Bull Group Int Rech Sci Stomatol et Odontol - Vol 38 n° 1-2, 1995

Anatomical considerations relevant to implant procedures in the mandible

O. OBRADOVIĆ*, L. TODOROVIC*, V. VITANOVIC**

* *Oral Surgery Clinic, Faculty of Stomatology, Dr Subotica 4, Beograd, Yugoslavia.*
** *Private practice, Beograd, Yugoslavia.*

SUMMARY

The authors review anatomical facts significant for preoperative planning of implant procedures in the mandible. This planning includes the precise evaluation of distinct anatomical factors, such as the position of the mandibular canal, the width of the mandibular cortical plates and the degree of involutive changes of the inferior dental artery.
The mandibular canal is usually situated centrally in the mandibular corpus, slightly closer to the lingual cortex in its distal parts; towards the front, it approaches the vestibular cortical layer. Mesially from the mental foramen, a clearly defined incisive canal is present in only one third of the edentate mandibles.
Mandibular corpus of the edentate mandibles consists of cancellous bone enclosed by a shell of compact cortical bone. Cortical layers demonstrate significant variations in width; nervertheless, the widths of lateral cortical layers, generally, enable safe placement of endosseal implants.
Finally, in patient's preoperative assessment, involutive changes of the inferior dental artery should also be considered. During the involution of the mandibular alveolar process, it shows changes of direction and calibre, changes in arborization and, sometimes, complete occlusion of the main trunk. The degree of these involutive changes points out the mandibular vascular supply and the regenerative capacity of the tissues needed for the success of the implant procedure.

KEY WORDS:

Mandible - Oral implantology.

RÉSUMÉ

Les auteurs passent en revue les faits anatomiques importants qu'il convient d'avoir à l'esprit en établissant le programme préopératoire pour la mise en place d'implants dans la mandibule.
Ce programme inclut l'évaluation précise des différents facteurs anatomiques tels que la position du canal mandibulaire, la largeur de la corticale mandibulaire et le degré des changements involutifs de l'artère dentaire inférieure.

Le canal mandibulaire est habituellement situé au centre du corps mandibulaire, très proche du cortex ventral dans ses portions distales; vers l'avant, il s'approche de la corticale vestibulaire. Mésialement par rapport au foramen mentonnier, un canal incisif bien défini est présent uniquement dans seulement un tiers des mandibules édentées.
Le corps mandibulaire des mandibules édentées consiste en un os réduit entouré par un os cortical de type compact. Les couches corticales démontrent des variations de largeur significatives; néanmoins, les largeurs des couches corticales latérales, permettent généralement le placement d'implants endo-osseux en toute sécurité.
Enfin, au cours de l'établissement du programme préopératoire du patient, les changements involutifs de l'artère dentaire inférieure devraient également être prises en considération. Au cours de l'involution du processus alvéolaire de la mandibule, cette artère montre des changements de direction et de calibre, des changements de l'arborisation et quelquefois, une complète oblitération de son tronc principal. L'importance de ces changements involutifs, met l'accent sur la suppléance vasculaire de la mandibule et la capacité régénérative des tissus nécessaires pour le succès de la mise en place des implants.

MOTS CLÉS:
Mandibule - Implantologie orale.

INTRODUCTION

Preoperative planning is the essential part of an endosseal implantation procedure. When considering the implant procedure in the partially or totally edentate mandible, the precise evaluation of distinct anatomical factors, such as the position of the mandibular canal, the width of the cortical plates and the degree of involutive changes of the inferior dental artery, is included. The final decision regarding the indication for implantation procedures depends on careful assessment of these anatomical details, as well as the choice of the appropriate type and design of endosseal implant.

POSITION OF THE MANDIBULAR CANAL

The mandibular canal (MC) is the main canal of the mandible which commences with the foramen at the inner side of the mandibular ramus, runs downwards, then forwards, under the lower teeth roots and ends by dividing into mental and incisive canals. From the mandibular foramen, the MC winds to the mental foramen in a double S-shaped curve, mainly placed closer to the lingual than to the buccal side of the mandible (Reich, 1980; Obradovic et al., 1991). The MC, as well as its branches, contains the main neuro-vascular bundle of the mandible — the inferior alveolar nerve and the same-named blood vessels (Williams and Warwick, 1980).

In the region of the mandibular corpus, which is especially significant for the implantation procedure, the average diameter of the MC was 2.6 mm, with a thin wall of cortical bone. It was situated more lingually in the molar region (Tab. I); towards the front, however, the MC approached the vestibular cortical plate, being closest to it in the region of the second premolar (Obradovic et al., 1993). Similar relationships of the MC and both cortical plates existed also in edentate jaws, although the MC was, generally speaking, situated more centrally in those cases.

Considering the vertical dimension, the position of the MC in edentate mandibles depends primarily on the degree of bone resorption. The MC is mostly in the central position in mandibular corpus (Fig. 1), but in 21% of the cases it was found in the upper part of the mandibular corpus (Todorovic et al., 1982), a fact that is of great clinical significance especially when the mental foramen is at the crest of the alveolar ridge (Fig. 2). This possibility emphasizes the significance of careful preoperative assessment of every implant candidate.

Mesially from the mental foramen, a clearly defined incisive canal was present in 92% of the dentate mandibles but only in 31% of the edentate ones. The average diameter was 0.9×0.4 mm in edentate ones. In these, the incisive canal was clearly defined only in a small number of cases and could hardly be noticed in poorly spongious bone of the resorbed mandible. However, it was sometimes clearly visible even in edentate mandibles.

TABLE I: Distances between mandibular canal and outer bony surfaces of edentate mandibles *.

TABLEAU I: Distances entre le canal mandibulaire et les surfaces osseuses externes dans les mandibules édentées.

Mandibular corpus	Buccal side	Lingual side	Mandibular base
Distal region	4.2	1.8	3.2
Central region	5.5	2.2	3.4
Premolar region	3.1	2.3	3.7

* Mean values in mm.

In regard to outer cortical plates, the incisive canal was, on the whole, situated more lingually, which was especially characteristic for the frontal segment.

Fig. 1: The mandibular canal centrally positioned in a specimen of edentate mandible.
Fig. 1: Le canal mandibulaire en position centrale dans exemple de mandibule édentée.

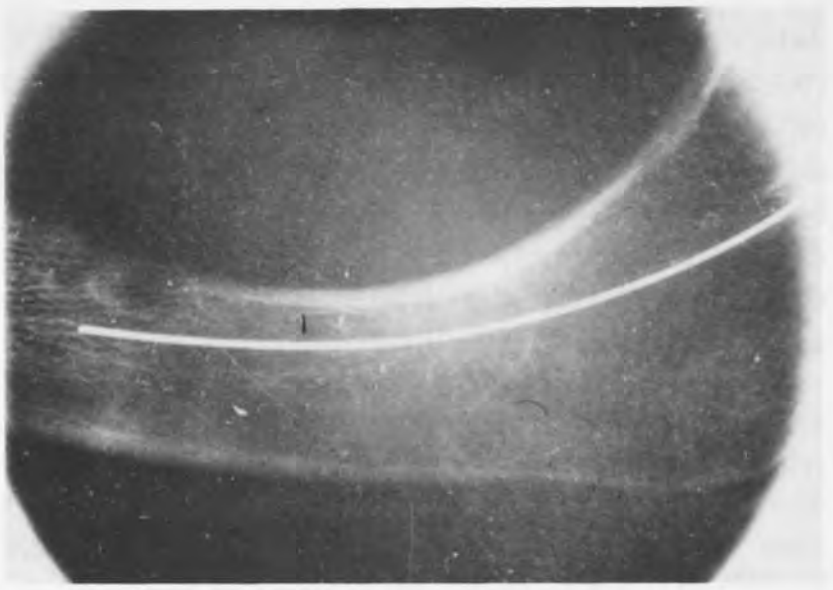

Fig. 2: Several positions of mandibular canal in the mandibular corpus: a. the upper position; b. the central position; c. the lower position.
Fig. 2: Diverses positions du canal mandibulaire dans le corps mandibulaire: a. position supérieure; b. position centrale; c. position inférieure.

This was less marked in edentate mandibles (Tab. II). For the implantation procedure, it is especially significant that the incisive canal, if present, is situated in the upper third of the alveolar bone. To avoid the injury of the neurovascular bundle in that segment, the implant should be placed slightly more vestibular from the central (vertical) axis of the alveolar ridge.

TABLE II: Distances between incisive canal and outer bony surfaces of edentate mandibles *.

TABLEAU II: Distances entre le canal incisif et les surfaces osseuses externes dans les mandibules édentées.

Region	Buccal side	Lingual side	Mandibular base
Frontal (incisors)	4.7	5.4	11.2
Lateral (canine-premolar)	5.4	4.3	13.3

* Mean values in mm.

COMPOSITION OF BONE AND THE WIDTH OF CORTICAL LAYERS

Mandibular corpus of the edentate mandibles consists of cancellous bone enclosed by a shell of compact cortical bone. Cortical layers demonstrate significant variations in width, especially at the inner and outer side of the corpus. The density of cancellous bone, however, is less distinguished in edentate than in dentate mandibles. From the median line backwards, the width of inner and outer cortical layers proportionally change: at the symphyseal region the inner (lingual) cortical layer is much wider than the outer one, but going backwards, the outer cortical layer widen while the inner one narrows (Tab. III).

TABLE III: The widths of mandibular cortical layers of edentate mandibles *.

TABLEAU III: L'épaisseur des couches corticales mandibulaires dans des mandibules édentées.

Region	Buccal cortex	Lingual cortex	Base
Frontal	1.26	2.98	5.46
Canine	1.58	1.18	3.96
Premolar	2.45	2.95	3.80
Molar	3.72	3.10	3.43

* Mean values in mm.

The cortical layer is on the average the widest in the molar region of edentate mandibles, especially at the buccal side — furthest distally, in the region of the extracted third molar, buccal cortex measured even 4.2 mm. Basal cortical layer is, however, widest in the frontal region, where the greatest width of all cortical layers was measured (6.26 mm). The upper cortical layer, at the alveolar ridge of the mandible is generally not very distinct, its margins to cancellous bone often being vague.

SIGNIFICANCE OF INVOLUTIVE CHANGES OF THE INFERIOR DENTAL ARTERY

Atrophic changes in the mandible during lifetime, especially after tooth loss are sometimes so unproportional that they cannot be explained only by simple senile atrophy and undoubtedly existing osteoporosis. Tooth loss and accompanied functional changes are certainly among the most important factors exerting influence on the mandibular alveolar process involution. However, changes in the inferior dental artery (IDA) and its branches obviously indicate that the arterial vascular system not only takes part in that involution, but possibly precede it (Obradovic et al., 1988; Obradovic et al., 1989).

Changes of the IDA during the mandibular involution can be classified into three groups: a. changes of direction and calibre; b. changes in arborization and c. occlusion of the main trunk (Todorovic et al., 1982).

In elderly patients, especially if atrophic changes of the mandible are extensive, the IDA is almost always winding, both in its extramandibular and intramandibular part. By involution of the alveolar process, the calibre of this artery becomes irregular and, on the whole, reduces from its proximal to distal part.

Dental branches disappear after the loss of teeth, although some of them may persist afterwards, probably taking on the diploic function. In any case, the loss or cutting of dental branches of the IDA is a characteristic feature of the involutive process of the mandible.

The IDA, in most of the cases (42%), was filled by contrast considerably less than the neighbouring arteries of similar diameter (Todorovic et al., 1982). In more than a third of the cases (35%) the intramandibular part of the IDA could not be identified at all, and in a fifth of the cases (23%) it was absolutely impossible to identify it on carotid arteriograms.

Histologic analysis of the IDA revealed arteriosclerotic changes, sometimes even unproportional to age. In any case, in edentate mandibles of aged people, massive arteriosclerotic proliferation of intima cells and thickening of elastic elements in the middle layer of the arterial wall were found, producing even complete occlusion, especially in small diploic branches of the IDA. These changes favour a hypovascularization of the mandible, a fact which could interfere with the success of an implantation procedure.

DISCUSSION

Changes of anatomical characteristics of the mandible arising after tooth loss exert influence not only upon the normal function of the stomatognathic system, but also upon planning surgical or any implantation procedure needed for successful prosthetic rehabilitation of the patient. According to this, the position of the MC, composition of bone and the width of cortical layers, as well as the involutive changes of the IDA are especially significant.

Fate of the alveolar process after tooth loss and position of the MC and mental foramen are essential when deciding to undertake the implantation procedure. During the placement of endosseal implant the MC should not be damaged or compressed as constant pressure upon the inferior dental nerve would interfere with its function. If the MC wall happened to be ruptured during preparation of the implant bed, its content would certainly be damaged demonstrating immediately excessive bleeding, or later, pain, paraesthesia or anaesthesia in the innervation region of the inferior dental nerve.

Similar complications occur when only a bone fragment, not the implant itself, is pressed into the canal, as well as when the subperiosteal implant compresses the mental nerve.

The position of the MC in an edentate mandible is determined by the degree and pattern of the alveolar process resorption. The MC is usually centrally positioned in the mandibular corpus, slightly closer to the lingual cortical plate in transversal section. To place an endosseal implant sufficiently deep into the bone tissue without damaging the MC content, the burs should be orientated in vestibular direction as much as possible during the implant bed preparation. The precise preoperative evaluation of the position of the MC, as well as the incisive canal, significantly influence the choice of the appropriate implant system, the surgical technique and, finally, the success of the implantation procedure itself.

An endosseal implant should be burried deep into the bone, but without breaking the integrity of the lateral cortical layers or the mandibular base. The width of the lateral cortical layers of the mandible, mainly, enable safe placement of the implant; however, in the frontal part of the mandible, especially in the canine region, the vestibular cortical layer can be thin and should not be broken in an attempt to avoid the damage of the incisive canal.

Finally, in the preoperative assessment of indications for endosseal implantation procedure in the mandible, involutive arteriosclerotic changes of the IDA should also be kept in mind. These changes not only contribute to the alveolar process involution, but also, at least indirectly, point out the degree of mandibular vascularization and expected effectiveness of osseointegrative processes, ie. acceptance of the implant.

Precise preoperative evaluation of the above mentioned anatomical characteristics and relationships in the mandible should be the basis for selecting the implant candidate and determinating a suitable treatment plan for the implantation procedure.

REFERENCES

[1] **Bogdanovic, D., Obradovic, O., Teofilovski, G., Pesic, V., Todorovic, Lj.** — Position and shape of neurovascular channel of the incisive region of human mandible in adults. *Acta Biol. Med. Exp., 10:* 1-4, 1985.

[2] **Obradovic, O., Bogdanovic, D., Cvetkovic, D., Pesic V., Petrovic, V., Dozic, S.** — Altérations atherosclereuses de l'artère dentaire inférieure en corrélation avec celles de la bifurcation carotidienne et de l'aorte abdominale. *Bull. Group. Int. Rech. Sci. Stomatol. et Odontol., 32:* 105-110, 1989.

[3] **Obradovic, O., Bogdanovic, D., Cvetkovic, D., Petrovic, V., Pesic, V.** — Altérations de l'artère dentaire inférieure en relation avec l'âge. *Bull. Group. Int. Rech. Sci. Stomatol. et Odontol., 31:* 165-176, 1988.

[4] **Obradovic, O., Bogdanovic, D., Pesic, V., Petrovic, V., Pejkovic, B.** — Les rapports du canal mandibulaire avec les faces externes du corps de la mandibule et risques qui en découlent de le leser. *Bull. Group. Int. Rech. Sci. Stomatol. et Odontol., 34:* 89-93, 1991.

[5] **Obradovic, O., Todorovic, Lj., Pesic, V., Pejkovic, B., Vitanovic, V.** — Morphometric analysis of mandibular canal: Clinical aspects. *Bull. Group. Int. Rech. Sci. Stomatol. et Odontol., 36:* 109-113, 1993.

[6] **Reich, R.H.** — Anatomische Untersuchungen zum Verlauf des Canalis Mandibularis. *Dtsch. Zahnaerztl. Z., 35:* 972-975, 1980.

[7] **Todorovic, Lj., Bogdanovic, D., Obradovic, O.** — Involution of the mandibular alveolar process and dental branches of the inferior dental arery. *Bull. Group. Int. Rech. Sci. Stomatol. et Odontol., 25:* 65-71, 1982.

[8] **Williams, P.L., Warwick, R.** (ed.) — Gray's Anatomy. 36th ed., Churchill Livingstone, London, pp. 315-318, 1990.

Address for correspondence:
Prof. dr Ljubomir Todorovic,
Faculty of Stomatology,
Oral Surgery Clinic,
FAH 506,
Dr Subotica 4,
11000 Beograd,
Yugoslavia.