1958; *Feldmann & Nordenram*, 1959; *Kristerson & Nordenram*, 1962; *Nordenram*, 1963; *Elomaa*, 1968).

For about five years the Bofors Pulp Tester* has been used in a number

* Ab Bofors, Nobel-Pharma, Mölndal, Sweden.

Received for publication, September 12, 1969.

of investigations (*Nordenram*, 1966; *Isaksson* et al., 1966; *Dahl* et al., 1967; *Feldmann* & *Nordenram*, 1967). The apparatus is based on the use of a measurable, pulsating, direct current, the strength of which can be read off accurately and instantly. It has been shown to satisfy great demands of exactness and reliability.

The following investigation was carried out with this apparatus in order to ascertain the normal threshold values of pulpal sensitivity to electrical stimulation in intact caries-free, non-filled teeth.

## MATERIAL AND METHOD

In all, 1209 intact caries- free, non-filled teeth of 157 persons were examined. Table I shows the distribution of the subjects in term of ages, sex, and tested teeth. Following careful drying by an air-steam and isolation by cellulose rolls, the tooth electrode was placed incisally or on the buccal cusps. The electrical current was then gradually increased from zero until the patient-who was unable to see the instrument panel, had a slight feeling of discom, fort. At this point the current was immediately broken, and its value in $\mu$A was read off. About five measurements were made before the final value was recorded in order that the patient could discriminate the minimum sensation in the tooth from the current impulses. Each experiment was carried out by the same investigator, who was thoroughly trained in the use of the apparatus.

Of the 157 patients, 51 took part in a second experiment and 9 in a third. There was an interval of at least one week between each experiment.

## RESULTS

Tables II and III show, for the upper and lower jaw respectively, the measured values in terms of sex, age and teeth. The pain threshold for women

Table I
*Distribution of the material*

| Age | Abbr. | Number of persons | | Number of teeth | | Total |
|---|---|---|---|---|---|---|
| | | Male | Female | Male | Female | |
| 10—19 | I | 54 | 21 | 327 | 191 | 518 |
| 20—29 | II | 65 | 12 | 562 | 49 | 611 |
| 30—39 | III | 2 | 3 | 80 | 0 | 80 |
| Total | | 121 | 36 | 969 | 240 | 1209 |

Table II

*Threshold values for maxillary teeth*

| Age | Tooth number | 1+1 | | 2+2 | | 3+3 | | 4+4 | | 5+5 | | 6+6 | | 7+7 | | 8+8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F |
| I | number | 9 | 13 | 8 | 10 | 9 | 4 | 69 | 27 | 40 | 16 | 8 | 2 | 3 | | 2 | |
| | mean | 6.3 | 6.6 | 5.5 | 6.9 | 7.1 | 8.3 | 11.9 | 14.0 | 14.4 | 18.8 | 16.3 | 25.0 | 19.3 | | 16.0 | |
| | S. E. | 0.7 | 0.6 | 1.0 | 1.0 | 1.1 | 1.4 | 0.5 | 1.6 | 1.0 | 2.4 | 2.0 | 3.0 | 2.3 | | 1.0 | |
| II | number | 64 | 7 | 61 | 4 | 51 | | 9 | | 4 | | 1 | | | | | |
| | mean | 6.5 | 5.9 | 5.7 | 6.5 | 7.5 | | 6.3 | | 8.3 | | 11.0 | | | | | |
| | S. E. | 0.3 | 0.5 | 0.4 | 0.3 | 0.5 | | 0.9 | | 1.3 | | -- | | | | | |
| III | number | 9 | | 8 | | 8 | | 4 | | 1 | | | | | | | |
| | mean | 5.8 | | 4.9 | | 5.5 | | 7.0 | | 7.0 | | | | | | | |
| | S. E. | 0.5 | | 0.8 | | 0.8 | | 1.5 | | — | | | | | | | |
| Total | number | 82 | 20 | 77 | 14 | 68 | 4 | 82 | 27 | 45 | 16 | 9 | 2 | 3 | | 2 | |
| | mean | 6.4 | 6.4 | 5.6 | 6.8 | 7.2 | 8.3 | 11.0 | 14.0 | 13.6 | 18.8 | 15.7 | 25.0 | 19.3 | | 16.0 | |
| | S. E. | 0.3 | 0.5 | 0.3 | 0.7 | 0.4 | 1.4 | 0.5 | 1.6 | 1.0 | 2.4 | 1.9 | 3.0 | 2.3 | | 1.0 | |
| I | number | 22 | | 18 | | 13 | | 96 | | 56 | | 10 | | 3 | | 2 | |
| | mean S. E. | 6.5 | 0.5 | 6.3 | 0.7 | 7.5 | 0.9 | 12.5 | 0.6 | 15.6 | 1.0 | 18.0 | 2.0 | 19.3 | 2.3 | 16.0 | 1.0 |
| II | number | 71 | | 65 | | 51 | | 9 | | 4 | | 1 | | | | | |
| | mean S. E. | 6.4 | 0.3 | 5.7 | 0.3 | 7.5 | 0.5 | 6.3 | 0.9 | 8.3 | 1.3 | 11.0 | | | | | |
| III | number | 9 | | 8 | | 8 | | 4 | | 1 | | | | | | | |
| | mean S. E. | 5.8 | 0.5 | 4.9 | 0.8 | 5.5 | 0.8 | 7.0 | 1.5 | 7.0 | | | | | | | |
| Total | number | 102 | | 91 | | 72 | | 109 | | 61 | | 11 | | 3 | | 2 | |
| | mean S. E. | 6.4 | 0.2 | 5.8 | 0.3 | 7.3 | 0.4 | 11.8 | 0.6 | 15.0 | 1.0 | 17.4 | 2.0 | 19.3 | 2.3 | 16.0 | 1.0 |

Table III

*Threshold values for mandibular teeth*

| Age | Tooth number | 1—1 | | 2—2 | | 3—3 | | 4—4 | | 5—5 | | 6—6 | | 7—7 | | 8—8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F |
| I | number | 10 | 22 | 12 | 23 | 10 | 19 | 84 | 32 | 51 | 22 | 8 | | 2 | 1 | 2 | |
| | mean | 4.0 | 6.4 | 5.0 | 6.9 | 6.2 | 9.7 | 12.6 | 12.4 | 15.6 | 16.2 | 14.1 | | 15.5 | 24.0 | 15.0 | |
| | S. E. | 0.5 | 0.5 | 0.5 | 0.6 | 0.7 | 1.0 | 0.5 | 0.8 | 1.0 | 1.0 | 2.0 | | 0.5 | — | 1.0 | |
| II | number | 109 | 12 | 103 | 12 | 101 | 10 | 40 | 3 | 14 | 1 | | | | | | |
| | mean | 4.5 | 4.1 | 4.5 | 4.5 | 6.1 | 7.0 | 7.7 | 10.0 | 10.4 | 11.0 | | | | | | |
| | S. E. | 0.2 | 0.4 | 0.2 | 0.5 | 0.3 | 0.7 | 0.8 | 2.5 | 1.3 | — | | | | | | |
| III | number | 14 | | 14 | | 13 | | 7 | | 2 | | | | | | | |
| | mean | 4.3 | | 4.1 | | 4.6 | | 4.7 | | 6.0 | | | | | | | |
| | S. E. | 0.4 | | 0.4 | | 0.7 | | 1.2 | | 1.3 | | | | | | | |
| Total | number | 133 | 34 | 134 | 35 | 124 | 29 | 131 | 35 | 67 | 23 | 8 | | 2 | 1 | 2 | |
| | mean | 4.4 | 5.6 | 4.5 | 6.1 | 5.9 | 8.8 | 10.7 | 12.2 | 14.3 | 16.0 | 14.1 | | 15.5 | 24.0 | 15.0 | |
| | S. E. | 0.3 | 0.4 | 0.2 | 0.5 | 0.3 | 0.7 | 0.5 | 0.8 | 0.5 | 1.0 | 2.0 | | 0.5 | — | 1.0 | |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | number | 32 | | 35 | | 29 | | 116 | | 73 | | 8 | | 3 | | | |
| | mean S. E. | 5.6 | 0.5 | 6.2 | 0.5 | 8.5 | 0.8 | 12.5 | 0.4 | 15.8 | 0.8 | 14.1 | 2.0 | 18.3 | 2.8 | | |
| II | number | 121 | | 120 | | 111 | | 43 | | 15 | | | | | | | |
| | mean S. E. | 4.5 | 0.1 | 4.5 | 0.2 | 6.2 | 0.3 | 7.9 | 0.7 | 10.5 | 1.2 | | | | | | |
| III | number | 14 | | 14 | | 13 | | 7 | | 2 | | | | | | | |
| | mean S. E. | 4.3 | 0.4 | 4.1 | 0.4 | 4.6 | 0.7 | 4.7 | 1.2 | 6.0 | 1.3 | | | | | | |
| Total | number | 167 | | 169 | | 153 | | 166 | | 90 | | 8 | | 3 | | 2 | |
| | mean S. E. | 4.6 | 0.3 | 4.9 | 0.2 | 6.5 | 0.3 | 11.0 | 0.4 | 14.7 | 0.6 | 14.1 | 2.0 | 18.3 | 2.8 | 15.0 | 1.0 |

Table IV

*Intraindividual comparisons at double determinations*

Upper jaw

| Tooth number | 3+ | | 2+ | | 1+ | | +1 | | +2 | | +3 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Examination | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd |
| Number of teeth | 19 | | 27 | | 29 | | 27 | | 24 | | 19 | |
| Mean | 7.0 | 6.8 | 5.5 | 5.3 | 6.5 | 5.9 | 6.8 | 6.3 | 6.3 | 5.5 | 7.5 | 6.8 |
| S. E. | 0.7 | 0.6 | 0.5 | 0.5 | 0.4 | 0.4 | 0.5 | 0.4 | 0.6 | 0.4 | 0.9 | 0.7 |

Lower jaw

| Tooth number | 4— | | 3— | | 2— | | 1— | | —1 | | —2 | | —3 | | —4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Examination | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd |
| Number of teeth | 20 | | 45 | | 48 | | 49 | | 48 | | 48 | | 45 | | 19 | |
| Mean | 6.7 | 5.8 | 5.4 | 5.3 | 4.3 | 4.2 | 4.5 | 4.2 | 4.5 | 4.0 | 4.4 | 4.1 | 6.1 | 5.7 | 6.4 | 6.4 |
| S. E. | 0.9 | 0.6 | 0.4 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 | 0.2 | 0.4 | 0.4 | 0.9 | 0.9 |

Table V

*Intraindividual comparisons at triple determinations*

| Tooth number | 1+ | | | 3— | | | 2— | | | 1— | | | —1 | | | —2 | | | —3 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Examination | 1st | 2nd | 3rd | 1st | 2nd | 3rd | 1st | 2nd | 3rd | 1st | 2nd | 3rd | 1st | 2nd | 3rd | 1st | 2nd | 3rd | 1st | 2nd | 3rd |
| Number of teeth | 7 | | | 7 | | | 8 | | | 8 | | | 8 | | | 8 | | | 7 | | |
| Mean | 5.4 | 5.7 | 5.9 | 4.9 | 4.1 | 4.3 | 4.5 | 3.6 | 3.6 | 4.5 | 3.8 | 3.9 | 4.6 | 3.6 | 4.0 | 4.6 | 3.9 | 4.0 | 7.7 | 6.0 | 6.3 |
| S. E. | 0.8 | 0.7 | 0.8 | 1.1 | 0.8 | 0.7 | 0.7 | 0.6 | 0.6 | 0.6 | 0.3 | 0.4 | 0.6 | 0.4 | 0.4 | 0.7 | 0.6 | 0.5 | 1.5 | 0.9 | 0.9 |

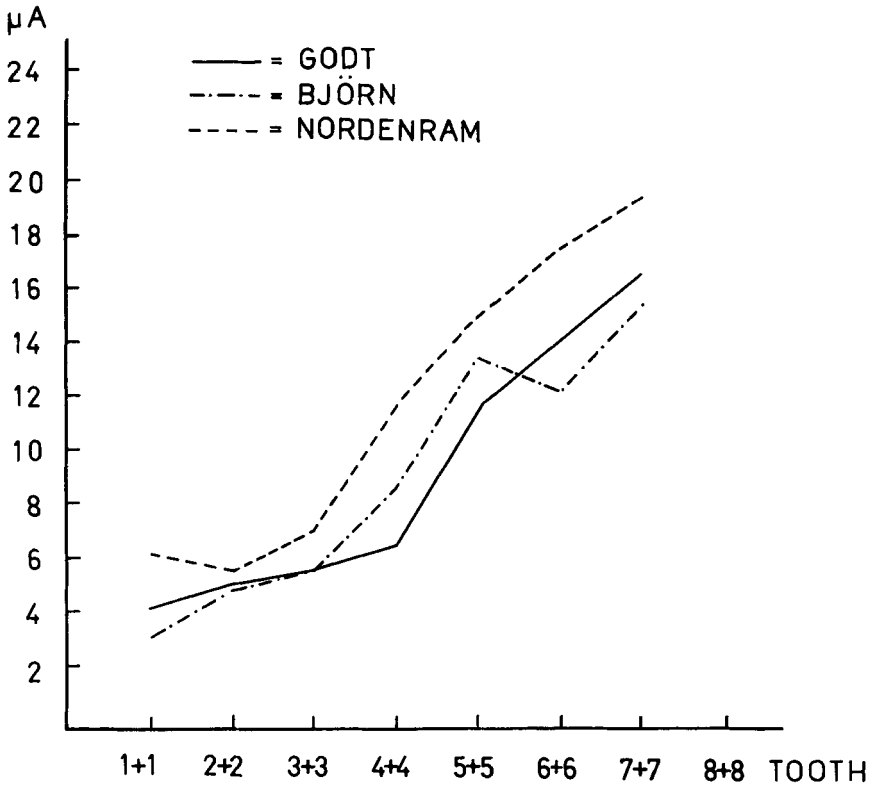


Fig. 1 a. Mean threshold values for maxillary teeth.

was generally somewhat higher than that for men, although the difference was less evident in the older age-groups, and the difference between the measured values for men and women was not statistically significant. These two groups were subsequently treated as one.

The measured threshold values decreased with age. The rate of decrease, however, was greater between the first and second age-groups than between the second and the third.

The difference in threshold values between the corresponding front teeth in the upper and the lower jaw became less apparent the further from the midline the comparison was made. The increase in the threshold values for consecutive tooth groups in both the upper and lower jaw was statistically significant.

The mean values of the results from all the groups are given and compared with values from some previous investigations (Fig. 1). Tables IV

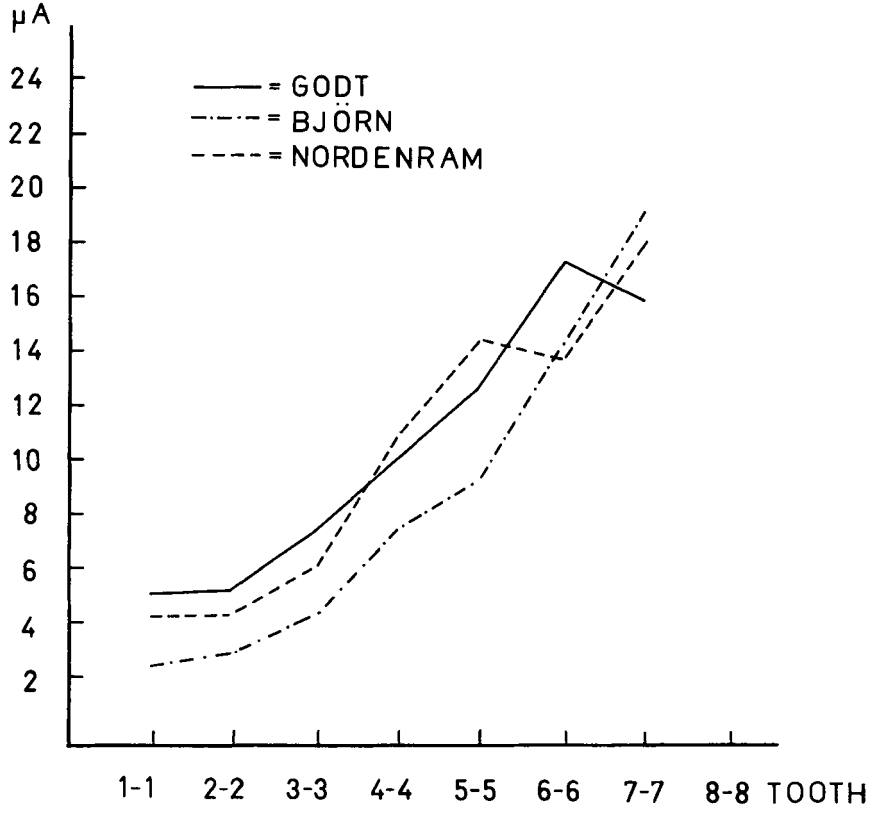


Fig. 1 b. Mean threshold values for mandibular teeth.

and V illustrate the reliability of the measured threshold values for a given patient on two and three different test occasions. In general a small decrease in the measured values could be noticed between the first and second examinations, while there was no difference between the second and the third.

## DISCUSSION

It should be noted that the values given in Fig. 1 are based on somewhat different samples (Table VI). Nevertheless the results ought to be fully comparable, since the distribution of patients within the age-groups for each investigator was such that 90 % of the patients belonged to the 18—30 age-groups. *Elomaa* (1968) found in a similar investigation that there was no difference in the threshold values with regard to sex. He also noticed the following: »The threshold of excitation of the teeth tested diminished dur-

Table VI

*Comparison of patient and tooth material in the present and two previous investigations (loc.cit.)*

| Investigator | Year | Number of patients | Age | Number of teeth | |
|---|---|---|---|---|---|
| | | | | upper jaw | lower jaw |
| Björn | 1946 | 51 | 11—50 | 202 | 231 |
| Godt | 1967 | 51 | 18—30 | 324 | 336 |
| Nordenram | 1969 | 157 | 10—40 | 451 | 758 |

ing at least 20 years after eruption. Differences between the threshold of excitation of different teeth decreased with advancing age.» The decrease at consecutive examinations, as shown in Tables IV and V, is not considered important from a clinical point of view as it was within the limits of reading accuracy at a single test.

SUMMARY

The importance and limitations of the determination of the sensitivity of teeth to an electrical test apparatus was reviewed. A study was made using the Bofors Pulp Tester, of the threshold values of 1209 caries-free non-filled teeth located within complete dentitions of 157 patients.

The results show that although small variations were observed there was no statistical difference in the threshold values in terms of sex, age and test occasions. There are however statistically significant increases in the threshold values for consecutive tooth groups in both the upper and lower jaws.

These observations on the use of this apparatus agree in general with the results obtained by other investigators when similar apparatus has been used.

RÉSUMÉ

SENSIBILITÉ DENTAIRE À UNE EXCITATION ÉLECTRIQUE

VALEURS DU SEUIL DE SENSIBILITÉ DE DENTS NON CARIÉES ET NON OBTURÉES

Le problème de l'importance à accorder et des limites inhérentes à l'emploi d'un appareil servant à tester à l'aide d'un courant électrique le seuil de la sensibilité dentaire a été étudié. Un »Bofors Pulp Tester» a été utilisé pour déterminer le seuil de sensibilité de 1209 dents non cariées et non obturées; cette étude a été effectuée chez 157 patients qui présentaient tous une denture complète.

Quoique quelques petites variations aient pu être notées, la valeur du seuil de sensibilité ne présente pas de différences significatives suivant l'âge, le

sexe et les différentes occasions au cours desquelles les tests ont été effectués. Une étude statistique a cependant montré que, progressivement des dents antérieures aux dents postérieures, on peut noter des augmentations significatives du seuil de la sensibilité, tant au maxillaire supérieur qu'au maxillaire inférieur.

Ces observations sur l'emploi de cet appareil sont dans l'ensemble conformes avec les résultats obtenus par d'autres chercheurs ayant utilisé des appareils similaires.

ZUSAMMENFASSUNG

PULPAREIZUNG DURCH ELECTRISCHE STIMULATION SCHWELLENWERTE KARIESFREIER, NICHT MIT FÜLLUNGEN VERSEHENER ZÄHNE

Auf die Bedeutung und die Grenzen, die der Sensibilitätsbestimmung an Zähnen durch elektrische Apparate gezogen sind, wird eingegangen. Eine Studie der Schwellenwerte bei 1209 kariesfreien, nicht mit Füllungen versehenen Zähnen, wurde mit Hilfe eines Bofors Pulpentesters vorgenommen Die getesteten Zähne befanden sich in den vollbezahnten Gebissen von 157 Patienten.

Das Resultat zeigte keinen statistisch sichergestellten geschlechtsbedingten, altersbedingten oder anlassbedingten Unterschied der Schwellenwerte, obwohl geringere Differenzen der Pulpaschwellenwerte beobachtet werden konnten. Statistisch sichergestellte Differenzen von Schwellenwerten wurden jedoch zwischen verschiedenen Zahngruppen im Ober- und Unterkiefer beobachtet.

Diese Beobachtungen bei Anwendung des oben genannten Testapparates stimmen mit denen anderer Verfasser, die ähnlichte Testapparate für ihre Untersuchungen benutzt haben, überein.

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