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A Hypothesis and Pilot Study of Age-Related Sensory Innervation of the Hard Palate: Sensory Disorder After Nasopalatine Nerve Division

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Background: The nasopalatine nerve may be injured during extraction of teeth embedded in the anterior hard palate. The neural recovery process and its impact on sensation in the anterior hard palatal region are controversial. In our clinical practice, we noticed a distinct recovery process in children compared with adolescents or adults after surgery. We hypothesized that the sensory innervations of the anterior palate might shift during later childhood and pre-adolescence, which is due to the development of the nasopalatine nerve along with the maxillary growth and permanent teeth eruption.

Material/Method: Forty patients (20 females and 20 males, mean age 11.8 ± 2.2) with impacted supernumerary teeth in anterior palatine area were included into our study, and were divided into 3 groups according to their age. A 24-week follow-up was conducted and the sensation in the anterior hard palate region was examined at every check point. All the data were collected and analyzed by Kaplan-Meier analysis.

Results: Fourteen children did not complain of any numbness immediately after anesthetization, and other children with sensory disorders had shorter healing periods compared to adolescent/adult patients.

Conclusions: The results indicated that the dominant nerve of the anterior hard palate region was dramatically changed from the greater palatine nerve to the nasopalatine nerve, which is important in deciding when to operate and in selection of anesthesia method.

MeSH Keywords: Child Development • Recovery of Function • Surgical Flaps • Tooth, Supernumerary

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Background

During surgical extraction of anterior palatal embedded teeth, which are bony impacted supernumerary teeth or canines, the palatal mucoperiosteal flap is a popular approach in most cases, considering the need for protecting adjacent teeth and general viewing. However, the number, shape, direction, and exact position of supernumeraries vary among patients, and the relation with adjacent structures also needs to be determined. If supernumeraries are hidden behind the nasopalatine canal [1], the nasopalatine bundle might be either traumatized or electively divided during surgery [2]. The effect of nasopalatine nerve division then becomes the key factor with which clinicians are concerned.

Previous studies have investigated the relevance of the nasopalatal nerve and sensation in the anterior palatal area after surgery. Langford et al. reported a considerable overlap in the receptive fields of the nasopalatine and anterior palatine nerves, with the latter dominating in this area. Their study revealed that surgical division of the nasopalatine nerve produced no sensory deficit in the patients [2]. However, Filippi showed that all patients exhibited objective sensory disorders by the 1-week postoperative follow-up exam. Furthermore, no symptoms of subjective or objective sensory disorders were undetectable in any patients after the 4-week postoperative exam, and younger patients recovered sensation faster [3]. Therefore, the role of the nasopalatine nerve in sensation of the anterior palatine area is disputed, as are the mechanisms of sensation recovery and nerve regeneration.

In clinical practice we noticed that children have a recovery process different from that of adolescents and adults following palatal mucoperiosteal flap surgery. In some 7–8-year-old children whose nasopalatine nerves were transected during surgery, sensation in the anterior palatine area recovered immediately following the effects of the anesthetic. More importantly, adolescents recovered nearly as quickly, implying nerve distribution and re-innervations mechanism might different between children and adolescents.

These clinical observations led us to hypothesize that the sensory innervations of the anterior palate might shift during later childhood and pre-adolescence, due to development of the nasopalatine nerve along with maxillary growth and eruption of permanent teeth. If this hypothesis is confirmed, patient stage of development should be considered as an important element in planning anesthesia and choosing the time of surgery.

To test this hypothesis, we collected clinical data to verify that the innervation of the anterior hard palate changes with patient age.

Figure 1. The panoramic radiograph. The images of supernumerary teeth are usually blurred.

Material and Methods

Study design

The aim of this study was to determine if the dominance of the nasopalatine nerve over the palatal sensation changes with age.

The study population included 40 patients with embedded supernumerary teeth in the anterior hard palatal area (verified by panoramic radiographs or periapical film, Figure 1) and who had been treated in the Oral and Maxillofacial Surgery Clinic at West China Hospital of Stomatology, Sichuan University, between 2010 and 2015.

All patients chosen were in accordance with these inclusion criteria: with at least 1 supernumerary tooth embedded between the incisor canal and roots of incisors, which needed nasopalatal nerve disconnection during the operation; without any systemic diseases; females not menstruating; and not on any medications. Patients were divided into 3 group according to age: the Child group, the Juvenile group, and the Adolescent/Adult group.

Considering of its 3D imaging ability [4], cone beam computerized tomography (CBCT) scans were performed in all cases to display the spatial relation between the embedded tooth and the nasopalatine canal. All CBCT scans were taken by an experienced radiologist using an Accuitomo 3D device (Morita, Kyoto, Japan) under an extended field of view mode (100×100 mm). The scanning time was 17.5 s, with 85 kV tube voltage and 4 mA tube current, and 0.25 mm voxel size. i-Dixel was used to view the images (Figure 2).

The palatal mucosa sensation was tested as the basal line using the “Touch-Test Sensory Evaluators” (North Coast, USA). The area of mucosa tested was divided into the 5 mm directly adjacent to the crown of each tooth and including the gingival margin, and a further 5 mm of mucosa extending apically (Figure 3). All tests were carried out by the same operator. The touch sensation was investigated and evaluated using

Figure 2. The supernumerary teeth in the nasopalatine canal.

Figure 3. (A) The palatal mucosa was divided into 6 zones according to adjacent teeth. (11 zone, 12 zone, 13 zone, 21 zone, 22 zone and 23 zone). (B) The sensory threshold values were tested by the Touch-Test Sensory Evaluators. (C, D) Touch-Test Sensory Evaluators.

Figure 4. The surgery process of extraction of the supernumerary teeth, and the nasopalatine nerve was cut off during surgery.

the Touch-Test Sensory Evaluators with bending forces ranging from 0.02 to 15 g, following the manufacturer's instructions. Briefly, before the test, clinicians explained the testing procedure to the patient carefully to ensure the patients understood. As Touch-Test, clinician pressed the filament of the evaluators at a 90° angle against the mucosa of the palate until it bows, and held it in place for 1.5 s. The patients were asked to respond by raising the left hand when the stimulus was felt. The scores were recorded when the stimulus was felt. All the data were recorded as the baseline [2].

All surgical procedures were performed by an experienced surgeon under local anesthesia (2% lidocaine with 1: 100 000 adrenaline). The supernumerary teeth were exposed and extracted by the palatal flap approach. The nasopalatal nerves in all patients were transected [3] (Figure 4). The full palatal flap was replaced after the operation. All patients involved this study accepted standard peri-operative care, including antibiotics use (amoxicillin, 20 mg/kg, q 8 h, P.O. from 1 h before surgery to 24 h after surgery), compound chlorhexidine gargle until 7 days after surgery, postoperative examination, and printed postoperative notes and directions. All of them were invited to attend follow-up examinations scheduled at 1 day, 1 week, 4 weeks, 8 weeks, 12 weeks, 20 weeks, and 24 weeks after the operation. All patients except the 6 defaulters were recalled at every checkpoint, while the objective sensory change was tested using the same method described above, and compared with the baseline. The palate mucosa was divided into 6 parts according to the adjacent tooth (11 zone, 12 zone, 13 zone, 21 zone, 22 zone, and 23 zone). Each zone represented 1 point, the mucosa of each zone received a sense test 3 times, and if the 3 scores were all bigger than baseline, we concluded there was mucosal paresthesia in this area, and 1

point was scored, with a full score being 6. The score of sensory disorders were also recorded.

The data were analyzed by Kaplan-Meier analysis using SPSS 19.0.

Results

Forty-six patients with embedded supernumerary teeth were recruited. All of them received tooth extraction for preventive or therapeutic purpose. Six of them did not finish the follow-up. The remaining 40 patients (20 females and 20 males; mean age 11.8 ± 2.2) were divided into 3 group according to their ages: the Child group (13 patients, mean age 9.4 ± 0.7); the Juvenile group (21 patients, mean age 12.2 ± 0.7); and the Adolescent/Adult group (6 patients over the age of 14 years, mean age 15.5 ± 0.8). No postoperative infections were found in our study.

Since the nerves were cut off during the procedure, we supposed that the sensation of the operative site should be abnormal. However, 14 patients complained only of pain without numbness around the surgery area at 1 day after the operation, and no subjective or objective sensory disorders were reported 1 week later.

The numbers of patients with sensory disorders of each group at each time point was recorded (Table 1), and the data were analyzed by K-M analysis (Figure 5). The recovery of sensation of the youngest group was more rapid than that of the other 2 groups ($p < 0.05$). The area with sensory disorder was also evaluated by Touch-Test (6 points detected in each patient), and the results are presented in Table 2.

Briefly, 1 week after the operation, except for the 14 patients mentioned above, the rest had suffered from various degrees of sensory disorders. The hypoesthetic zone extended from the incisor papilla area to the palatal mucosa of anterior teeth. The hypoesthetic areas of older patients were wider than those of younger patients.

At the end of 4 weeks postoperatively, the number of patients with sensory disorders declined to 3 (3/13) and 7 (7/21) in Group 1 and Group 2, respectively. However, all patients (6/6) in the adolescent/adult group were still complaining of numbness, while the hypoesthetic range became narrower than at the first week.

After 8 weeks, sensory function in the operative area in Group 1 had recovered completely. Eight patients had sensory disorders: 5 in Group 2 (5/21) and 3 in Group 3 (3/6).

Table 1. Patients with palatal numbness/Total Patients, the number of patients with palatal numbness decreased with time in all three group, and all patients recovered at last. The healing speed of patients in group 1 was quickest among the 3 groups.

	Group 1 (Age, 7–10)	Group 2 (11–14)	Group 3 (14–)
1 Day	9/13	11/21	6/6
1 Week	9/13	11/21	6/6
4 Week	3/13	7/21	6/6
8 Week	0/13	5/21	3/6
12 Week	0/13	2/21	3/6
20 Week	0/13	1/21	2/6
24 Week	0/13	0/21	0/6

Figure 5. The analysis result of patients with sensory disorder, using K-M curve.

Figure 6. The analysis result of numb points using K-M curve.

Table 2. A/B: The sensation of palatal mucosa was tested at different time point after operation, the mucosa of palate was divided into 6 parts according to the anterior tooth (11 zone, 12 zone, 13 zone, 21 zone, 22 zone and 23 zone). Each zone represented one point, when the mucosa of the certain zone was diagnosed paresthesia, the patients get one point, full score is 6.

	Group 1 (Age, 7–10)	Group 2 (11–14)	Group 3 (14–)
1 Day	25/(9×6=54)	51/(11×6=66)	32/(6×6=36)
1 Week	22/(9×6=54)	49/(11×6=66)	31/(6×6=36)
4 Week	7/(9×6=54)	20/(7×6=66)	24/(6×6=36)
8 Week	/	10/(5×6=66)	9/(3×6=36)
12 Week	/	4/(2×6=66)	5/(3×6=36)
20 Week	/	1/(1×6=66)	3/(6×6=36)
24 Week	/	/	/

A(numerator) – the score of patients with paresthesia, e.g: There were total 25 test points showed numbness in group 1 at 1st day after operation, so A=25. B(denominator) – full marks. E. g: There were 9 patients complained numbness in group 1 at 1st day after operation, so the theoretically full marks B=9×6=54.

During the following check points, sensation recovered gradually, and the patients in Group 2 were better than Group 3. There was no objective or subjective sensory disorder detectable in any patients after 24 weeks. According to the results of K-M analysis (Figure 6), children (Group 1) recovered faster than older patients (Groups 2 and 3) ($p < 0.05$).

Discussion

Supernumerary teeth, also called hyperdontia, are characterized by the presence of more teeth than are found in primary or permanent dentition. The incidence of supernumerary teeth ranges from 0.1% to 3.6% [5–7]; 90–98% of all supernumeraries are found in the maxilla, and the anterior region appears to be the site of predilection [8,9]. Clinical complications caused by supernumerary teeth include abnormal eruption (delayed eruption or impacted, displacement or rotation and crowding of adjacent teeth, retained primary teeth, and ectopic eruption), odontogenic cyst or tumor, root resorption of adjacent teeth, and bone destruction [10–13]. The removal of supernumerary teeth is the preferred treatment method in most circumstances.

The palatal operative approach, as a convenient way to deal with embedded teeth, has been widely used for anterior hard palatal region embedded teeth extraction [2]. In some cases, the nasopalatine nerve needs to be transected during the operation, which might lead to sensory disorders in the anterior hard palatal region.

However, the innervations and sensory recovery after surgery in this area are controversial. Langford and de Jongh reported that the nasopalatine nerve has limited influence on sensation in the anterior hard palatal region. In contrast [2], Filippi's results indicated variations in nerve distribution and recovery ability in different patients [3]. Additionally, the relationship between patient age and the recovery period was considered due to the regenerative ability of the nasopalatine nerve. It is intriguing that re-innervation was completed in a few weeks, inconsistent with the mechanism of nerve regeneration.

All patients in our study received nasopalatal neurectomy during the operation; therefore, we considered this nerve was in a nonfunctional state. Moreover, 14 patients (mainly in the Child group) did not complain of numbness around the surgery area immediately after anesthetization. When we cut the nasopalatine nerve off during operation, the neural stump immediately retracted into the canal, leaving the faint possibility of neuragenesis, especially at such a limited stage. Hence, the reasonable explanation is that sensation in the anterior hard palatal region in these young patients might be innervated to a large degree by the anterior palatine nerve. It is interesting

that such an instant recovery did not occur in older patients (the adolescent/adult group).

Based on the present results and taking into account all the former studies, we hypothesize that the receptive fields of the nasopalatine nerve change with development of the anterior maxilla. The occurrence rate of palatal mucosa sensory disorder after nasopalatine nerve division is different between younger patients (7–14 years) and older patients (over age 14). It seems that the overlap of the nasopalatine and anterior palatine nerve changes with age and persists throughout the growing period. At an early age, sensation in the anterior palatal mucosa is dominated by the anterior palatine nerve only. For most people, the nasopalatine nerve begins to take over the function of the anterior palatine nerve gradually from a particular point in time (e.g., 12–14 years old). But for some other people, sensation in the anterior palatal mucosa will be innervated by the anterior palatine nerve at some point in their lifetime.

Based on this hypothesis, we performed bilateral greater palatine nerve block instead of nasopalatine nerve block during the operation in younger patients in our study, and achieved satisfactory anesthetization. However, if we conducted greater palatine nerve block only, older patients usually complained of pain during the operation, which also supports our hypothesis.

The embryonic and adolescent period are 2 growth spurts in human life [14]. The maxillofacial region also has an accelerative stage of development around the adolescent period, including replacement of dentition and development of maxillofacial bone, and even the secondary development of nerves.

Children younger than 7 years old could not cooperate well with surgery, so the anesthetic effects are difficult to evaluate. Furthermore, because of inadequate inclusion of patients, the groups were not precisely divided according to tooth age, which made our result a hypothesis rather than a conclusion. Further studies with larger sample sizes are needed to test this hypothesis, which could lead to development of better anesthesia methods and help select the best time at which to perform surgery in the anterior hard palatal region.

Conclusions

Our results imply a surprising transition in which innervations of the anterior hard palate are shifting with age, which means the sensation in the anterior hard palate is relayed from the anterior palatal nerve to the nasopalatine nerve, accompanied by the development of hard palate and tooth eruption. This transition might be an important factor in choice of anesthesia method and operation timing. It also suggests a

secondary neuro-development from later childhood to pre-adolescence. Further studies are needed to determine more details of this transition.

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Conflicts of interest statement

The authors declare that they have no conflict of interest in any matter related to this work.