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THE INNERVATION OF THE MAXILLARY FIRST PERMANENT AND PRIMARY MOLARS AS DETERMINED BY THE DEPOSITION OF LOCAL ANESTHETIC SOLUTIONS

A PRELIMINARY REPORT*

by

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There has been general acceptance of the premise that the tuberosity injection will anesthetize all the molar teeth, except for the mesial buccal root of the first permanent molar, which is innervated by the middle superior alveolar nerve (20, 21, 22, 29). *Smith* (26), for example, stated (without presenting statistical substantiation) that the entire first permanent molar would be anesthetized in only five per cent of the cases, because in these few teeth the sole innervation is the posterior superior alveolar nerve (p. 426). A consideration of the inconstancy of this middle nerve supply, as described in the literature (4, 5, 8, 16, 20, 23, 30, 32) is a cause to question the classic description of nerve supply.

Since clinical experience with nerve block technics had indicated that not only the entire first permanent molar, but also the primary molars might often be anesthetized by a single tuberosity injection, thereby saving time by eliminating multiple infiltrations, a series of such injections was made as outlined below.

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MATERIAL AND METHODS

The selection of the method, children and teeth

The term anesthesia is commonly used in the United States to describe the analgesic effect which follows the deposition of local anesthetic solutions about nerve fibers. The technic of injection of the anesthetic solution here employed is known by several names: the Posterior superior alveolar, the Zygomatic, or the Tuberosity. The latter term most accurately reflects the position of the needle and its relationship to the bony and soft tissues. In children it is necessary to use a needle in a bent hub*) to fix precisely the site of deposition of the anesthetic solution. Before being able to secure such hubs, thirty-two preliminary injections were accomplished with a 1⅝ inch straight, tapering needle, in order to aid in establishing the criteria by which the success of the deposition of the anesthetic solutions could be judged. These preliminary trials are not presented in the tabulations because the tip of the straight needle could not be accurately guided to the anatomic position desired.

The deposition of anesthetic solutions in the region of the maxillary tuberosity was accomplished with 1⅝ inch tapering needles which were bent at an approximate angle of 45° by the special hub. The hub is screwed to the threaded tip of a metal carpule syringe (See Fig. 3) commonly employed in dental practice.

The children in this study were from an area in Southern California with a population of approximately 250,000. The subjects chosen, over a period of several months, were those who required local anesthesia for the treatment of pathological lesions involving dental structures in the posterior quadrants of the maxillary dental arch. All the children, about whom results are reported, exhibited a "normal" dento-facial complex. They did not exhibit signs of any gross irregularities in their total development. In other words, children requiring pre-operative sedation or with such abnormalities as a cleft palate, cerebral palsy, or other serious incapacities were excluded. The eighty-five tuberosity injections reported include several instances of bilateral

*) The tapering needles and hubs were from the Mizzy, Inc., Clifton Forge, Virginia.

injections in the same individual. The dentitions were full primary or mixed primary and permanent.

To ascertain whether the extent of an injection of local anesthetic could be determined, the decayed molar, or the most medial molar if several were involved, was opened with a water-cooled 57 carbide bur (approximate diameter 1 mm) revolving at maximum speed in a Midwest Company air-rotor contrangle handpiece. Pain response was usually verbally expressed, but autonomic reflexes such as the "beading" of perspiration upon the upper lip, or bridge of the nose, were considered to be overt signs of fright and possibly pain. If the subject felt no discomfort, no injection of local anesthetic was made. Extractions were an indication for the deposition of anesthetic solution.

The tuberosity injection

The injections were made in accordance with the measurements described by *Jorgensen* [17, 18]. The height of the maxilla was measured by placing a Boley gauge at the gingival margin of the 1st or 2nd primary molar and measuring "up" to the infraorbital margin. To avoid injury to the eye, the Boley gauge was placed on the skin just below the bony infraorbital margin. The distance in millimeters was recorded (See Fig. 1).

The significance of this measuring technic lies in the fact that the maxillary height at the tuberosity is approximately the same as that in the infraorbital region. The majority of the posterior superior alveolar nerves enter the foramina of the tuberosity approximately half-way between the gingival margin of the fully-erupted molar teeth and the posterior border of the floor of the orbit. Thus, if the anterior measurement of maxillary height is halved (Fig. 2), the resulting number of millimeters represents the distance from the posterior gingival margin to the foramina for the transmission of the posterior alveolar nerves. Deposition of the anesthetic solution at the area where the largest number of nerve fibers are concentrated, plus spread of the solution along the supra-periosteal surface of the maxilla account for the success of the injection [11].

After the preparation for the injection was made by ascertaining the maxillary height, as just indicated, the recorded num-

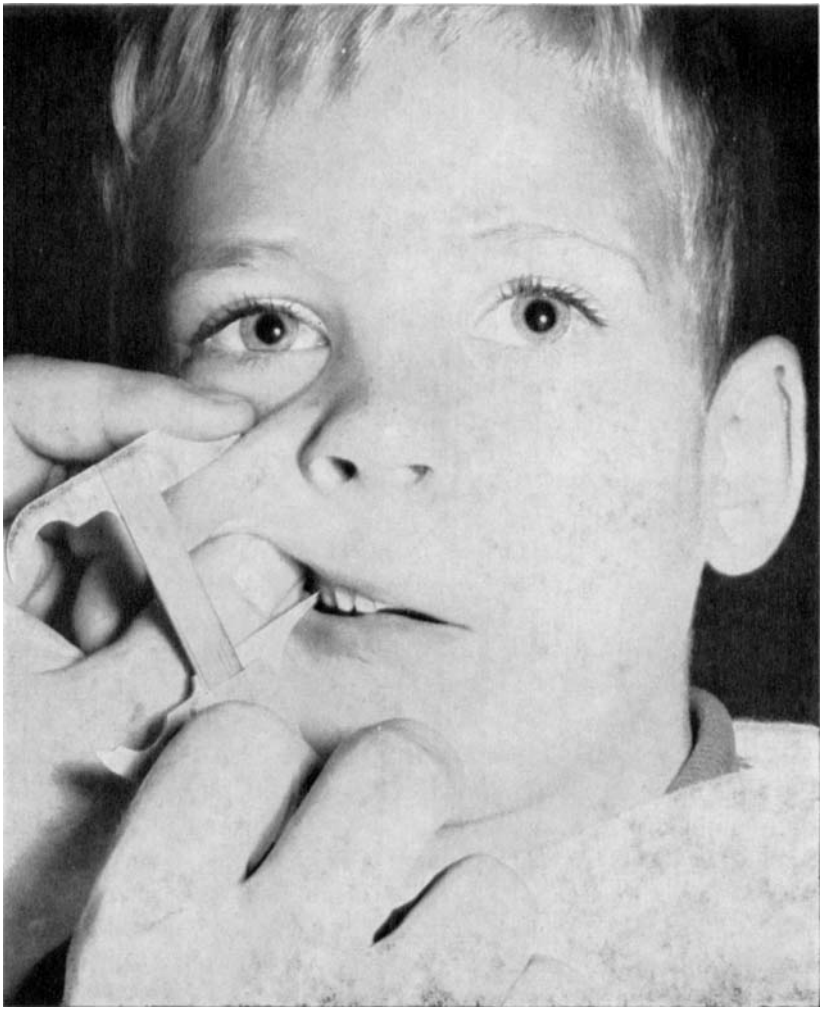

Fig. 1. Measuring the maxillary height.

ber of millimeters was marked by a piece of rubber band which had been placed on the tapering needle prior to sterilization (See Figs. 3—5).

The technic of the injection was to palpate digitally both the tuberosity of the maxilla and the posterior surface of the zygomatic process of the maxilla, and leave the index finger on

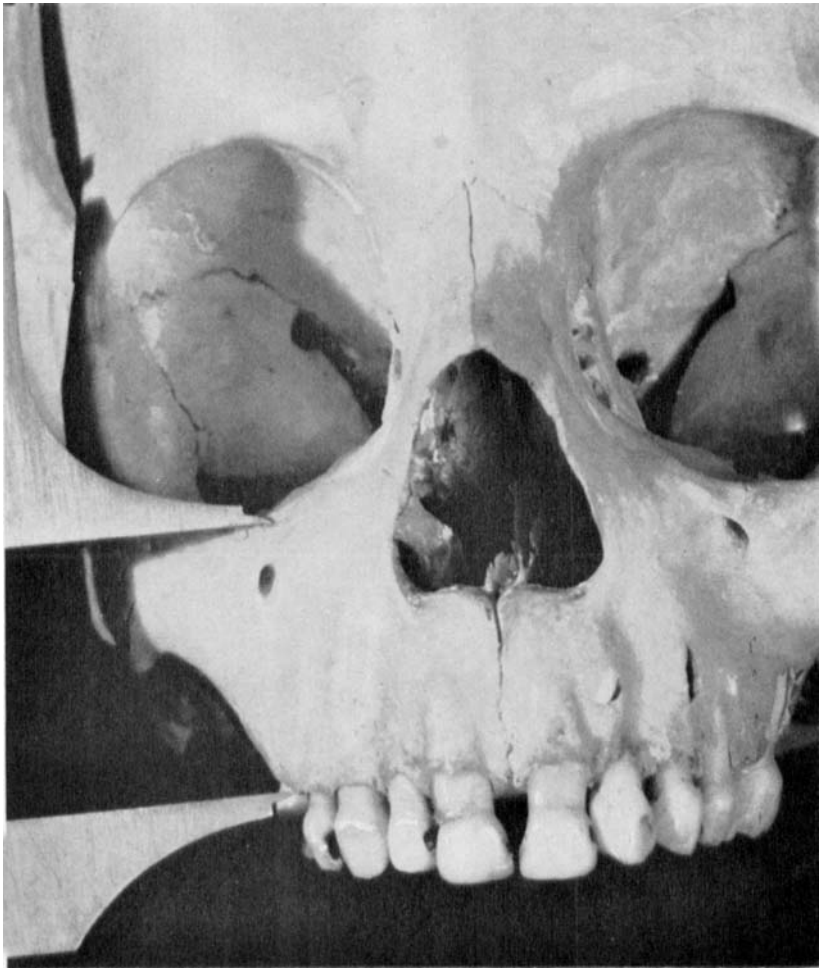

Fig. 2. Relation of primary molars, maxilla, infraorbital canal, and infraorbital margin in a 6 year old.

the zygomatic process. The lip was retracted, and the tissues prepared for the injection. The tip of the needle was inserted in the fornix of the vestibule, just a little distal to the midpoint between the posterior surface of the tuberosity and the posterior surface of the zygomatic process of the maxilla. The needle was stepped superiorly and distally, while injecting a few minims of

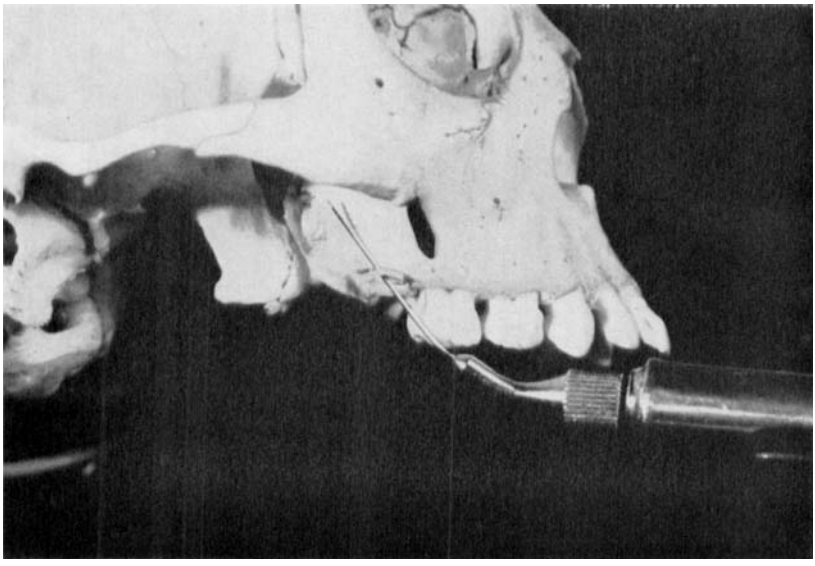

Fig. 3. Position of the needle on the tuberosity, primary dentition.

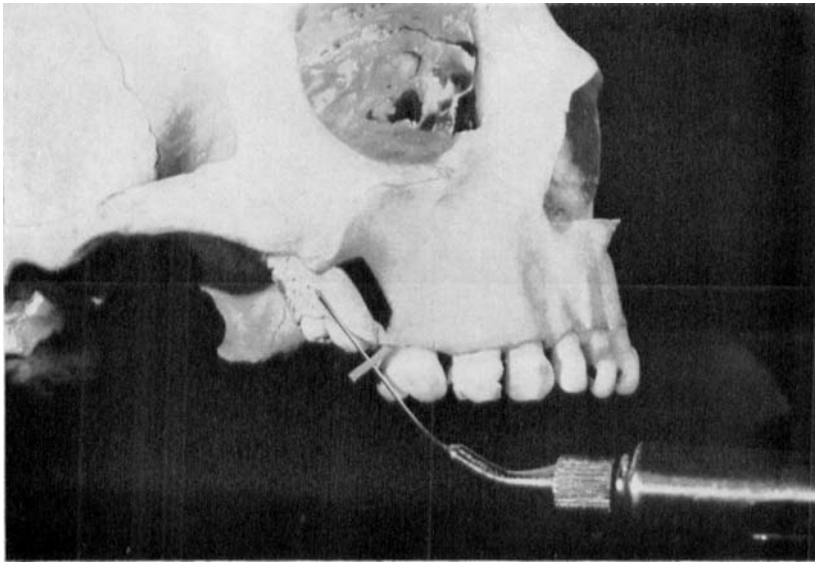

Fig. 4. Position of the needle on the tuberosity, as the first permanent molar starts to erupt.

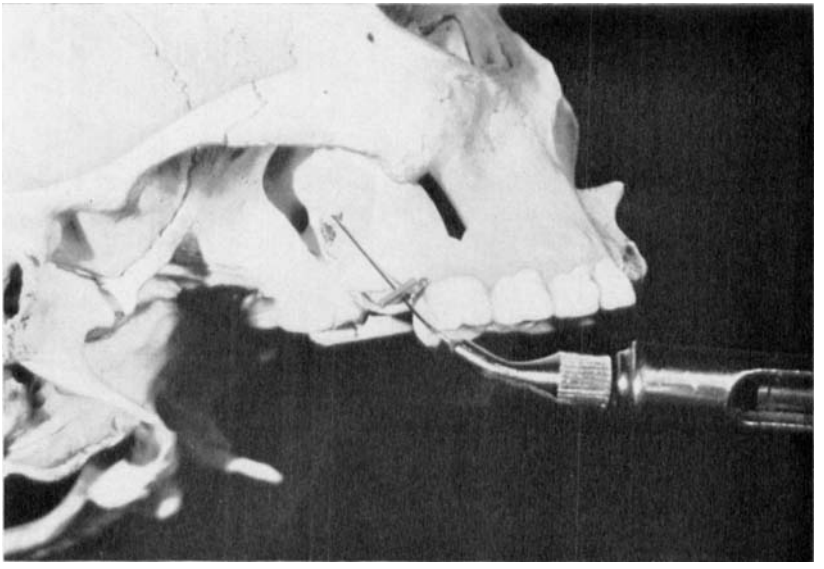

Fig. 5. Position of the needle on the tuberosity, mixed dentition.

solution as the needle was advanced, until the rubber marker lay at the same height as the gingival margin of the primary molars. The bulk of the solution was deposited at the terminal position of the needle tip. Aspiration was practiced with all injections. Approximately 1 cc of Meprylcaine (Orocaine*) was slowly deposited in the area of injection. No injection was repeated if it was not immediately successful.

For the purpose of evaluating the results of the deposition of anesthetic solution, two categories were recorded: 1) anesthesia of the tooth or teeth, and 2) incomplete, or no anesthesia of the tooth or teeth.

The mesio-buccal root of the first permanent molar may in some instances be anesthetized by infiltrating the solution in the para-apical region of the mesio-buccal root. The principles are those underlying infiltration anesthesia for any dental structure. A 1-inch tapering needle is employed. Although this injection was made to accomplish restorative work on some of the patients

*) Mizzy, Inc.

in this series, such teeth are listed in the incomplete or no anesthesia column.

RESULTS

Tuberosity injections in eighty-five cases produced the following results:

Table 1

Permanent and Primary molars considered as one group

Teeth Observed	Anesthesia	
	Complete	Incomplete or no
1st Permanent Molars	77	8
2nd Primary Molars	34	7
1st Primary Molars	16	9

$\chi^2 = 10.156$

Because the above results possessed significance, two additional χ^2 tests were employed, the first considering the permanent and 2nd primary molars as one group and the 1st primary molars as another.

Table 2

1st Permanent and 2nd Primary molars considered as one group

Teeth Observed	Anesthesia	
	Complete	Incomplete or no
1st Permanent and 2nd Primary Molars	111	15
1st Primary Molars	16	9

$\chi^2 = 8.92$

The second test considered the permanent and primary molars as two separate groups.

Table 3

1st Permanent molars and Primary molars considered as two groups

Teeth Observed	Anesthesia	
	Complete	Incomplete or no
1st Permanent Molars	77	8
1st and 2nd Primary Molars	50	16

$\chi^2 = 6.08$

The Chi square values of Tables 1—3 indicate that the observed difference in the anesthesia obtained in the three teeth located successively anterior to the point of injection is significant. For Tables 1—2 there is a 99 % probability that the differences in anesthesia were not due to chance. For Table 3 the probability was at least 98 %. However, to determine the efficiency of the tuberosity injection in terms of clinical practice, two additional estimates were required. First, the fewest number of times the injection might be expected to succeed and would this level of success be meaningful in dental practice? Secondly, did the observed anesthesia equal or exceed the statistically derived estimate of success? Table 4 presents the calculated and the observed values.

Table 4

Percentages of anesthesia resulting from tuberosity injections

Teeth	Least Estimated Occurrence*)	Observed Occurrence
1st Permanent Molar	79.5 %	92 %
2nd Primary Molar	63.1 %	83 %
1st Primary Molar	26.6 %	64 %

*) Lower level of 99 % Binomial confidence levels ([19]).

Since the 99 % level embraces three standard deviations, the least estimated occurrence of anesthesia is conservative (even for this small sample), particularly when compared to the observed anesthesia.

A summarization of the results reported in Tables 1–4 may be stated as follows: 1) the observed occurrence of local anesthesia in the first permanent and second and first primary molars is not due to chance and, 2) the percentage of successful results indicated that the tuberosity injection is the method of choice for the first permanent molar, particularly when the second and first primary molars require restoration. The time-consuming mesial-buccal infiltration is necessary in the minority of cases, although it is obvious that supplementary anesthesia will often be required as the first primary molar is approached.

DISCUSSION

A review of the literature revealed that studies of the nerves to the teeth have fallen into four general classifications: (1) dried bones [8, 30], (2) gross and microscopic dissection of fetal and adult specimens [2, 4, 9, 14, 16, 20, 23, 31], (3) histologic sections and serial sections with or without accompanying reconstructions [6, 7, 10, 13, 15, 28], and (4) observations made from the anesthetization of certain regions [1, 3, 11, 24, 25]. Many of the reports were parenthetical in nature, and more specific investigations usually did not state two criteria which may be of importance: 1) the age of the specimen, and 2) the condition of the dentition. Nerve block technics have proved to be a method of obtaining pertinent information in a much shorter period of time than is possible by means of dissection or reconstruction.

From the review of the literature one may state two general observations. First, there were several patterns of innervation of the maxillary teeth. Secondly, even in the same individual, the innervation in the right maxilla may differ from that in the left. The patterns of innervation may be summarized as follows:

a) The maxillary first permanent and second primary molars may be innervated by the posterior superior alveolar nerve, while the first primary molar is supplied by the middle and not infrequently the anterior, superior alveolar nerve. Such a distribution of nerves seemingly predominated in the clinical trials with local anesthetics and required that the tuberosity injection be supplemented with infiltration anesthesia for the first primary molar.

b) The maxillary first permanent molar may be innervated by the posterior superior alveolar and middle superior alveolar nerves, which latter nerve also serves the primary molars. Such a pattern requires infiltration anesthesia for the mesio-buccal root of the permanent molar, and for the primary molars.

c) The maxillary first permanent molar may be innervated by the posterior superior alveolar nerve, and the primary molars by the middle superior alveolar nerves. In this case the primary molars may be anesthetized by infiltration or infraorbital block anesthesia.

d) The middle superior alveolar nerves may be absent. In such a case it is necessary to block the posterior or the anterior superior alveolar nerves.

The posterior and middle superior alveolar nerves may leave the parent trunk at almost the same location. Indeed, the anterior superior alveolar nerve may branch from the posterior extremity of the infraorbital nerve, and it usually leaves the trunk posterior to the midpoint, and is apparently constant in its distribution to the canine and incisors (16), not infrequently supplying the first primary molars (13). There have been several reports of the absence of the middle superior alveolar nerves, the function of these nerves being served by the posterior or anterior superior alveolar nerves (4, 5, 8, 16, 20, 23, 30).

To determine the extent of anesthesia it was necessary to choose a stimulus which was adapted to the physiologic and psychologic responses evoked by dental procedures. The choice of the air-driven carbide bur was based on the criteria of *Hardy, Wolff & Goodell* (12). Although the chosen stimulus did not meet all the enumerated requirements, it routinely produces the noxious stimulus for which practitioners administer local anesthetics, and under the conditions of the present study it is as valid as the more precisely graduated pulp-tester.

If there was evidence of pain a tuberosity injection was given, and the bur reapplied. Anesthesia was determined by the response of the patient. The results were tabulated and subjected to a Chi Square test. The test did reveal a statistically significant result. Under the conditions of the present study, the possibility of anesthetizing the molar teeth was greater than is generally accepted by authorities who stated their results after observing

the deposition of anesthetic solutions on the maxillary tuberosity. This becomes of importance in clinical practice because it is often impossible to anesthetize the first permanent molar by infiltration anesthesia. An examination of Fig. 5 will show that the first permanent molar lies directly under the buttress of the zygomatic process of the maxilla, often called the key ridge. The thickness of bone in this area precludes successful infiltration anesthesia. In later life, the molar may be anterior to this ridge (marked with the black pointing to the molars). Indeed, as *Jorgensen* (18) demonstrated, examination of the maxillae of children and adults will reveal that the former may have a much thicker external plate of cortical bone. In children this thickness of bone may almost obscure the outlines of the roots of the teeth, whereas it is not uncommon to see the roots well outlined in the adult, and often the apices are revealed through perforations in the bone.

Although *Goldberg & Sadove* (11) reported that the placement of the needle was of secondary importance to the spread of the solution, the results of the present study lead to the observation that the reasons that most operators failed in obtaining successful anesthesia of the first permanent molar by means of the tuberosity injection may be two. First, they did not measure the maxillary height to obtain the proper depth of insertion of the needle. Secondly, as pointed out by *Smith* (26) they did not employ a needle in a curved hub. Without such an adaptation it was difficult to pass the needle to the foramina on the curved tuberosity. If the needle was not precisely placed, a soft tissue infiltration anesthetic was the probable result. Because profound and lasting anesthesia of soft tissue structures may cause apprehension in children, with a possible chewing of the oral mucous membrane, it is best administered in conjunction with premedication. The advantage of a precisely placed tuberosity injection is that there is not marked soft tissue anesthesia, particularly in the outer corners of the lips, which children find annoying in the case of a second division or an infraorbital nerve block.

McDaniel (20) and others (23) have pointed out that the nerve supply to the first premolar may be from the anterior superior nerve, while that to the first permanent molar and second pre-

molar may be from the posterior superior alveolar nerve. The present investigation supports such a contention for the primary dentition. An examination of the data presented in the tabulation of the results of the present study indicates that the number of anesthetized first primary molars is considerably less than for the 2nd primary and first permanent molars.

CONCLUSIONS

1. The bony substrate supporting the maxillary molars in the mixed and young permanent dentition often prevents successful infiltration anesthesia of these teeth.

2. The distribution of the superior alveolar nerves to these teeth follows a pattern which may vary among individuals, and bilaterally in a single person.

3. A precisely placed tuberosity injection, using a curved needle in a bent hub, has produced anesthesia of the first permanent and second primary molar with such frequency that it may be suggested as the method of choice when these teeth are to be restored. The first primary molar, in such cases is usually partially and not infrequently totally anesthetized.

SUMMARY

The nerve supply to the teeth of living children was investigated by means of nerve block technics. The maxillary first permanent and primary molars were opened with a dental bur under controlled conditions. If the patient expressed pain, the injection was given by means of a precise, reproducible technic of depositing anesthetic solution on the maxillary tuberosity. Eighty-five such injections were made and the number of teeth anesthetized was recorded, and evaluated by the Chi Square test. No injections were repeated. Some subjects received bilateral tuberosity injections, and it was noted that the innervation of the teeth in the two maxillae might be similar, or dissimilar.

RÉSUMÉ

INNERVATION DE LA PREMIÈRE MOLAIRE SUPÉRIEURE PERMANENTE ET DES MOLAIRES SUPÉRIEURES TEMPORAIRES, D'APRÈS LES INDICATIONS OBTENUES PAR DÉPÔT DE SOLUTIONS D'ANESTHÉSIQUE LOCAL: RAPPORT PRÉLIMINAIRE

L'innervation des dents d'enfants vivants a été étudiée en procédant à des anesthésies tronculaires. La première molaire supérieure permanente et les molaires supérieures temporaires ont été ouvertes à l'aide d'une fraise dentaire dans des conditions déterminées. Lorsque le patient se plaignait de ressentir une douleur, une injection lui était faite, la solution anesthésique étant déposée au niveau de la tubérosité du maxillaire supérieur suivant une technique précise et susceptible d'être reproduite. Quatre-vingt-cinq injections ont ainsi été effectuées, et le nombre de dents anesthésiées a été enregistré et évalué par le test du χ^2. Aucune injection n'a été répétée. Chez quelques sujets, des injections bilatérales au niveau des tubérosités ont été faites, et l'innervation des dents des deux maxillaires supérieurs s'est révélée pouvoir être semblable ou dissemblable.

ZUSAMMENFASSUNG

FESTSTELLUNG DER INNERVATION DER ERSTEN OBEREN BLEIBENDEN MOLAREN UND DER MILCHMOLAREN DURCH DEPONIERUNG VON LOKALANÄSTHETIKA. VORLÄUFIGE MITTEILUNG.

Die Nervenversorgung der Zähne lebendiger Kinder wurde vermittels Nervenblockierungen untersucht. Die ersten bleibenden Molaren und die ersten Milchmolaren wurden mit Bohrer unter kontrollierten Bedingungen geöffnet. Falls der Patient Schmerz fühlte, wurde die Injektion vermittels eines genau reproduzierbaren Verfahrens auf dem Tuber maxillae gegeben. Fünfundachtzig solche Injektionen wurden gegeben, und die Zahl der anästhesierten Zähne wurde vermerkt und laut dem "Chi Square test" geschätzt. Keine Injektionen wurden wiederholt. Einigen Kindern wurden bilaterale Tuberinjektionen gegeben, und es wurde beobachtet, dass die Innervation der Zähne der beiden Seiten gleich oder verschieden sein konnte.

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