Original Contributions

Nutrient canals and porosity of the bony palate

A basis for the biological plausibility of the anterior middle superior alveolar nerve block

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ABSTRACT

Background. The authors investigated morphologic parameters of the palatal cortex that affect the diffusion of local anesthetic solution in the region of the anterior middle superior alveolar (AMSA) nerve block injection site.

Methods. The authors used computed tomographic (CT) and micro-CT imaging to assess 20 human skulls from an anatomic collection. Analysis of the CT images included frequency, distribution, and width of the nutrient canals in the bony palate, according to to the person's sex and age. Micro-CT analysis involved measuring the thickness and porosity of palatal cortical bone in the area of the AMSA injection site in relation to the thickness and porosity of the opposite buccal cortical bone.

Results. There was a statistically significant difference ($P = .042$) in the location of the nutrient canals between male specimens (> 50% in the border region) and female specimens (> 50% in the palatal process). Furthermore, the female skulls had significantly wider nutrient canal foramina ($P = .042$) than did the male skulls. Despite greater thickness, the palatal cortex in the area of the AMSA injection site had slightly greater porosity than did the buccal cortex. A significantly greater number of microcanals penetrated the whole cortical thickness in palatal than in buccal cortical bone ($P = .001$).

Conclusions. The distribution and width of nutrient canals differed between male and female skulls. At the microscopic level, structural characteristics of the palatal cortex provide a good anatomic basis for the potential of a satisfactory AMSA injection success rate.

Practical Implications. The AMSA technique success rate might be increased if the clinician adjusts the injection site to the distribution of nutrient canals, depending on the sex of the patient.

Key Words. Bone; anesthesia; dental; maxilla; nerve block; palate; nutrient canals; porosity.

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Dental procedures involving multiple teeth with surrounding soft and bone tissue in the maxilla may require up to 5 injections to achieve proper anesthesia: greater palatine, posterior superior alveolar, middle superior alveolar (MSA), anterior superior alveolar (ASA), and nasopalatine nerve blocks.[1] Although effective, these techniques result in an increase in injection discomfort, as well as in the volume of drug administered.[2] In addition, superfluous soft-tissue anesthesia is inconvenient for the patient, in the sense that it negatively affects speaking, eating, and smiling and poses a risk of leading to self-inflicted trauma.[2-4] To minimize these inconveniences and reduce the number of injections, a relatively new technique—anterior middle superior alveolar (AMSA) nerve block—has been proposed for maxillary procedures and is capable of anesthetizing both the ASA and MSA nerves, as well as palatal nerve branches in that region.[4-6] The confluence area of the ASA and MSA nerves (or between the ASA and posterior superior alveolar nerves when the MSA nerve is absent) and associated subneural dental plexus in the region of the apexes of the premolars are the target site for the AMSA injection.[1,4-7] The recommended injection site is located palatally, at the intersection of a vertical line bisecting the premolars and a horizontal line halfway between the midpalatine raphe and the crest of the free gingival margin.[2] Another description is that the injection site can be located conveniently at approximately halfway between the midline and the crest of the interdental gingival papilla of the 2 maxillary premolars.[8]

Investigators have reported that the AMSA injection anesthetizes the maxillary teeth extending from the mesiobuccal root of the first molar to the central incisor, the entire palatal gingiva to the midpalate, the buccal gingiva from the mesiobuccal root of the first molar to the central incisor, and the surrounding alveolar bone.[4,5] Because of its anesthetic effect after a single needle penetration, minimal dosage of anesthetic solution, and ability to avoid collateral anesthesia and lip numbness, the AMSA nerve block injection has become a promising anesthetic technique for multiple teeth in the maxilla.[8] This technique could be useful in patients with some systemic diseases in whom anesthesia of multiple teeth is required and anesthetic dose should be taken into account.[4,5]

However, there is growing evidence that the AMSA technique's efficiency is too unpredictable for it to be recommended as a first choice for clinical use.[9,10] It seems that the pattern of anesthesia achieved with the AMSA technique generally has moderate to low success rates; a slow, gradual onset of pulpal anesthesia; and decreasing effectiveness over 60 minutes.[9,10] These confounding factors diminish the quality of the effectiveness of the pulpal anesthesia. The use of computer-controlled injection systems result in improved AMSA technique success.[11-13] However, results from previous clinical studies of AMSA technique success are not supported by using analysis of anatomic features of the palatal cortex in terms of the distribution of the nutrient canals and porosity.[6-12] It is reasonable to assume that those parameters may influence the diffusion of local anesthetic solution considerably.[5,6] Also, because the biological plausibility of the AMSA injection is based on the penetration of the anesthetic solution into the palatal tissues and diffusion via numerous nutrient canals and pores in the cortical bone of the maxilla, the anesthetic efficiency could be influenced by variations of the nutrient canals, as well as the porosity and thickness of the palatal cortex. These anatomic and structural differences could be individually variable and might depend on the patient's sex and age.[13,14]

Therefore, our aim in this study was to analyze the anatomic features of the palatal cortex that could be responsible for the biological plausibility of the AMSA anesthetic technique: frequency, distribution, and width of the nutrient canals in the alveolar and palatal maxillary processes with regard to patients' sex and age. In addition, we assumed that architectural characteristics of the palatal cortex on a microscopic level might affect the degree of local anesthetic diffusion. Thus, we assessed the microstructure of the palatal cortical bone in the area of the recommended injection site via micro—computed tomographic (CT) analysis and compared it with that of the buccal cortical bone.

METHODS

This study comprised bone samples from the skeletal collection of the Laboratory for Anthropology, Institute of Anatomy, School of Medicine, University of Belgrade, Belgrade, Serbia, that were derived from a medieval archaeological context in Serbia. This study received formal ethical approval from the Ethical Comitee of the School of Dentistry, University of Belgrade (registered under 36/5, 5.2.2015).

Anthropological analysis

We performed anthropological analysis in the for Laboratory for Anthropology. We followed standard osteological procedures to estimate age at death and determine the sex of each skeleton.[15,16] After a careful inspection of the 26 preserved skulls in the skeletal material, especially their maxillary bones, we excluded 6 skulls with detected signs of fracture lines, pathologic changes (cysts, tumors, fistulas, and so on), or other minor damage from the study, and we selected 20 skulls for further analysis. Ten skulls were male, and the other 10 were female. The skulls were from 3 age groups: juvenile, aged 15 through 20 years; adult, aged 21 through 40 years; and mature, aged 41 through 60 years.

CT imaging

We imaged the 20 selected skulls with a multisection CT scanner (SOMATOM Sensation 16, Siemens). We scanned the skulls with 2 series: one without contrast material and another with

ABBREVIATION KEY

AMSA: Anterior middle superior alveolar.
AP: Alveolar process.
ASA: Anterior superior alveolar.
BZ: Border zone.
CT: Computed tomographic.
MS: Maxillary sinus.
MSA: Middle superior alveolar.
NA: Not applicable.
NS: Nasal cavity.
PP: Palatal process.