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Traumatic Damage to the Inferior Alveolar Nerve Sustained in Course of Dental Implantation. Possibility of Prevention

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SUMMARY

The results of inferior alveolar nerve functional state investigation for 383 patients after dental implantation are presented in the article. Besides, structural and anatomical variations of the mandible and its canal that is of significant importance in planning dental implantation, based on the analysis of mandible ortopantomograms of 750 patients as well as the referral data are showed.

Traumatic injury of the inferior alveolar nerve following dental implantation is found in 17.75% of cases. According to the type of the functional disturbance of the nerve and the dynamics of its recovery, which objectively may be assessed using sensography, three grades of the nerve injury have been estimated: the first type or mild nerve damage is found to 9.92 % of patients, the second or moderate damage – 7.05%, the third type or severe damage – in 0.78% of cases.

The subjective clinical symptoms of the injury of inferior alveolar nerve relieve more rapidly and nerve function recovers faster if the following treatment is applied: in the first type cases – administration of NSAID, antihistamine (or glucocorticoides), vasodilatators, diuretics, B group vitamins; in the second type cases; a good therapy effect is gained if the above mentioned treatment is proceeded after nerve decompression; in case of the third type nerve injury the removal of dental implant and symptomatic treatment is recommended.

The prevention of traumatic injury of inferior nerve is proper and rational planning of implantation method, in accordance with the anatomical features of the mandible and individual variations of the topography of mandible canal.

Key words: inferior alveolar nerve, traumatic injuries of peripheral nerves, neurological complications of dental implantation.

INTRODUCTION

The inferior alveolar nerve (IAN) is often injured in course of dental implantation.

The injury is followed by certain clinical symptoms that have a negative effect on patients' psycho-emotional as well general health condition.

The incidence of the nerve injury in course of dental implantation is referred to in different figures by various authors. According to R. Bourtling *et al.* (2), only 8,5% of IAN injury cases occur in course of dental implantation; meanwhile, J. Kan *et al.* (14) claim that on the average 52,4% of patients suffer from neuro-sensory troubles following dental implantation; in case of certain implantation methods, these numbers amount even to 77,8%.

Only sporadic studies dealing with some IAN injury issues (13) are provided in scholarly literature sources.

Therefore, we have set the following tasks and objectives in our study:

- to research into the IAN injury cases that occurred in course of dental implantation operations in our practice; to suggest the method and criteria for the detection of the severity of injury, and assess possibilities for functional recovery;
- based on the data of our research as well as scholarly literature, to analyze the variations of the inferior mandible and its canal structure that may be of importance to choosing a safe dental implantation method.

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MATERIAL AND RESEARCH METHODS

The trial group consisted of 383 patients who had undergone dental implantation (Chart 1). In all cases implantation was performed subsequently to the general examination of the patient. Disturbances of the immune system, diabetes, osteoporosis, applied anti-cancer chemo- or radiotherapy were all considered as contraindications to implantation. Inferior mandible ortopantomograms were made prior to the operations. Bone quality was evaluated following the LEKHOLM – ZARB classification (17).

The possibility to apply implantation was determined following data obtained from ortopantomograms performed using an OSTEOFIX 04 system implant pattern, and considering the 20% magnification of the ortopantomogram. Single stage (transmucosal) dental implants of 8, 10, 12, 14 mm length and 3,8 and 4,2 mm in diameter were used. 1152 dental implants were screwed in total.

The clinical symptoms of the IAN damage were determined based on the patient's complaints.

The sensographic method was used to examine the condition of the nerve. Tactile and pain sensitivity thresholds were indicated by irritating the nerve branches with 50 Hz frequency and 0,1 ms duration orthogonal impulses produced by an UEI – 2 electrostimulator. Sensography was performed during the first 2 days following implantation, as well as in 7, 14, 21, 28, 45, 60, 90 days and 1 and 2 years after the operation. The severity degree of the IAN damage was assessed according to the classification offered by R. Kubilius (15).

The characteristics of the first type or mild IAN damage include a statistically reliable reduction of the nerve's tactile and pain thresholds, as compared to the analogous indexes of an unharmed trigeminal nerve.

After 21 days following the injury, tactile and pain thresholds come to the norm. Tactile and pain thresholds higher than those of an undamaged trigeminal nerve branch are characteristic of the second type or moderate damage. After 45 days, the sensitivity of the nerve revives.

Chart 1. Classification of the Trial Patients According to Their Age and Sex.

Trial Patients	Total	Sex				Age (Years)							
		Male		Female		<15		15–44		45–59		>60	
		n	%	n	%	n	%	n	%	n	%	n	%
With Neurostomotological Illnesses	750	309	41,20	441	58,80	–	–	38	5,07	295	39,33	417	55,60
With Dental Implants	383	246	64,23	137	35,77	–	–	181	47,26	169	44,12	33	8,62

Chart 2. Sensographic Data of the Inferior Alveolar Nerve Damaged in Course of Dental Implantation.

Injury Type, or Degree of Severity	Total n=383		Estimate Results (in Volts)			
			Of the Injured Inferior Alveolar Nerve:		Of the Unharmed Branch of the Nerve (II):	
	n	%	Tactile Threshold	Pain Threshold	Tactile Threshold	Pain Threshold
I (Mild)	38	9,92	5,3±0,4*	11,3±0,6*	10,3±0,6	22,6±0,3
II (Moderate)	27	7,05	19,8±0,9*	32,4±0,7*	10,4±0,5	22,8±0,7
III (Severe)	3	0,78	31,9±0,8*	63,6±0,5*	10,2±0,3	22,5±0,4
Total	68	17,75				

* a statistically reliable difference, as compared to the unharmed branch of the nerve ($p<0,05$).

Chart 3. Average Dimensions of the Dental-Mandible Segments, as Pointed out by S. Michailov

Title of Segment	Average Dimensions (mm)				
	The Height of the Dental Ridge	The Thickness of the Compact Lamella on the Entryway Surface	The Thickness of the Compact Lamella on the on the Lingual Surface	The Thickness of the Porous Substance on the Entryway Surface	The Thickness of the Porous Substance on the Lingual Surface
Central Incisors	12,5–16	0,4–0,6	0,6–1,3	0,1–0,4	0,1–0,4
Side Incisors	13–15	0,4–0,6	0,6–1,3	0,2–0,25	0,2–0,25
Canine	15–17	0,5–1,2	0,5–1,35	0,2–3	0,2–3
1st Premolar	13,6–17	0,3–1,3	0,5–1,5	4	4
2nd Premolar	14,5–17,5	0,3–1,3	0,5–1,5	4	4
1st Molar	14–16,7	4,5	3,5	3	3
2nd Molar	12–15,5	4,5	3,5	3	3
3d Molar	11–10,5	4,5	3,5	3	3

In case of the third type or severe nerve damage, tactile and pain thresholds rise considerably. Up to the 90th day following the operation, the parameters of these indexes slightly decrease but do not change substantially afterwards. Sensograms performed repeatedly to such patients after 1 and 2 years are not in essence different from those performed after 90 days.

The second research group consisted of 750 patients suffering from neurostomotological illnesses (Chart1). Their inferior mandible ortopantomograms were analyzed after they had been made with the "Cranex – 3" ortopantomograph (Finland).

In addition, scholarly literature data was analyzed in relation to the different variations of the inferior mandible and its canals, which are of considerable importance to the planning of a proper method of dental implantation.

DISCUSSION OF THE RESULTS

Subsequently to the dental implantation operations performed by us to 383 patients, 68 (17,755%) of them showed the symptoms of the IAN functional damage. Chart 2 presents the results of these patients' sensographies performed during the first 2 days following the operation.

32 (9,92%) patients were diagnosed with a mild IAN damage. Such patients complained about paresthesia and the increased sensitivity of the derm of their underlip and chin on the side of the injury. It is remarkable that 30 patients incurred the mentioned symptoms only after 1 – 2 days following the implantation, meanwhile 8 patients- as soon as the effect of local anesthesia had ceased (2 – 4 hours following the operation).

14 patients were not prescribed any special treatment. Their IAN sensitivity normalized and clinical damage symptoms disappeared during the 3d and 4th week after the operation.

24 patients were given a medicament treatment: nonsteroid antiflamatory drugs, diuretics, antihistamine. More than half (17) of the patients recovered the function of their nerve during the first week; the rest of them (7) did that during the second week after the operation.

27 (7,05%) patients complained about a non-ceasing post implantation numbness in their underlip and chin derm. Based on IAN sensography showings, they were diagnosed with a second type (moderate severity) nerve damage (Chart 2).

20 patients felt paresthesia in the area of hypesthesia: itching, "running of ants", etc.

In addition to the above mentioned paresthesia, 4 patients suffered from a permanent nagging pain; 3 patients complained about a searing pain.

With regard to the treatment applied after the operation, all the patients were divided into 3 groups.

10 patients of the first group were prescribed the following combination of medicaments (Variant 1): nonsteroid antiflamatory drugs, antihistamine, vasodilators, diuretics, B group vitamins (Neurotin or Neuro Max).

The second group was formed of 10 patients who, instead of antihistamine in Variant 1, were prescribed prednisolone (40 mg a day for the duration of 5 days).

The 7 third-group patients were performed an inferior mandible canal decompression following 2 – 3 days after the implant had been screwed in: the side-wall of the canal was removed from the area of the implant. Pursuant to the operation, Variant 1 combination of medicaments was prescribed.

The third-group patients were declared to have achieved the best treatment results. Already as soon as 2 – 3 days after the operation, none of the patients complained about any subjectively unpleasant clinical symptoms. The IAN functional condition fully recovered after 28 days following the operation.

The first-group patients had no more subjective complaints after 1 month following implantation; meanwhile, their IAN function recovered 1,5 month later.

3 patients were diagnosed with a severe IAN damage. Variant 2 integrated treatment applied to them for one week appeared to be ineffective. Canal decompression performed with regard to 2 patients did not give any results either. Only having removed the implants and applying a subsequent integrated medicament treatment, pain ceased in two weeks, but the nerve function never recovered. Having performed an IAN sensography two years later, considerably increased tactile and pain thresholds were indicated.

The above provided research results prove that there are 3 possible IAN damage types or degrees of severity that can be sustained in course of implantation: mild, moderate and severe. Each type of damage is characterized by a certain functional condition of the nerve defined by tactile and pain thresholds. Moreover, damage types are distinguishable as a result of different processes and consequences of nerve functional recovery.

The first-type nerve damage is of recurrent, i.e. functional, manner. The functional disturbances of the nerve include increased sensitivity characterized by the reduction of tactile and pain thresholds.

Having researched into the peripheral nerves' reaction to a trauma, W. H. Davis *et al.* (13) gave the name of a "metabolic bloc" to such a functional condition of the nerve, and, accordingly, the name of *neurapraxia* to the type of damage. According to Sunderland (13), nerve injuries of this type are classed as the first degree damage (as based on a 5-degree assessment scale).

The characteristic symptom of the second type- moderate- IAN damage is that the function of the nerve ceases, which is shown by the increase of tactile and pain thresholds. Structural alterations of the nerve are indicated that are of a recurrent manner.

In case of the above-described condition of the nerve the myelin layer is impaired (13); the damage itself is defined as *axonotmesis*, and corresponds to the second degree damage as based on Sunderland. A full recovery of the nerve function follows this type of damage.

According to Sunderland, the third and fourth degree damage is conditioned by an axonic integrity disturbance; meanwhile, the fifth degree damage is caused when the nerve trunk is cut off completely. The latter three damage types are classed as the so called *nerotmesis* (13).

This kind of injury coincides with the third- severe-type of IAN damage in our classification.

As based on our data, in course of dental implantation IAN damage of the first type occurs in 9,92% of cases, second-type- 7,05%, and third-type- in 0,78% of cases.

According to other authors, neurological complications follow dental implantation in the inferior mandible from 8,5% (2) to 77,8% (14) of cases. However, the authors do not analyze the occurrences of complications based on the types of nerve damage.

Sources of scholarly literature reveal various periods of IAN functional recovery.

As indicated by J. M. Hirsch ad P. I. Branemark (12), the average period of nerve functionial recovery amounts to 3,8 weeks following nerve lateralization, and up to 5,7 weeks following nerve transposition. According to other authors, IAN function recovers after 4 months (2), 16 months (27), or after 1 or even 2 years (13).

On the ground of our data, the period of IAN functional recovery depends on the type of nerve damage sustained and treatment applied. Undoubtedly, the degree of damage caused to blood circulation also influences the process of recovery, as has been proved by R. Kubilius (15) based on research results. Therefore, the condition of blood circulation in the inferior alveolar artery must be evaluated in order to be able to foresee the period of IAN recovery and to properly plan treatment.

Other authors (20) concur with the previously provided opinion. They also note that during the pre-operational examination of patients the condition of their inferior alveolar artery must be evaluated, on which the inferior mandible vascularization mainly depends. Vascularization is prerequisite for the capability of tissue regeneration, which, in turn, is a mandatory condition for a successful operation.

In order to avoid IAN injury in course of dental implantation, one should acquire such information as the exact localization of the mandible canal, its variations, relation to the teeth, distance from the dental ridge of the mandible, etc. This type of knowledge grants the possibility to choose a safe method of dental implantation. Inferior mandible ortopantomograms are the fastest and cheapest way to get relevant information. Accordingly, we have analyzed inferior mandible ortopantomograms of 750 neurostomotological patients.

As seen in ortopantomograms, the width of the inferior mandible ranges from 2 to 6 mm. The walls of the canal are pictured as two straight dark lines.

Canals are usually divided into 3 categories.

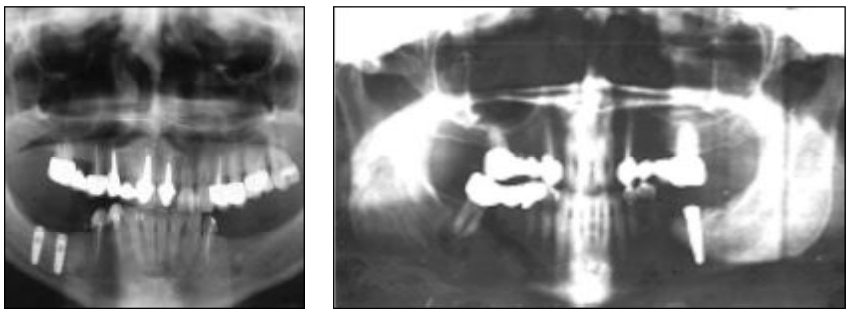
The first-category canal is nearly horizontal (Picture 1A). It begins next to the inferior mandible foramen, which has vague lines and whose diameter is larger than that of the canal. The canal ends up with the mental foramen, usually next to the 2^{d} premolar or between the 1st and 2^{d} premolars. The length from the lower ridge of the mandibular body to the mental foramen is usually 10 to 17 mm, and that from the dental ridge may reach 2 to 20 mm, subject to the level of atrophy. The diameter of the foramen is 1,5 – 1 mm. It is characteristic of these canals that closest to them are located the roots of the 3^{d} and 2nd molars. Sometimes the roots of the 3^{d} molar are located within the canal itself. The length from the dental ridge to the canal amounts to 8 – 10 mm in the area of the 3^{d} molar, 8 – 12 mm in the area of the 2nd molar, 13,5 – 17 mm in the area of the 1st premolar, and 14 – 17 mm in the area of the 2nd premolar.

The proximal part of the second-category canal rises quite high into the branch of the mandible and, having widened, ends up next to the inferior mandible foramen (Picture 1B). The mental foramen is usually located next to the 1st premolar or between the latter and the canine. The shortest distance from the lower ridge of the inferior mandibular body is detected in the area of the premolars and 1st and 2^{d} molars. These are the areas where the distance is longest from the dental ridge to canal- 14 – 18 mm on average.

The third-category canal is diagonal; its proximal end finishes high in the branch, and the arched distal end finishes with the mental foramen next to the canine root or between the latter and 1st premolar. The canal is closest to the lower ridge of the inferior mandibular body in the area of the 1st and 2nd premolars- 6 – 8 mm on average. The tip of the canine root is closest to the canal.

The success of implantation depends largely on the choice of a proper method of implantation selected subject to certain conditions- such as the position of the inferior mandible, the condition of the dental ridge- that may be estimated in many cases with the help of inferior mandible ortopantomograms.

Picture 1. Types of the Inferior Mandible Canals: A – Type One; B – Type Two; C – Type Three. See further explanation in the text.



Picture 2. The ortopantomogram of a patient who has incurred the third type or severe damage of the inferior alveolar nerve following dental implantation in the area of the 2nd molar. See for further explanation in the text.

Our research has revealed that there exist three types of inferior mandible canals, as based on their position with respect to the lower ridge of the inferior mandibular body and the dental root tips.

It is worth mentioning that in most cases the inferior mandible does not end with the mental foramen but a narrow canal stretches out to the central line. The canal branches off on its sides thus allowing nerves and blood-vessels reach the front teeth (3). In case this canal is absent, nerves and blood-vessels find their way through the porous substance of the mandible.

According to O. Obradovic *et al.* (20), in 92% of cases bone canals are found in the mental part when the inferior mandible contains teeth and in 31% in case of edentulous mandible.

In order to plan a proper dental implantation method and select implants of a relevant type, it is important to be aware of the position of the inferior mandible in connection with the side compact lamellas. The canal stretches throughout the mandible body forming an "S" shape curve. It approaches the lingual surface of the mandible in the area of the molars, and, stretching forwards to the front part, comes close to the vestibulum surface (13, 20). Next to the 1st and 2nd molars, the longest distance between the canal and mandibular vestibulum surface is up to 5 mm (12, 21).

Besides, the vestibulum cortical bone layer is stronger and of more compact structure than the lingual layer (7, 22, 26).

Wide lateral cortical layers condition that endoseaous implants are screwed in safely (20). Chart 3 presents average dimensions of dental-mandible segments, as pointed out by S. Michailov (1984).

Most authors recommend that an implant is not located closer than 1 – 2 mm from the mandible canal in order to avoid further complications, which should be kept in mind to select a proper size of the implant and a relevant place where it is going to be screwed in (2, 3).

The above-mentioned requirement appeared to have been violated in all cases explored by us when neurological complications emerged after implantation.

In case of the third type (severe) IAN damage (3 cases in all), implants were screwed in throughout the entire diameter of the mandible canal (Picture 2).

The inferior mandible atrophy makes the planning of dental implantation a more strenuous job. The possibility of neurocomplications increases greatly as the topography of the mandible canal alters. In course of mandible atrophy, the dental ridge becomes lower, and thus the canal approaches its surface (13).

A number of classifications have been offered to assess clinically the altered structures of the inferior mandible. M. R. Felon *et al.* give a comprehensive analysis concerning these classifications (10).

In case of atrophy the mentioned classifications should be followed while planning implantation. We were using the LEKHOLM-ZARB classification.

CONCLUSIONS

1. In 17,75% of cases patients suffer from traumatic damage to their inferior alveolar nerve following dental implantation.

2. Nerve damage is divided into three categories subject to the type of the functional disturbance of the nerve and the dynamics of its recovery, which can be assessed objectively using the sensographic method: 9,92% of patients incur the first type or mild damage, 7,05%- the second type or moderate damage, and 0,78% of patients suffer from the third type or severe damage.

3. When patients are applied relevant treatment, the subjective symptoms of the injury to their inferior alveolar nerve disappear sooner, and nerve function recovers more rapidly: in first type cases it is recommended to prescribe nonsteroid antiflamatory drugs, antihistamine (or glucocorticoides), vasodilators, diuretics, B group vitamins; in second type cases a good therapy effect is achieved when the described treatment is applied following nerve decompression; in case of the third type nerve damage the removal of the dental implant and symptomatic treatment is recommended.

4. The prevention of the traumatic injury to the inferior alveolar nerve constitutes a diligent rational planning of an implantation method with regard to the anatomical features of the inferior mandible and individual variations of the topography of the mandible canal.

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