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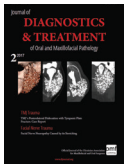

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Modern Diagnostic Methods Used in Surgical Treatment of Peripheral Neuralgia

Olena P. Vesova*

Department of Maxillofacial Surgery, Stomatology Institute, Shupyk NMAPE, Kyiv, Ukraine (*Prof, ScD*)

ABOUT ARTICLE

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ABSTRACT

Purpose.
To determining the possibility of using stereolithography in the diagnosis of lesions of peripheral nerves in conditions of ossificated bone canals of the maxillary bone.
Material and Methods.
We examined 31 patients with secondary neurogenic lesions of trigeminal nerve using stereolithography.
Results.
Diagnostic capabilities of color stereolithography for diseases of the second branch of the trigeminal nerve were studied.
Conclusions.
High efficiency of stereolithography is proved. The method is recommended for use in medical practice.

Introduction

In modern medical practice, one of the main methods of diagnosis, of course, after a clinical examination of the patient, is radiography. The difficulties that arise when decoding it are related not only to the lack of a volumetric picture of the pathological process, which was localized both in the bone and in surrounding tissues, but also with an insufficient "visibility" of the bone canal in which the maxillary branch of the trigeminal nerve passes. When the bone canals narrow, there is no radiologic imaging of the pathological focus. Many pathological processes located inside the canals (ossification) are not available for diagnosis and examination using the radiography method. In the early 70-ies of the last century, as a result of scientific and technological progress, computer tomography was introduced into practice. This was a major achievement of modern medicine and, first of all, radiology. Computer tomography is a fundamentally new, noninvasive diagnostic method that allows one to visualize the relationship of individual organs and tissues in the norm and under different pathological conditions, based on the use of the principle of mathematical modeling of an X-ray image, followed by computer-aided construction of images of horizontal "slices" of the body on the display screen.

Computer tomography has taken a firm place in the diagnosis of diseases of the maxillofacial region. However, the unreal sizes of the prototype and certain difficulties in specifying the detailed location of the pathological focus, as well as revealing its relationship with other anatomical structures, creates many inaccuracies in diagnosis and difficulties in planning and during some surgical interventions on peripheral nerve trunks.

In recent years, a new modern technology for creating prototypes of the human skeleton appeared based on data obtained during medical scanning (CT, MRI). There are several types of this technology. One of the most famous among them is stereolithography. The basis of this method is the principle of layer-by-layer construction of the three-dimensional structure of the object and the creation of a model that corresponds exactly to the dimensions and shapes of parts of the human body (skull, upper jaw, lower jaw, etc.). In the literature, we did not find information on the possibilities of using stereolithography for lesions of the peripheral branches of the trigeminal nerve located in the bone canals of the maxillofacial skeleton.

The aim of the study was to determine the possibilities of using stereolithography in the diagnosis of peripheral nerve lesions [1-13] in conditions of ossificated bone canals of the maxillary bone.

Material and Methods

We examined 31 patients with diseases of the second branch

* *Corresponding author. Department of Maxillofacial Surgery, Stomatology Institute, Shupyk NMAPE, 4-a Pidvysotskogo Street, Kyiv 01103, Ukraine.*
Tel., fax: +38 (050) 332 26 89.
E-mail address: anna.vesova@rambler.ru (O.P. Vesova)

(neuralgia, neuralgia-neuritis) of the trigeminal nerve with the method of stereolithography. All examinees necessarily had a general clinical examination, which included x-ray of the jaws in different projections, computed tomography, stereolithography. Stereolithographic models were produced by combining in a single technological chain of computer diagnostics the automated design of a virtual model and laser stereolithography. Stereolithographic models of the jaws were produced in the Technical Department of Belgium by a stereolithographic machine "SLA" from photopolymerized translucent composite materials with successive curing of individual thin layers joined together in a single unit. When the peripheral branches of the trigeminal nerve were stained in a different color, a color stereolithographic model of the maxillary bone was obtained. The data obtained during the diagnosis by conventional and color stereolithography was compared with the results, which were revealed during radiography, computer tomography and those acquired after the operation.

Results and Analysis

In the practice of maxillofacial surgeons and otorhinolaryngologists one of the main diagnostic methods, of course, after a clinical examination of the patient, is radiography. The difficulties that arise when deciphering it are related not only to the lack of a three-dimensional picture of the pathological process, which was localized both in the bone and in surrounding tissues, but also with insufficient "visibility" of some bone orifices and canals in which the maxillary branch of the trigeminal nerve passes. When the bone channels narrow, there is no radiologic imaging of the pathological focus. Many pathological processes located inside the canals (ossification) are not available for diagnosis and examination using the radiography method. In the early 70-ies of the last century, because of scientific and technological progress, computer tomography was introduced into practice. This was a major achievement of modern medicine and, first of all, radiology. Computer tomography is a fundamentally new, noninvasive diagnostic method that allows one to visualize the relationship of individual organs and tissues in the norm and under different pathological conditions, based on the use of the principle of mathematical modeling of an X-ray image, followed by computer-aided construction of images of horizontal "slices" of the body on the display screen. Computer tomography has taken a solid place in the diagnosis of diseases of the middle zone of the face. However, the unreal sizes of the prototype and certain difficulties in specifying the detailed location of the pathological focus, as well as revealing its relationship with other anatomical structures, creates many inaccuracies in diagnosis and difficulties in planning and during some surgical interventions on peripheral nerve trunks.

In recent years, a new modern technology for creating prototypes of the human skeleton appeared based on data obtained during medical scanning (CT, MRI). There are several types of this technology. One of the most famous among them is stereolithography. The basis of this method is the principle of layer-by-layer construction of the three-dimensional structure of the object and the creation of a model that corresponds exactly to the dimensions and shapes of parts of the human body (skull, upper jaw, lower jaw, etc.). In the literature, we did not find information on the possibilities of using stereolithography for lesions of the peripheral branches of the trigeminal nerve located in the bony canals of the maxillofacial skeleton. Stereolithographic models were produced by combining in a single technological chain of computer diagnostics the automated design of a virtual model and laser stereolithography. Stereolithographic models of the jaws were produced in the Technical Department of Belgium by a stereolithographic machine "SLA" from photopolymerized translucent composite materials with successive curing of individual thin layers joined together in a single unit. When the peripheral branches of the trigeminal nerve were stained in a different color, a color stereolithographic model of the maxillary bone was obtained. The data obtained during the diagnosis by conventional and color stereolithography was compared with the results, which were revealed during radiography, computed tomography and those acquired after the operation.

On the orthopantomogram, as well as the x-ray patterns of the maxillary bones, we did not succeed in detecting the foci of narrowing of the bone orifices and canals (sections of ossification) in the examined cases (Fig 1).

When carrying out a computer tomography of the facial bones (Fig 2), we also could not detect pathological foci (areas of narrowing of the bone apertures or canals) in the bones of the maxillofacial skeleton. When carrying out the usual stereolithographic models of the maxillary bones, the exit points of the peripheral branches of

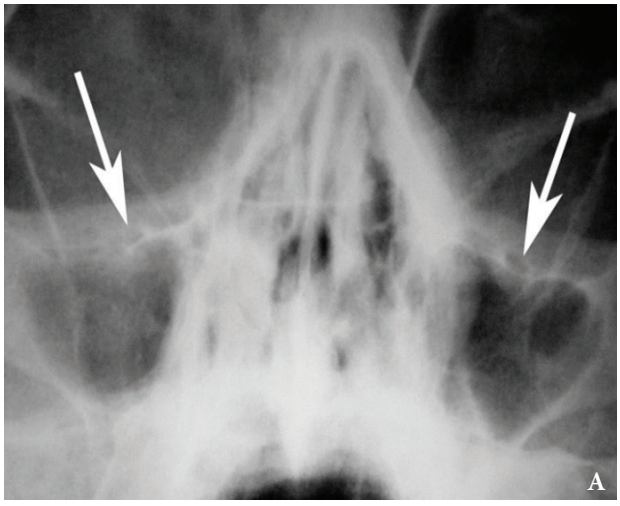

FIGURE 1. Radiograph of facial bones in a semi-axial projection (**A**). The *arrows* indicates the areas where the outlets of the infraorbital branches of the trigeminal nerve are located (**A**). **(Fig 1 continued on the next page.)**

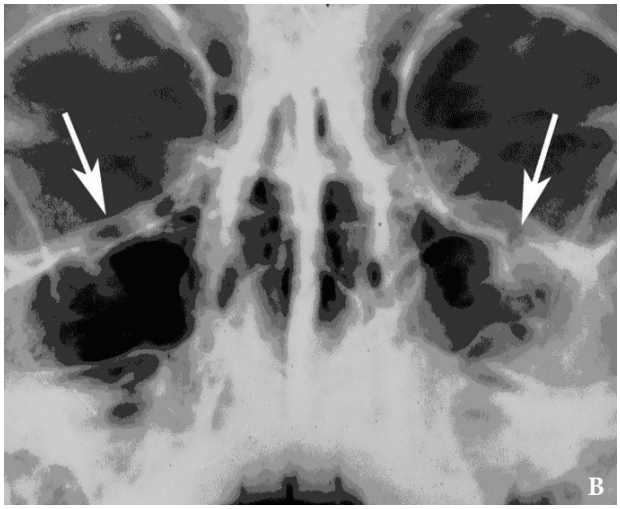

FIGURE 1 (cont'd). Radiograph of facial bones in a semi-axial projection (**B**). The *arrows* indicates the areas where the outlets of the infraorbital branches of the trigeminal nerve are located (**B**).

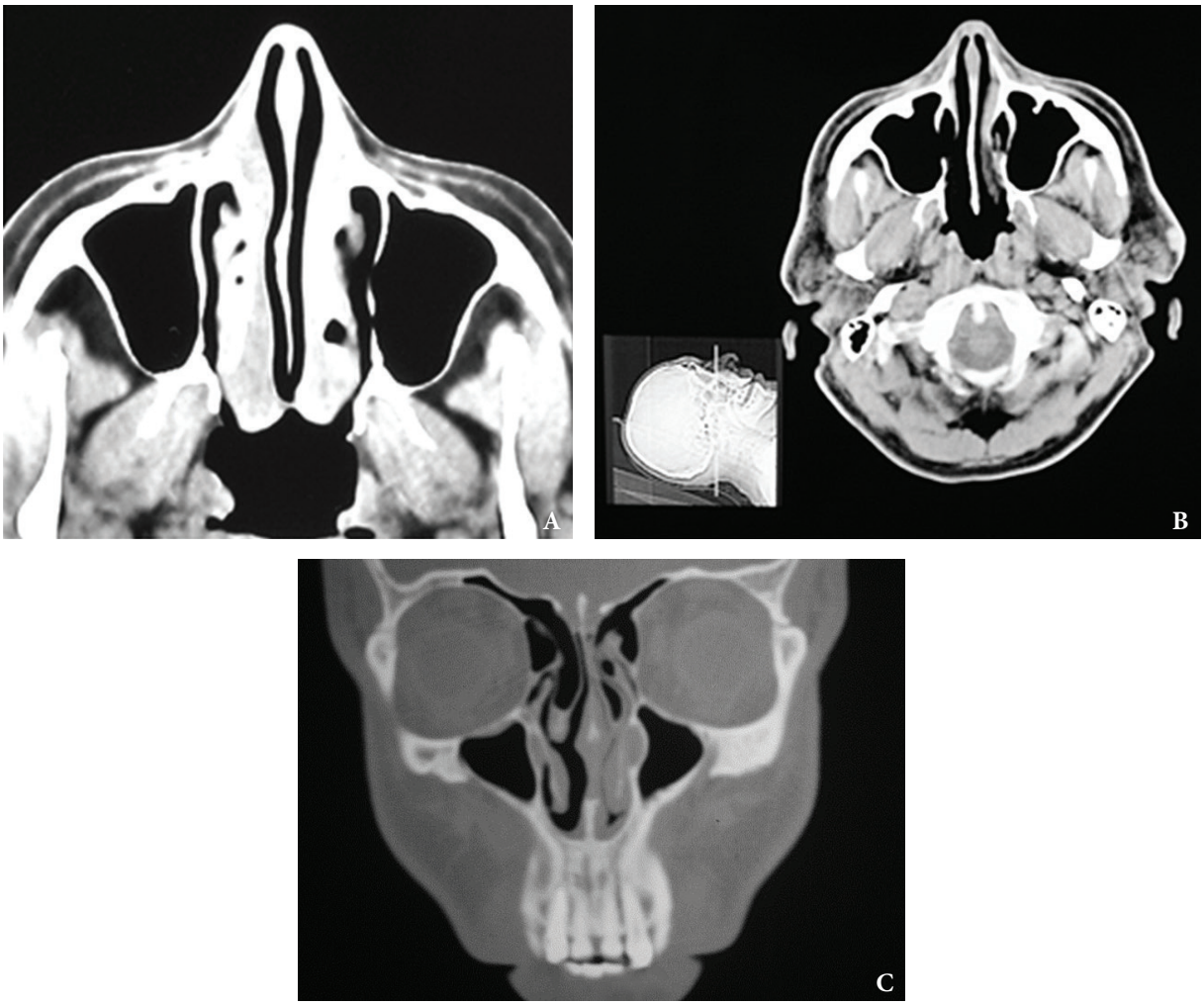

FIGURE 2. Computer tomography of facial bones in different projections. Sections are made at different levels (**A**, **B**, **C**).

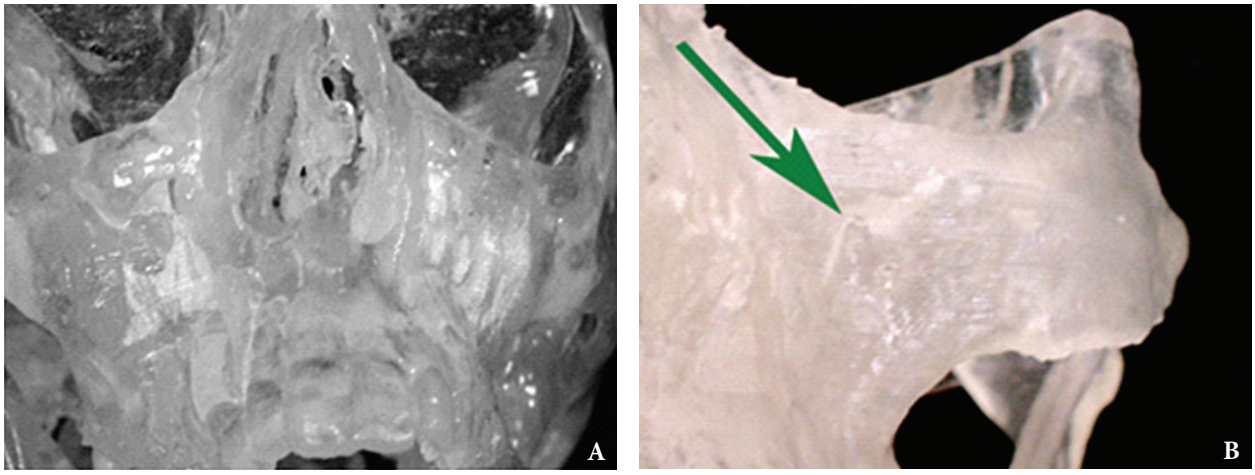

FIGURE 3. Stereolithographic model of the upper jaw of the patient with a narrowing of the infraorbital aperture (**A**, **B**). The projection of the infraorbital foramen is indicated by an arrow (**B**).

nerves from the infraorbital foramen "merged" into one color and were not visualized either at the point of nerve exit from the bone nor at the place of its passage in the corresponding canal (Fig 3).

In the making of colored stereolithographic models of the facial bones, the second branch of the trigeminal nerve was colored in a different color (dark red) to visualize the peripheral branches in the bone (Fig 4).

In the place of the exit of the maxillary nerve from the infraorbital foramen it is defined as a colored rounded portion with a diameter of 2 to 3 mm (in norm), (Fig 4).

The narrowing of the bone orifices less than the minimum size indicated by us coincided with the clinical manifestation of neurogenic lesion of the peripheral branch on the diseased side (Fig 4B). If along the course of the corresponding nerve in the bone canal, its colored contours (orientations) are "lost", then this indicated ossification, which was observed in a certain area of the given bone canal and always coincided with the pathological focus detected during the operative treatment - decortication of the corresponding part of the canal. Based on our survey we can state that color stereolithography makes it possible to obtain the real size of the pathological focus (ossification) in the bone canal, and also to determine its exact location (bone or canal). This circumstance gave us the opportunity to carefully study the localization and evaluate the complexity of the planned surgical intervention, as well as assess the options for approaching the location of the pathological focus.

Thus, with neurogenic diseases of the maxillofacial region due to narrowing of the bone canals through which the second branch of the trigeminal nerve passes, stereolithography made it possible to reveal the exact location of this narrowing along the bone tunnel and plan

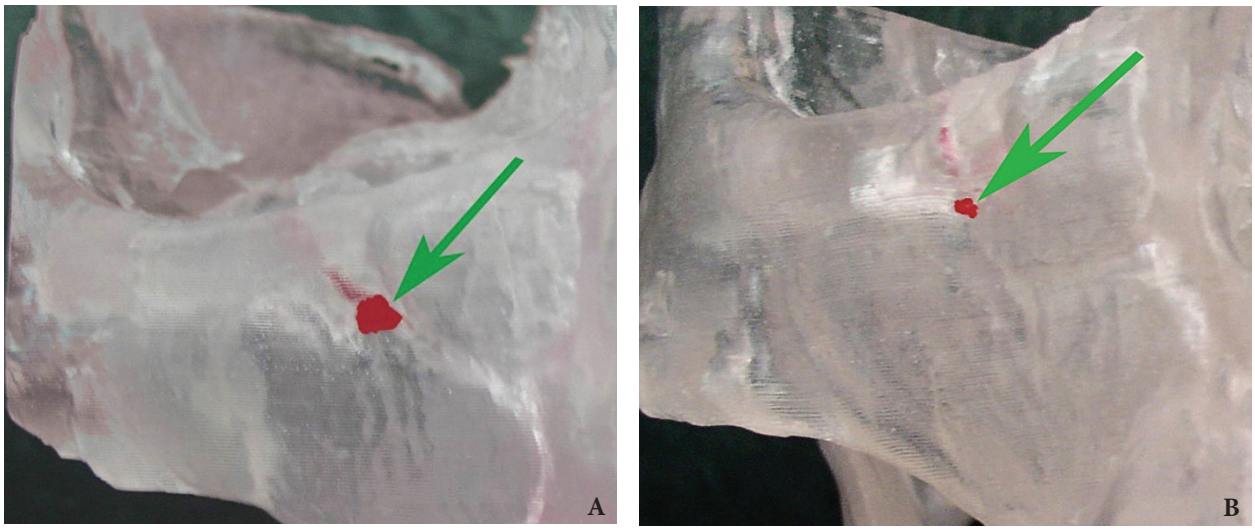

FIGURE 4. Stereolithography model of the maxillary bone in color. The location of the infraorbital nerve is colored dark red. The form of the infraorbital foramen (indicated by the arrow) is normal (**A**) and when it is narrowed (**B**).

in advance access to this portion of the jaw, and therefore carefully select the technique of conducting surgical intervention with minimal traumatic damage to the jaw bones.

Neuralgia of the trigeminal nerve is divided into two of their forms: central (lesion of the gasserian ganglion) and peripheral (lesion of the peripheral branches of the trigeminal nerve) [14-22]. You cannot mix neuralgia of central and peripheral genesis into one disease, because each of these forms has its own peculiarities of the clinical course, which requires different methods of their treatment.

Peripheral neuralgia arises as a result of the impact of the pathological process on various parts of the peripheral part of the trigeminal nerve.

To the etiological factors that may cause neuralgia of the trigeminal nerve of peripheral genesis may be included ossification of the infraorbital aperture (through it comes the infraorbital nerve).

Surgical methods for the treatment of peripheral neuralgia of the trigeminal nerve are reduced to conducting a neurotomy – dissection of the nerve and neurectomy – excision of the nerve region, nerve exeresis – removal of the nerve by twisting it out.

To date, there are many different methods of neurectomy of the second and third branches of the trigeminal nerve. The most promising methods for treating peripheral forms of neuralgia of the trigeminal nerve are decompression operations, i.e. with the release of peripheral nerve branches from the bone canals.

Decortication of the infraorbital or mandibular canal with resection of the neurovascular bundle is widely used in our clinic (Department of Maxillofacial Surgery of the Shupyk National Medical Academy of Postgraduate Education). A positive effect was observed in almost 90% of cases.

Electrophysiological methods that allow determining the presence or absence of irreversible changes in the peripheral branches of the trigeminal nerve. From special methods of examination, we performed a measurement of the electrophysiological parameters (conductivity, tone, resistance) of the trigeminal nerve at the points of its exit (the study was performed on the hardware-software complex "DIN-1"). With these electrophysiological studies of the branches of the trigeminal nerve (with neuralgia), we were able to prove that in more than 80% of cases its function remained, despite its violations, which were expressed in varying degrees.

Operations are usually performed under local anesthesia (local anesthetic solution Artikain-ZT) at the round foramen and infiltration of surrounding soft tissues (with premedication or with neuroleptanalgesia) or under general anesthesia. This provides painless intervention, calm behavior of patients during the operation and in the next few hours after it. In cases with severe psycho-emotional lability, we usually use narcosis

The question of the size and degree of disturbances in the sensitivity of the face after surgery is of interest. It, basically, corresponds to a zone of an innervation of a corresponding branch of a trigeminal nerve. Most of all, pain sensitivity is disturbed. Tactile and temperature sensitivity changes to a lesser extent, so damage to the denervated area by hot food, sharp objects takes place. However, over time, there is a tendency to narrow the zone and the degree of violation of all types of sensitivity. Complete restoration of sensitivity does not occur even a few years after the operation.

Along with the marked disorders of sensitivity, patients (in the first weeks or months after the operation) feel a tingling sensation, "creeping crawling", a feeling of tension in the denervated area. Patients prefer to eat with healthy side while eating. Any features in the process of using removable dentures, which will be made for the patients in the future, do not arise. The speech functionality does not suffer.

The disturbance of the sensitivity of the facial skin, although unpleasant to the patient, but in comparison with the neuralgic pains that preceded the operation, is incomparably less painful. They can get relatively used to it.

The next day after the operation, patients were assessed the electrophysiological parameters of the third branch of the trigeminal nerve with the help of the hardware-software complex "DIN-1". Depending on the received indices and complaints of patients, a course of rehabilitation treatment was appointed to optimize the postoperative course.

Patients were prescribed a course of treatment of electrostimulation in the area of the infraorbital opening, taking into account the data that we obtained in the diagnosis at the given point the day after the operation. Thus, we improve the trophic of the second branch of the trigeminal nerve in the postoperative period. The course of rehabilitation treatment using the hardware-software complex "DIN-1" consisted of 5 electrical stimulations. The course of electrostimulation was carried out daily or every other day. All patients for antiseptic treatment of the oral cavity, in the postoperative period, used the drug "Givalex" for the prevention of inflammatory phenomena.

After completion of the ongoing treatment of patients, i.e. at the time of their discharge from the hospital, we noted a complete recovery of all types of sensitivity in the innervation zone of the nerve. Neuralgic pain of the trigeminal nerve in the operated cases were not revealed.

Conclusions

Color stereolithography is the most modern method of examining a patient, which allows obtaining a three-dimensional model of bones of the facial skeleton. This method makes it possible to present a three-dimensional picture and to detect the exact location of the pathological focus (ossification), determine its real size, choose the method and place for operation (bone or a certain part

of the length of the bone canal) of decorticating the maxillary canal. Color stereolithography is a method of diagnostics that allows the surgeon to think and work out the technique of the planned operation, to reduce the risk of occurrence of unforeseen situations during complex operations, which reduces the incidence of postoperative complications.

Stereolithography can be used in the diagnosis of ossification of the bone canals of the jaw bones, i.e. in places where the second peripheral branch of the trigeminal nerve passes. It is recommended for wide application in practical medicine.

Funding

None.

Ethical Approval

Approval was obtained from the Medical Ethics Committee of the Shupyk National Medical Academy of Postgraduate Education, Kyiv, Ukraine.

Patient Consent

Not required.

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Сучасні методи діагностики, що використовуються у хірургічному лікуванні периферичних невралгій

Олена Петрівна Вєсова

Професор кафедри щелепно-лицевої хірургії Інституту стоматології Національної медичної академії післядипломної освіти імені П.Л. Шупика, доктор мед. наук, професор.

ПРО СТАТТЮ

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Ключові слова:

Трійчастий нерв
Вторинні неврогенні ураження
Стереолітографія

РЕЗЮМЕ

Мета. Визначити можливості використання стереолітографії у діагностиці уражень периферичних нервів при осифікації кісткових каналів верхньощелепної кістки.

Пацієнти та методи. Нами проведено обстеження 31 хворого з вторинними нейрогенними ураженнями другої гілки трійчастого нерва за допомогою метода стереолітографії.

Результати. Вивчені діагностичні можливості кольорової стерео літографії при захворюваннях II гілки трійчастого нерва.

Висновки. Доказана висока ефективність стереолітографії. Метод рекомендован для використання у медичній практиці.

Современные методы диагностики применяемые в хирургическом лечении периферических невралгий

Елена Петровна Весова

Профессор кафедры челюстно-лицевой хирургии Института стоматологии Национальной медицинской академии последипломного образования имени П.Л. Шупика, доктор мед. наук, профессор.

О СТАТЬЕ

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Ключевые слова:

Система тройничного нерва
Вторичные неврогенные поражения
Стереолитография.

РЕЗЮМЕ

Цель. Определить возможности использования стереолитографии в диагностике поражений периферических нервов при оссификации костных каналов верхнечелюстной кости.

Пациенти и методы. Нами проведено обследование 31 больного с вторичными неврогенными поражениями второй ветви тройничного нерва с помощью метода стереолитографии.

Результаты. Изучены диагностические возможности цветной стереолитографии при заболеваниях II ветви тройничного нерва.

Выводы. Доказана высокая эффективность стереолитографии. Метод рекомендован для использования в медицинской практике.