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Comprehensive Reconstruction of Mandibular Defects With Free Fibula Flaps and Endosseous Implants

New Technique

Minimally Invasive Techniques for Management of Salivary Gland Pathology

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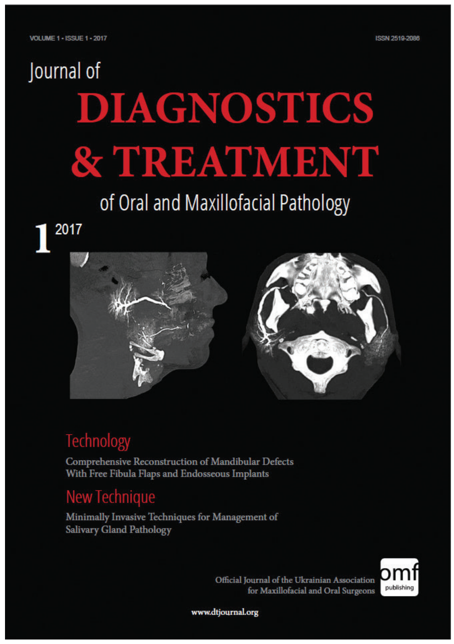

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Prof Oleksii O. Tymofieiev

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Comprehensive Reconstruction of Mandibular Defects With Free Fibula Flaps and Endosseous Implants

Rui P. Fernandes[1,*], Anastasiya Quimby[2], Salam Salman[3]

[1] Department of Oral and Maxillofacial Surgery, University of Florida, College of Medicine, Jacksonville, USA (Assoc Prof)
[2] Oral and Maxillofacial Surgery Residency Program, PGY3, University of Florida, College of Medicine, Jacksonville, USA
[3] Department of Oral and Maxillofacial Surgery, University of Florida, College of Medicine, Jacksonville, USA (Assoc Program Director)

ABOUT ARTICLE

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ABSTRACT

Purpose.
The goal of this paper is to review the use of fibula free flaps in reconstruction of various mandibular defects, as well as illustrate that placement of dental implants into free fibula flaps is a viable option ensuring a superior functional outcome.
Patients and Methods.
Nine of patients with mandibular fibula free flap reconstruction who underwent dental implant placement were included in this study to demonstrate the versatility of this reconstructive technique.
Results.
In all nine patients, fibula flaps provided adequate bone stock for implant placement. All 30 implants were placed in bicortical fashion and none had issues with primary stability at the time of placement.
Conclusion.
Fibula free flap reconstruction is the treatment of choice for patients with various disease processes resulting in significant mandibular defects and can ultimately be restored with fixed dental prostheses.

Introduction

The advent of microvascular surgery facilitated the development of novel techniques that provided superior esthetic and functional reconstruction of large maxillofacial defects. One of the major advantages of microvascular free tissue transfer is that it contains its own vascular pedicle, thus allowing for improved healing in wounds compromised by radiation and chronic infection [1]. The goal of any reconstructive surgery is to restore natural form and function. Mandibular defects resulting from ablative surgery due to malignant or benign pathology, osteonecrosis, or trauma often result in significant functional and esthetic compromise. The free fibula flap is considered the gold standard for mandibular reconstruction due to its versatility, outcome predictability, and suitability for dental implant placement [2]. Dental rehabilitation plays a pivotal role in improving patient's quality of life, since edentulism has been shown to result in significant psychological morbidity to patients [3].

The goal of this paper is to review the use of fibula free flaps in reconstruction of various mandibular defects, as well as illustrate that placement of dental implants into free fibula flaps is a viable option ensuring a superior functional outcome.

Patients and Methods

Retrospective review of patient charts treated from 2005-2015 was completed. Total of 116 patients with mandibular fibula free flap reconstruction were identified. Nine of these patients who underwent dental implant placement were included in this study to demonstrate the versatility of this reconstructive technique. Exclusion criteria were lack of dental implant placement, lack of adequate follow up, or incomplete and lacking records. Although dental implant placement can be recommended to everyone, the cost of dental implants is often prohibitive for a majority of our patients. Unfortunately, many medical and dental insurance companies do not offer 100% coverage for dental implant rehabilitation, even in cases of malignant disease. The selected patient group included 4 females, 5 males, age ranged from 20 to 72 years old with a mean

TABLE 1. Patient Data.

Patient Age, Gender	Diagnosis	Jewer Classification	Fibula Class	Timing of Implant Placement (months) after FFF
20M	GSW[a]	LCL	Class III	41
33M	Ameloblastoma	L	Class I	33
42F	Ameloblastoma	L	Class I	3
45M	Ameloblastoma	CL	Class II	9
49M	SCCA[b], post op XRT[c]	CL	Class II	Immediate at time of FFF[d] surgery
52M	Glandular odontogenic tumor	LCL	Class II	9
52M	SCCA, post op XRT	L	Class I	7
55F	SCCA, no XRT	C	Class II	8
72F	Bisphosphonate related osteonecrosis	L	Class I	12

[a] Gunshot wound
[b] Squamous Cell Carcinoma
[c] Radiotherapy
[d] Fibula free flap

* Corresponding author. Department of Oral and Maxillofacial Surgery, University of Florida, College of Medicine, 653 West 8th St., Jacksonville 32209, USA.
Tel.: 904-244-5502, fax: 904-244-6252
E-mail address: rui.fernandes@jax.ufl.edu (R.P. Fernandes)

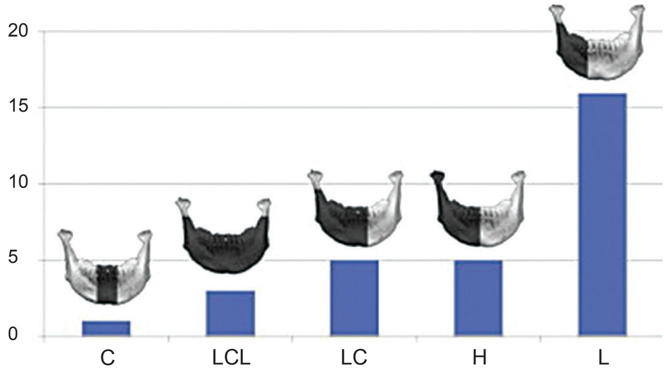

FIGURE 1. Location of mandibular defects according to the Jewer classification (C = central defect; LCL = bilateral defect; LC = central and lateral defect; H = hemimandibulectomy; L = lateral defect) [4].

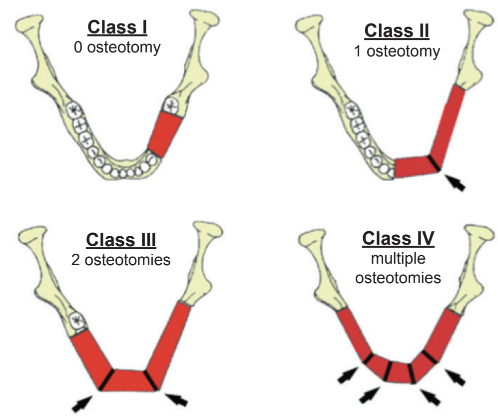

FIGURE 2. Fibula classes according to number of osteotomies [5].

age of 42. Follow up ranged from 1 year 5 months to 6 years 9 months, and median was approximately 4 years. The diagnoses included squamous cell carcinoma, ameloblastoma, glandular odontogenic tumor, and self-inflicted gunshot wound. The resulting mandibular defects and reconstruction were classified based on Jewer and fibula osteotomy classifications (Figs 1, 2). Detailed patient information, including timing of implant placement, is presented in Table 1.

Results

In all nine patients reviewed, single barrel free fibula flaps were utilized. No intra-operative or immediate post-operative complications were noted and no flap failure occurred. Two out of nine patients developed intra-oral dehiscences that healed uneventfully and required no additional operating room interventions. In all nine patients, fibula flaps provided adequate bone stock for implant placement. All 30 implants were placed in bicortical fashion and none had issues with primary stability at the time of placement. No implants required removal to date. Additional surgical procedures, such as vestibuloplasty, keratinized mucosa grafting, and flap debulking were completed in four out of nine patients (Table 2). One patient with diagnosis of medication related osteonecrosis of the jaw did not complete dental rehabilitation due to issues with recurrent infection, need for fibula hardware removal and delayed healing complicated with extra-oral fistula. Three patients had implant supported overdentures fabricated and reported satisfaction with the results. Two patients underwent fixed partial denture fabrication and were also happy with the functional and esthetic results. The remaining four patients were awaiting final prosthesis delivery at the time of study.

The most common complication encountered in our group was peri-implant tissue inflammation and infection. Peri-implantitis resolved with granulation tissue removal and meticulous oral hygiene without causing peri-implant bone loss in two patients. One of the patients developed bone loss adjacent to the terminal implant that at the time of evaluation did not appear to compromise stability of the implant. Although eventual loss of implant with compromised bone support is certainly possible, conservative measures to address peri-implantitis were undertaken to prolong the life-span of the existing prosthesis.

TABLE 2. Patient outcomes.

Patient Age, Gender and Diagnosis	Jewer Classification	Number of implants in fibula	Additional Implant Surgery	Prosthesis	Complications
20M, GSW	LCL	2	Flap debulking	Overdenture	None
33M, amelobasltoma	L	3	None	Fixed partial denture	Periimplantitis requiring granulation tissue debridement, oral hygiene
42F, ameloblastoma	L	3	None	In process of being fabricated [2]	None
45M, ameloblastoma	CL	4	Vestibuloplasty	In process of being fabricated	None
49M, SCCA	CL	3	None	In process of being fabricated [2]	None
52M Glandular odontogenic tumor	LCL	4	Vestibuloplasty	Overdenture	None
52M, SCCA	L	3	None	Fixed partial denture	Peri-implantitis, radiographic bone loss distal implant
55F, SCCA	C	4	Vestibuloplasty, flap debulking, palatal mucosa graft	Overdentures	Peri-implantitis requiring granulation tissue debridement, antibiotic treatment, oral hygiene
72F, BRONJ	L	4	None	None	Hardware infection requiring removal, extraoral fistula

Discussion

Free fibula flap for reconstruction of mandibular defects was first introduced by Hidalgo in 1989 [6]. Numerous studies since then have demonstrated the effectiveness and predictability of free fibula flaps for mandibular reconstruction (Figs 3-6).

In order to facilitate comprehensive orofacial rehabilitation, a flap has to satisfy several requirements. First, it must provide sufficient bone length to ensure adequate repair of the continuity defect. Up to 26cm of fibula can be harvested, which allows for reconstruction of mandibular defects spanning almost the entire length of mandible [7]. The long segment of bone can be osteotomized in multiple locations, thus allowing for esthetic reconstruction of patient’s anatomy. Complex defects, requiring more than 2 osteotomies can be reconstructed with

FIGURE 3. Fibula harvesting.

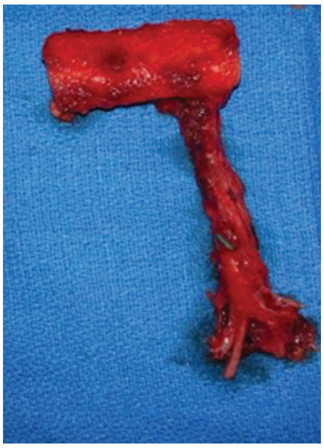

FIGURE 4. Fibula segment with pedicle.

computer assisted virtual surgical planning [7] (Fig 7A, B). Second, adequate bone and tissue stock has to be available for endosseous implant placement and provide satisfactory long-term implant survival rates. The dense cortical bone of the fibula, and its 1-3cm thickness, provide ample primary implant stability by allowing bicortical engagement of conventional 12-14mm implants [7]. Skin paddle size can reach up to 32cm x 14cm thus allowing reconstruction of significant intraoral and extraoral soft tissue defects as well [8]. Next, for a successful microvascular anastomosis, donor and recipient vessels must be of similar caliber. The flap is based on the peroneal artery, 1.5-2.5mm diameter, and two venae comitantes, 2-4mm in diameter which is similar to the diameter of commonly used recipient vessels in the head and neck [7-9]. In addition, donor site morbidity is minimal with anticipated return to normal ambulation in 4 weeks after surgery [8].

Several specific considerations must be taken into account when planning implant placement into fibula free flap. Optimal results can be achieved only when orofacial reconstruction is approached with the end result in mind. Thus input from the restorative dentist responsible for fabrication of the final prosthesis is essential in order to avoid unfavorable outcomes.

Optimal timing of implant placement has yet to be agreed upon to date. Eight out of nine patients included in this study underwent delayed implant placement with mean delay of 23 months, ranging from 3 to 41 months. In one case

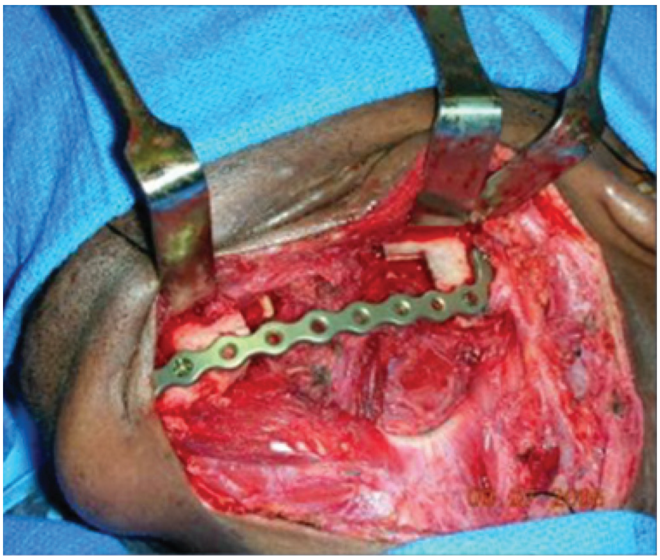

FIGURE 5. Recipient site.

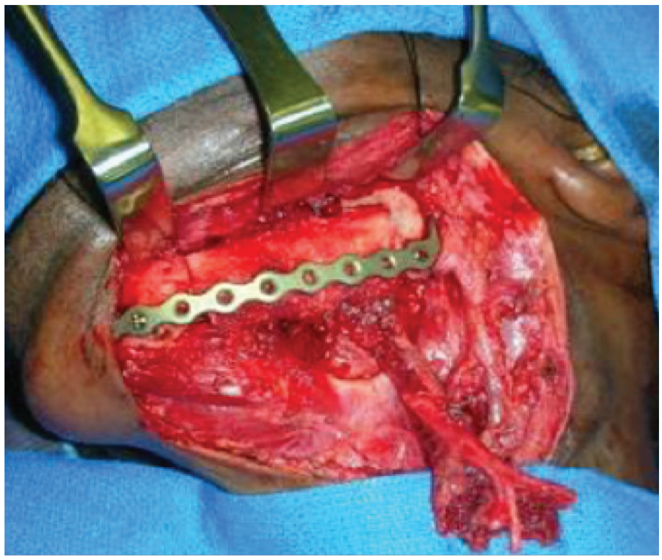

FIGURE 6. Inset fibula with vascular pedicle.

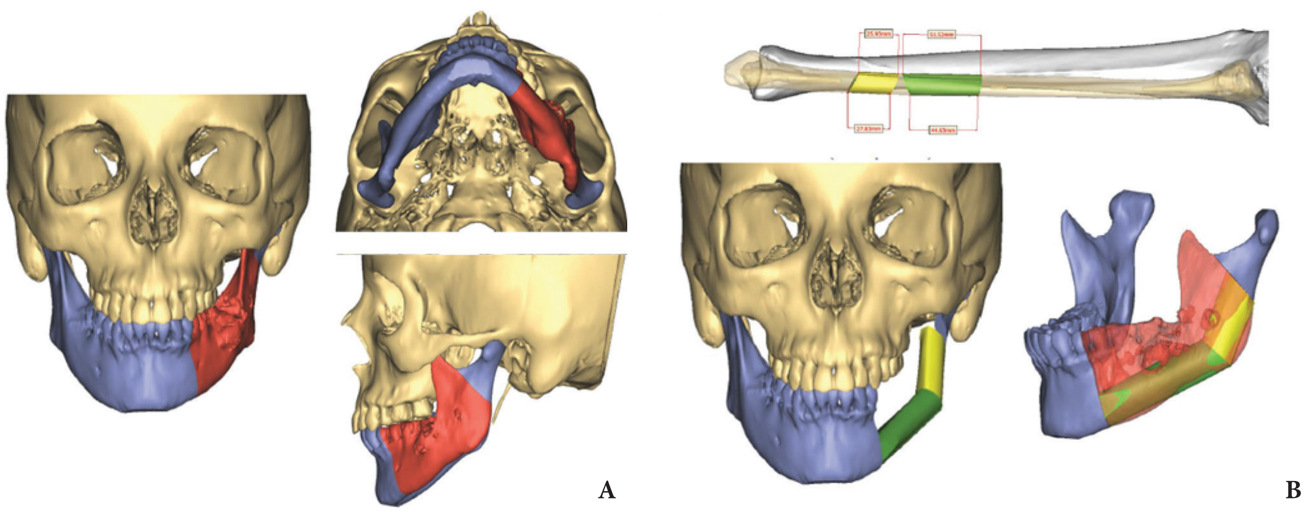

FIGURE 7. Virtually assisted surgical planning demonstrating resection margins (**A**). Virtually assisted surgical planning demonstrating free fibula flap reconstruction (**B**).

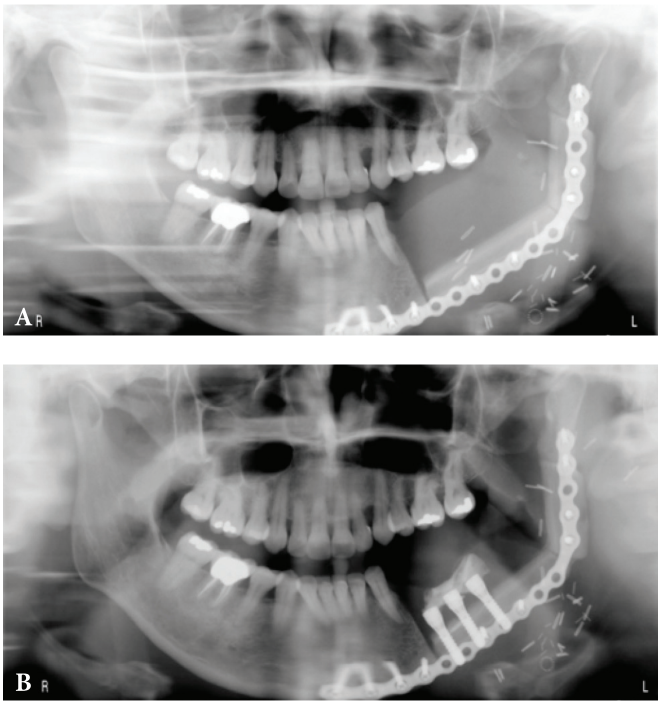

FIGURE 8. A – Immediate post-operative panoramic radiograph of free fibula flap reconstruction; **B** – 3 months post-reconstruction panoramic radiograph after dental implant placement and flap debulking.

immediate implant placement was performed at the time of reconstruction. Prolonged interval to implant placement was primarily a result of socioeconomic or personal issues rather than medical complications. The timing of implant placement did not appear to have an effect on the overall outcome in our patients. Some authors recommend at least a 6-month period of healing prior to implant surgery [10], while others advocate immediate implant insertion into fibula at the time of reconstructive surgery [11]. Delayed implant placement allows for sufficient bone remodeling and soft tissue healing thus allowing more precise implant placement (Fig 8A, B) [12]. In cases of malignant disease, a 6-12 month waiting period also allows monitoring for early disease recurrence, presence of which would discourage implant surgery due to poor overall prognosis. Disadvantages of this treatment option include need for additional surgery and prolonged period of time with suboptimal function due to delayed prosthetic rehabilitation. Immediate implant placement eliminates the need for additional surgery and its associated morbidity. However, it increases the risk of future implant disuse due to difficulty predicting final implant position once bone remodeling and soft tissue healing reach its final stages [13]. Since cone beam CTs became widely used in dental practices, computer assisted surgical planning has also gained wide acceptance and has been shown to provide more predictable results with optimal final restorations [14]. Nevertheless, desired implant placement may be impossible due to position of internal fixation screws necessary to secure the flap to native mandible. With delayed implant placement, simultaneous removal of fixation hardware is also possible, thus eliminating the risk of future hardware infection development. A total of 12 to 16 weeks are recommended for healing and osseointegration of implants prior to uncovering [8].

Discrepancy in the bone height between native mandible and fibula was implicated in creation of unfavorable crown to fixture ratio that may increase the risk of implant failure [10]. Several strategies were devised to circumvent this problem. Positioning of the fibula superior to the inferior border of the mandible improves the crown to implant ratio, but may result in evident facial deformity [9]. Placement of the reconstruction plate along the inferior border is often used to correct this issue [9]. Double-barrel fibula and vertical distraction osteogenesis are more technically challenging and demanding options available for fibula height correction [8]. From a restorative stand point, a milled bar framework may be used to help correct the height discrepancy, as well as facilitate distribution of masticatory forces (Fig 9) [8].

All of our patients were reconstructed with fibulas that were aligned with inferior border of the mandible and 8 out of 9 were satisfactorily restored with dental prosthesis, or are in the process of being restored, without the above-mentioned corrections. One patient with a history of medication related osteonecrosis of the jaw (MRONJ) did not have a prosthesis fabricated to date due to delay in healing that was complicated by hardware infection.

One of the disadvantages from the standpoint of dental rehabilitation is the excessive mobility and thickness of the fibula skin paddle. Reconstruction of intraoral soft tissue defects often results in vestibular obliteration and requires vestibuloplasty with tissue debulking to facilitate prosthesis fabrication and use [8]. Lack of attached mucosa adjacent to the implant abutments increases risk of irritation and inflammation of the hypermobile fibula skin paddle [10].

One of our patients required vestibuloplasty, flap debulking, and keratinized tissue graft. Two others required vestibuloplasty and one more patient required flap debulking. In total 4 out of 9 patients (i.e 44%) required additional procedures, which is consistent with reports in the literature [6].

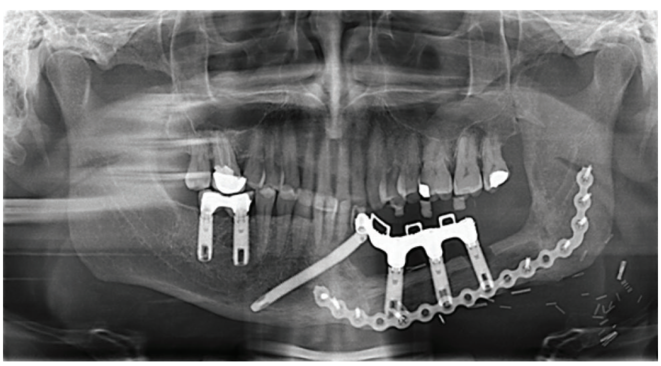

FIGURE 9. Milled bar framework for a fixed partial denture.

FIGURE 10. Implant supported prosthesis.

Conclusions

Implants placed in fibulas have high success rates comparable to native mandible, >95% [15]. Immediate or late implant failure is uncommon, and in our cohort, no implants were lost. Two out of nine patients developed peri-implantitis that had eventually resolved, although required invasive intervention. Peri-implant tissue inflammation is one of the most common complications reported in the literature [16]. Chronic peri-implantitis may result in peri-implant bone loss as was observed in one of our patients.

As illustrated by our selection of cases, fibula free flap reconstruction is the treatment of choice for patients with various disease processes resulting in significant mandibular defects and can ultimately be restored with fixed dental prostheses (Fig 10).

Since comprehensive orofacial rehabilitation is a multi-step complex process involving different healthcare specialists and multiple surgeries, patients' prognoses, interest and enthusiasm needs to be assessed. Multiple studies have shown that patient's quality of life is dramatically improved when these surgical techniques are used to restore patient's form and function [17].

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J Diagn Treat Oral Maxillofac Pathol 2017;1:6–10.

Комплексна реконструкція дефектів нижньої щелепи вільними малогомілковими клаптями та внутрішньокістковими імплантатами

Руї П. Фернандес[1], Анастасія Квімби[2], Салам Салман[1]

[1] *Відділення оральної та щелепно-лицевої хірургії, Університет Флориди, Коледж медицини, Джексонвіль, США*
[2] *Резидентура з оральної та щелепно-лицевої хірургії, 3-й рік піследипломного навчання, Університет Флориди, Коледж медицини, Джексонвіль, США*

П Р О С Т А Т Т Ю

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Ключові слова:

Вільний малогомілковий клапоть (ВМК)
Внутрішньокісткові імплантати
Дефекти нижньої щелепи
Трансплантація кератинізованої слизової
Циторедукція клаптя
Периімплантит

Р Е З Ю М Е

Мета. Розглянути використання ВМК при реконструкції різних дефектів нижньої щелепи, а також проілюструвати, як розміщення зубних імплантатів в ВМК є життєздатним варіантом забезпечення чудового функціонального результату.

Пацієнти та методи. Дев'ять пацієнтів з реконструкцією нижньої щелепи ВМК, в які встановили імплантати були включені в це дослідження, щоб продемонструвати універсальність цього методу реконструкції.

Результати. Найбільш частим ускладненням в нашій групі був периімплантит та інфікування.

Висновки. Реконструкція ВМК є методом вибору при лікуванні хворих з різними патологічними процесами, в результаті яких утворюються значні дефекти нижньої щелепи і в кінцевому рахунку можуть бути відновлені фіксованими зубними протезами.

Комплексная реконструкция дефектов нижней челюсти свободными малоберцовыми лоскутами и внутрикостными имплантатами

Руи П. Фернандес[1], Анастасия Квимби[2], Салам Салман[1]

[1] *Отделение оральной и челюстно-лицевой хирургии, Университет Флориды, Колледж медицины, Джексонвиль, США*
[2] *Резидентура с оральной и челюстно-лицевой хирургии, 3-й год последипломного образования, Университет Флориды, Колледж медицины, Джексонвиль, США*

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Свободный малоберцовый лоскут (СМЛ)
Внутрикостные имплантаты
Дефекты нижней челюсти
Трансплантация кератинизированой слизистой
Циторедукция лоскута
Периимплантит

Р Е З Ю М Е

Цель. Рассмотреть использование СМЛ в реконструкции различных дефектов нижней челюсти, а так же проиллюстрировать как размещение зубных имплантатов в свободных малоберцовых лоскутах является жизнеспособным вариантом обеспечения превосходного функционального результата.

Пациенты и методы. Девять пациентов с реконструкцией нижней челюсти СМЛ, в которые установили имплантаты были включены в это исследование, чтобы продемонстрировать универсальность этого метода реконструкции.

Результаты. Наиболее частым осложнением в нашей группе был периимплантит и инфицирование.

Выводы. Реконструкция СМЛ является методом выбора при лечении больных с различными патологическими процессами, в результате которых образуются значительные дефекты нижней челюсти и в конечном счете могут быть восстановлены фиксированными зубными протезами.

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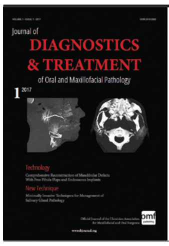

Minimally Invasive Techniques for Management of Salivary Gland Pathology

Rui P. Fernandes[1,*], Salam Salman[2], Anastasiya Quimby[3]

[1] Department of Oraland Maxillofacial Surgery, University of Florida, College of Medicine, Jacksonville, USA (Assoc Prof)
[2] Department of Oral and Maxillofacial Surgery, University of Florida, College of Medicine, Jacksonville, USA (Assoc Program Director)
[3] Oral and Maxillofacial Surgery Residency Program, PGY3, University of Florida, College of Medicine, Jacksonville, USA

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ABSTRACT

Purpose.
The goal of this article is to describe the technique used at our institution and highlight potential pitfalls during sialendoscopy.
Discussion.
Indication for sialendoscopy, sialendoscopy technique are discussed.
Results.
Despite the high reported success rates with sialendoscopy, the procedure is deemed to be technically challenging and correlation between success rates and operator experience has been shown.
Conclusion.
Sialendoscopy is a minimally invasive technique that is gradually replacing the classic open surgical approach to the treatment of obstructive salivary gland diseases as the standard of care.

Introduction

Obstructive salivary gland disease is common and regardless of etiology historically it has been treated with gland excision. Although removal of the gland results in complete symptom resolution, the surgery itself carries inherent risks. Depending on which major salivary gland is involved the risks range from minor cosmetic defects to major complications such as facial nerve damage or airway compromise. These considerations encouraged the development of minimally invasive approaches in order to avoid surgical gland resection.

Sialendoscopy takes advantage of the naturally present salivary gland duct orifice thus obviating the need for surgical incisions. Small endoscopes may be utilized to examine and assess the pathologic process within the ductal system, i.e. diagnostic sialendoscopy, as well as intervene as indicated, i.e. therapeutic sialendoscopy. Use of endoscopes to remove a sialolith was first described by Katz in 1991 (Katz, 1991) [1]. Following the introduction of this technique numerous authors have reported success utilizing sialendoscopy for a wide range of indications. In addition to removal of sialoliths, it has been used for retrieval of foreign objects (Nahlieli, Nakar, Nazarian, & Turner, 2006) [2], breaking up of adhesions (Ardekian, Shamir, Trabelsi, & Peled, 2010) [3], treatment of juvenile recurrent parotitis (Singh & Gupta, 2014) [4], and radio-iodine induced and autoimmune sialadenitis (Atienza & Lopez-Cedrun, 2015) [5].

The purpose of this article is to describe the technique used at our institution and highlight potential pitfalls during sialendoscopy.

* Corresponding author. Department of Oral and Maxillofacial Surgery, University of Florida, College of Medicine, 653 West 8th St., Jacksonville 32209, USA.
Tel.: 904-244-5502, fax: 904-244-6252
E-mail address: rui.fernandes@jax.ufl.edu (R.P. Fernandes)

Discussion

Sialendoscopy is indicated in any situation where there is a physical obstruction to the salivary outflow that eventually results in inflammatory or infectious processes within the gland parenchyma. Therefore, patients most commonly present with complaints of painful facial or submandibular swelling that may also be associated with overlying skin erythema and systemic fever, especially during or after meals. Complete assessment consists of history, physical exam, including an attempt to "milk" a salivary gland, and imaging. The imaging modalities used include plain radiographs, ultrasound, non-contrast CT (Fig 1), and MRI (Hitti, Salloum, & Mufarrij, 2014) [6]. Plain radiographs and US are adequate to assess a minimally symptomatic patient with no suspicion of retrotropharyngeal or parapharyngeal abscess formation. Non-contrast CT allows visualization of deep neck spaces as well as provides sufficient gland tissue detail, has 100% sialolith detection sensitivity (Hitti et al., 2014) [6] and can be quickly obtained, thus making it a good choice of imaging in

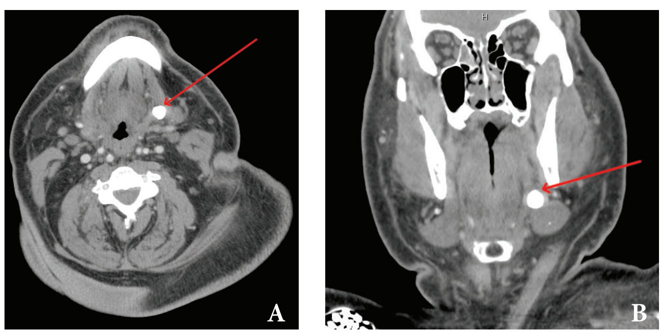

FIGURE 1. Non-contrast CT images (**A**, **B**) with *arrows* pointing to sialolith in the left submandibular gland duct (Wharton's duct).

patients who are suspected to have more extensive disease.

Several different types of etiologies lead to the same obstructive symptomology but may require different therapeutic approaches. Intraluminal obstruction of the salivary gland ductal system most frequently is due to sialolithiasis (Marchal et al., 2001) [7] with submandibular gland being affected 80% of the time and parotid gland involved in 20% (Zenk et al., 2012) [8]. Small size of the sialolith, oval shape, mobility and distal location within the duct were determined to be positive prognostic factors for simple removal (Luers, Grosheva, Stenner, & Beutner, 2011) [9]. Specifically, it has been shown that simple removal of 3mm stones from parotid gland and 4mm stones from submandibular gland can be easily achieved with wire baskets, mini graspers, or forceps (Marchal et al., 2001) [7]. Where a stones of larger diameter, up to 8-9mm, require fragmentation by either direct instrumentation or lithotripsy (Zenk et al., 2012) [8]. Ductal mucous plugs and less commonly foreign bodies such as tea leaves and hair were reported (Nahlieli et al., 2006) [2]. Ductal strictures have also been implicated as a cause of recurrent sialadenitis and their incidence was thought to be underestimated (Ardekian et al., 2010) [3]. Etiology of ductal strictures is not well defined, although it is assumed to be the result of epithelial healing after traumatic, infectious, or recurrent inflammatory insults (Ardekian et al., 2010) [3].

Sialendoscopy Technique

After appropriate patient selection and review of relevant pre-operative images, parotid and submandibular sialendoscopy can be performed either under general endotracheal anesthesia (GETA), intravenous sedation, or local anesthesia. It has been shown that patients with no co-morbidities and small sialoliths tolerate sialendoscopy under local anesthesia well (Luers, Stenner, Schinke, Helmstaedter, & Beutner, 2012) [10]. The authors prefer nasal GETA due to improved access, patient cooperation, and risk of airway compromise if inadvertent fluid extravasation into the floor of mouth during submandibular procedures.

The basic set up includes the following armamentarium:

- IV tubing and extension with 3-way stopcock
- 60cc syringe
- 500cc bag of 0.9% NaCl solution
- Endoscopy tower and monitor
- Salivary probes and dilators (Figure 2)
- COOK® Kolenda Introducer Set (Figure 3)
- Karl Storz® ALL-IN-ONE Sialendoscopes, ERLANGEN model (Figure 4):
    - All endoscopes are 0°angle
    - 0.8mm diameter for diagnostic sialendoscopy
    - 1.1mm and 1.6mm diameter for therapeutic sialendoscopy
- Karl Storz® Foreign Body Forceps
- Disposable Items:
    - Karl Storz® Stone Extractors (wire baskets)
        - 0.4mm or 0.6mm diameters
    - Karl Storz® Balloon Catheter
        - 0.7mm diameter
    - COOK® NGage Stone Extractor

The procedure, both for parotid and submandibular sialendoscopy, is initiated by serial dilatation of the salivary gland ducts. In case of difficulty with visualizing salivary gland papilla milking of the gland or use of methylene blue was suggested in the literature (Kent, Walvekar, & Schaitkin, 2016) [11]. Schaitkin salivary gland dilators can be used, or serial dilation with standard salivary gland dilators from size 0000 to 8. Marchal bougies can then be used to further dilate the ducts (Fig 2).

FIGURE 2: Sialendoscopy dilation set. Standard dilators No. 0000 to 8, conical bougie, Marchal dilators, papillotomy scissors, grasping forceps. (From top left to bottom left in clockwise orientation).

Once appropriate dilation has been performed, COOK® Kolenda Introducer Set can be placed in the duct to secure ductal access (Fig 3).

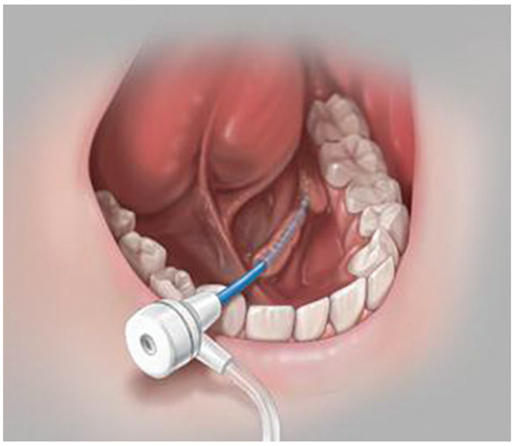

FIGURE 3. COOK® Kolenda Introducer Set.

Local anesthesia (1% lidocaine with 1:100,000 epinephrine) is injected into the duct with an flexibile angiocatheter tip. Diagnostic sialendoscopy is then performed with the Karl Storz® ALL-IN-ONE Sialendoscopes (Fig 4), ERLANGEN model 0.8mm diameter endoscope.

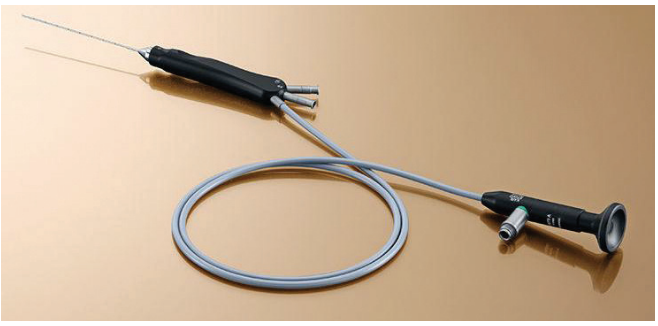

FIGURE 4. Karl Storz® ALL-IN-ONE Sialendoscopes, ERLANGEN model.

Following diagnostic sialendoscopy, therapeutic endoscopy can then be performed with either the 1.1mm or 1.6mm diameter endoscopes. If possible, the authors prefer to use the 1.6mm diameter scope for improved ability to perform stone extraction. It is important to maintain a constant and steady flow of fluid insufflation during the entire procedure to prevent ductal collapse and improve visualization (Figs 5-7). A three-way stopcock is attached to a 60cc syringe to allow the assistant to apply controlled insufflation during the procedure.

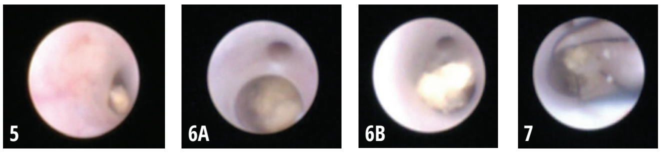

FIGURE 5. Sialolith visualiziation.
FIGURE 6A. Sialolith proximal to duct bifurcation.
FIGURE 6B. Sialolith distal to ductal bifurcation.
FIGURE 7. Wire basket applied to sialolith.

If performed this procedure for stone extraction, wire baskets are then used to attempt stone removal (Fig 7). They are introduced in the closed position through the working port of the endoscopy and passed beyond the stone. Once beyond the stone, the wire basket can be opened and rotated until it is engaging the stone. The basket and the endoscope are then retracted from the duct together, keeping visualization on the stone. For stones larger than 3mm or 4mm, parotid or submandibular respectively, papillotomy may need to be performed to allow for stone retrieval. For more advanced techniques and larger stones, laser lithotripsy can be performed to fragment the stone.

After stone extraction, 0.8mm endoscopy is used again to evaluate the salivary gland system to ensure that all stones have been removed and to irrigate all remaining debris and mucous plugs.

If performed for salivary duct strictures, similar initial procedures are performed with the exception of using wire baskets. Using the 1.6mm diameter endoscope, balloon catheters can be introduced through the working port in a closed position. Once the area or areas of strictures are encountered, the balloon is opened and held in place for roughly one to two minutes. The balloon catheter is then retracted and the stricture evaluated. If adequate dilation has not been achieved, catheter inflation can be performed again.

Once the procedure is completed, the endoscopes and COOK® Kolenda Introducer Set can be removed. Minor papillotomy can be performed at this time if needed. Compressive head dressing is then placed followed by patient emergence from general anesthesia and extubation.

Post-operative care includes instructing the patient to perform frequent warm compress massages over the involved salivary gland and appropriate hydration. Post-operative antibiotic use is not indicated, only the standard peri-operative prophylactic dose. In the literature, practice of prescribing antibiotics appears to be center or surgeon specific, although reported post-operative rates of glandular infection are around 2.5% (Nahlieli, Bar, Shacham, Eliav, & Hecht-Nakar, 2004) [12]. Local infection of papilla has been reported around 23%, thus suggesting that use of antiseptic mouth rinse, such as chlorhexidine, maybe warranted in the immediate post-operative period.

Pearls and Pitfalls

There are several technical problems and complications that can occur during sialendoscopy. Some technical errors are maceration of the papilla, which can be avoided by decreasing the amount of traction or force placed on the endoscope. Over insufflation or excessive pressure while irrigating can lead to significant edema, it is important to maintain a controlled level of pressure during irrigation to avoid this. This is monitored by the assistant using a 60cc syringe attached to a three-way stopcock, and only irrigating fluid with enough pressure to maintain duct patency for visualization. False passages and ductal perforation can also be created with using excessive force during dilation or blindly passive instruments through the working port. The most severe or life-threatening complication can occur during submandibular gland sialendoscopy, which is floor of mouth edema leading to airway compromise. The reported incident of upper airway obstruction occurred in the setting of irrigating solution extravasation after excessive pressures resulted in ductal tear (Baptista, Gimeno, Salvinelli, Rinaldi, & Casale, 2009) [13]. If this occurs, it is imperative to keep the patient intubated until the edema has subsided. The most common complication described in one study was failure of procedure due to peculiar duct anatomy, distal ductal stenosis or retained stone (Walvekar, Razfar, Carrau, & Schaitkin, 2008) [14]. Multiple other studies have validated sialendoscopy as a safe method with minor complications such as ductal tears, papillary infection, and facial swelling that usually self-resolve with minimal to now additional interventions (Marchal & Dulguerov, 2003) [15]. Possibility of lingual nerve damage exists, however it is seldom mentioned in the available reports.

Despite the high reported success rates with sialendoscopy, the procedure is deemed to be technically challenging and correlation between success rates and operator experience has been shown (Walvekar et al., 2008) [14]. In order to achieve the success rates of >90% as reported in literature, completion of 50 cases appears to be the benchmark (Steck, Stabenow, Volpi, & Vasconcelos, 2016) [16]. The most commonly cited difficulties surgeons new to sialendoscopy experience are difficulty canalizing the papilla, creation of false passage and duct lacerations (Steck et al., 2016) [16], (Farneti et al., 2015) [17]. Catheterization of the papilla is deemed the rate limiting step, since failure to achieve this step precludes completion of either diagnostic or therapeutic sialendoscopy (Farneti et al., 2015) [17]. Use of magnifying loops or even microscope, if available, may be beneficial in identifying and canalizing the papilla. There appears to be a consensus that surgeons experienced with endoscopic sinus surgery or dacryocystorhinostomy have no trouble with this aspect of the procedure. It has been suggested that practicing this skill on fresh cadavers of human or pig heads should be part of standardized training (Steck et al., 2016) [16] (Farneti et al., 2015) [17]. Laceration of the duct is undesirable due to potential of future ductal stenosis thus increasing patient's chance for recurrent obstructive symptoms and possible need for eventual gland removal. Moreover, false passage can be created through the laceration increasing the risk for irrigant extravasation and making completion of the procedure more arduous. Definitive papilla identification, clear visualization of the intraductal lumen, and gentle instrument manipulation and irrigation reduce the likelihood of duct laceration. Even though sialendoscopy can be performed under local anesthesia, general anesthesia is recommended until adequate level of comfort and confidence is achieved by the operator.

There is a steep learning curve when beginning the practice of sialendoscopy. In the authors' experience, several challenges have been encountered that have led to implementing changes in our technique. First, to prevent trauma to the ductal papilla by entering the duct repeatedly with the endoscopes, use of the COOK® Kolenda Introducer Set was implemented. This device allows one to maintain passage of the endoscopes and instruments into the duct without having to reenter the papilla. Second, use of the 0.8mm scope initially is essential. This allows you to visualize the ductal anatomy, locate sialoliths and mucous plugs, and measure the approximate depth or distance a sialolith is prior to using the therapeutic sialoscopes. Finally, when attempting to remove a large sialolith, if one encounters difficulty encircling the stone, do not hesitate to use instrumentation, i.e. Karl Storz® Foreign Body Forceps, to break the stone apart into smaller fragments. Attempting to force a wire basket around the stone can lead to inadvertent laceration of the salivary gland duct.

Conclusion

Sialendoscopy is a minimally invasive technique that is gradually replacing the classic open surgical approach to the treatment of obstructive salivary gland diseases as the standard of care. Although the initial challenges to the implementation of sialendoscopy into routine practice include high cost and need for specialized training, benefits have proven to be substantial. Ability to perform sialendoscopy in an outpatient setting and, in appropriate situations, under local anesthetic dramatically reduces patient's financial burden, post-operative morbidity, and recovery time. As cited in literature and per author's experience serious complications are rare and minor complications that do occur, frequently resolve on their own with no need for additional surgical intervention. In addition to providing an overall better experience for patients and allowing for quicker return to normal daily life, an overall reduction in patient care time per patient provides a surgeon with an opportunity to take care of greater number of patients. Thus, inclusion of sialendoscopy in surgeon's arsenal of practical skills is most definitely recommended.

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Мінімально інвазивні методики лікування патології слинних залоз

Руї П. Фернандес[1], Салам Салман[1], Анастасія Квімбі[2]

[1] Відділення оральної та щелепно-лицевої хірургії, Університет Флориди, Коледж медицини, Джексонвіль, США
[2] Резидентура з оральної та щелепно-лицевої хірургії, 3-й рік післядипломного навчання, Університет Флориди, Коледж медицини, Джексонвіль, США

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Розсічення під'язикового сосочку
Стеноз протоку
Внутрішньопротокові пробки із слизу

РЕЗЮМЕ

Мета. Мета данної роботи – описати метод, який використовується в нашому закладі та висвітлити потенційні труднощі під час сіалендоскопії.
Обговорення. Обговорюються показання до сіалендоскопії і методики її проведення
Результати. Незважаючи на зафіксований в світі високий рівень успішних сіалендоскопій, процедура вважається технічно сладною і частота успіху залежить від досвіду хірурга в данній методиці.
Висновки. Сіалендоскопія – це мінімально інвазивна методика, яка по поступово заміняє традиційний відкритий хірургічний доступ в лікуванні обструктивних захворювань слинних залоз, як стандарта лікування.

Минимально инвазивные методики лечения патологии слюнных желез

Руи П. Фернандес[1], Салам Салман[1], Анастасия Квимби[2]

[1] Отделение оральной и челюстно-лицевой хирургии, Университет Флориды, Колледж медицины, Джексонвиль, США
[2] Резидентура с оральной и челюстно-лицевой хирургии, 3-й год последипломного образования, Университет Флориды, Колледж медицины, Джексонвиль, США

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Рассечение подъязычного сосочка
Стеноз протока
Внутрипротоковые пробки из слизи

РЕЗЮМЕ

Цель. Цель данной работы – описать методику, которая используется в нашем учреждении и осветить потенциальные сложности во время сиалэндоскопии.
Обсуждение. Обсуждаются показания к сиалэндоскопии и методики ее проведения.
Результаты. Невзирая на зафиксированный в мире высокий уровень успешных сиалэндоскопий, процедура считается технически сложной и частота успеха зависит от опыта хирурга в данной технике.
Выводы. Сиалэндоскопия – это минимально инвазивная методика, которая по нарастающей замещает традиционный открытый хирургический доступ при лечении обструктивных заболеваний слюнных желез, как стандарта лечения.

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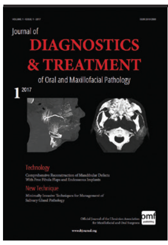

Features of Diagnostics, Clinical Course and Treatment of the Branchial Cleft Cysts

Oleksii O. Tymofieiev[1,*], Ievgen I. Fesenko[2], Olga S. Cherniak[3], Valentyna I. Zaritska[4]

[1] Chair of the Department of Maxillofacial Surgery, Stomatology Institute, Shupyk National Medical Academy of Postgraduate Education, Kyiv, Ukraine *(ScD, Prof)*

[2] Oral and Maxillofacial Surgery Department, KMU of UAFM, Kyiv, Ukraine *(Assis Prof)*

[3] Head of the Department of Ultrasound at the Regional Diagnostic Center, Kyiv Regional Clinical Hospital, Kyiv, Ukraine

[4] Department of Pathology, Shupyk National Medical Academy of Postgraduate Education, Kyiv, Ukraine *(PhD, Assoc Prof)*

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Pseudosolid appearance

ABSTRACT

Purpose.
The aim of the present study was to determine the features of diagnostics, clinical course and treatment of the branchial cleft cysts.
Patients and methods.
The study composed of the branchial cleft cysts investigation and their complications in patients of different age groups, methods of diagnostics, anatomical features, surgical stages and pathomorphological study.
Results.
Diagnostic value of sonography, MDCT and MRI, pathomorphological study in verification of branchial cleft cysts and their complications have been proved. Surgical treatment technique is presented.
Conclusion.
Presented methods of diagnostics of the branchial cleft cysts and their complications, variants of clinical course and treatment can reduce the risk of failure at the pre-, intra- and post-operative stages.

Introduction

Branchial cleft cyst (*synonyms:* lateral cyst of the neck, congenital lateral cyst of the neck, branchial cyst, lateral branchial cyst of the neck, lateral lymphoepithelial cyst) according to our data has been found in 25% of all cysts of the soft tissue in maxillofacial and neck area [1-15]. The branchial cleft fistulas are rarely detected.

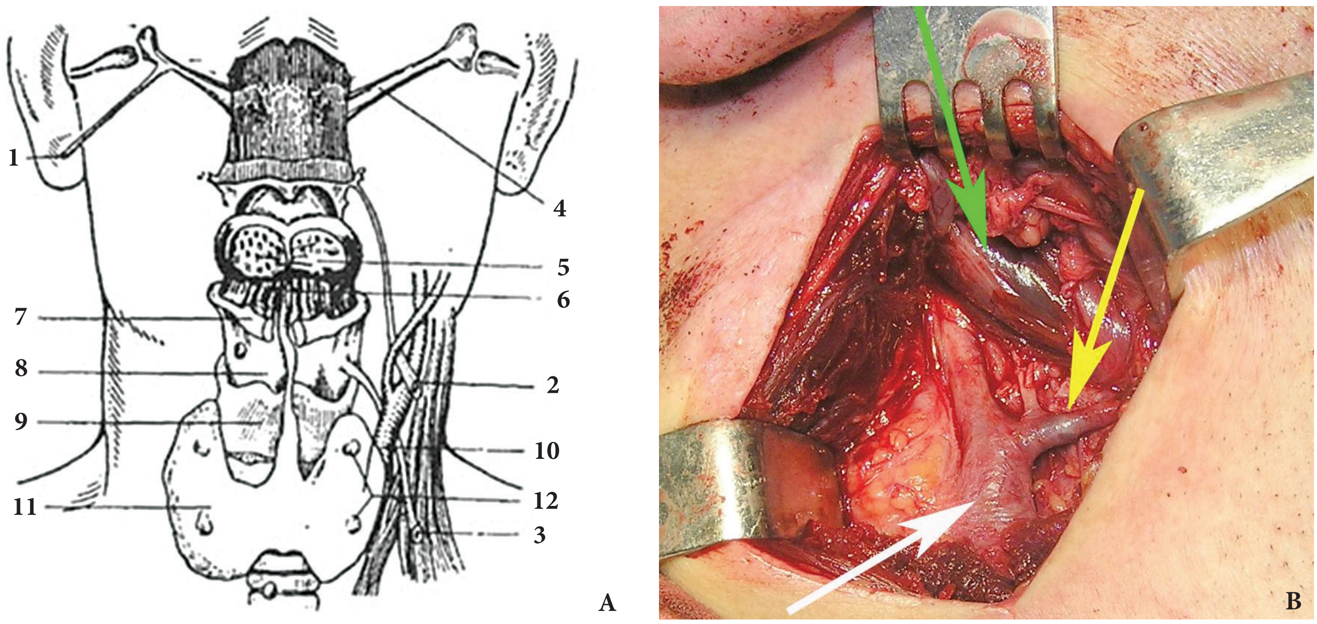

FIGURE 1. Location scheme of branchial neck fistulas (**A**): 1 – I branchial pocket; 2 – II branchial pocket; 3 – III branchial pocket; 4 – auditory tube; 5 – tongue; 6 – thyroglossal duct; 7 – the hyoid bone; 8 – thyroid-hyoid membrane; 9 – thyroid cartilage; 10 – common carotid artery; 11 – thyroid gland; 12 – parathyroid glands. Location of the inner pole (**B**) of BCC after its removal. Internal jugular vein is marked by *white arrow*, facial vein – *yellow arrow*, posterior belly of the digastric muscle – *green arrow*.

* *Corresponding author. Department of Maxillofacial Surgery, Stomatology Institute, Shupyk NMAPE, 4-a Pidvysotskogo Street, Kyiv 01103, Ukraine.*
Tel., fax: +38 (044) 528 35 17. E-mail address: tymofeev@gmail.com *(O.O. Tymofieiev)*

Branchial cleft cysts (Greek, *branchia* gill) have dysontogenetic origin.

With regard to the pathogenesis of branchial cleft cysts (BCCs) and fistulas there is disagreement till present day. There are two theories of its origin. According to the **"thymus"** theory these cysts and fistulas are formed from the remnants of thymopharyngeal duct. **"Branchial"** theory links the origin of these lesions with abnormal development of branchial (pharyngeal) pockets. Anomalies of the 2nd or 3rd pair of pharyngeal (branchial) pockets are the source of the formation of the BCCs and fistulas. Internal branchial pockets are formed by endoderm and the external (or grooves) by ectodermal germ layers. BCCs can be both of endodermal and ectodermal origin (Fig 1A).

Cysts occur at any age, but are much more common in children and young adults (Fig 2). Their appearance is preceded (provoke) by the infections of the respiratory tracts (tonsillitis, flu, etc.). The sizes of the BCCs can be different (Fig 2). In contrary to dermoid (epidermoid) cysts the BCCs are often suppurate [1, 2, 3].

First, BCCs were classified according to their localization. Bailey H. (1929), divided them into 4 types [16]: **type 1** – deep to platysma, anterior to sternocleidomastoid (SCM); **type 2** – abutting internal carotid artery and adherent to internal jugular vein (most common); **type 3** – extending between internal and

FIGURE 2. Clinical view of the patients of different ages with BCCs (*arrows*) of various sizes (**A**, **B**, **C**, **D**). **(Fig 2 continued on the next page.)**

external carotid arteries; **type 4** – abutting pharyngeal wall and potentially extending superiorly to skull base.

CLINICAL PICTURE

BCCs are the round-shaped mass at the upper neck anteriorly to the sternocleidomastoid muscle (in carotid triangle). At the same time, they may be located in the middle and even lower parts of the neck. Typically, the BCCs localized in the upper or middle third of the neck adjacent to the anterior edge of the sternocleidomastoid muscle or partly comes under it. It is located between the 2nd and 3rd fascial leaf of the neck (between the superficial and deep fascia leaf of the own neck fascia) on the neurovascular bundle. The upper pole of the cyst is often found near or under the posterior edge of the digastric or stylohyoid muscles. Medially the cysts are adjacent to the internal jugular vein at the level of common carotid artery bifurcation. BCCs can be located in the upper, middle and lower parts of the neck. Along the length the cyst may extend down to the clavicle, and in the upper part of the neck reaches mastoid process (Fig 1B).

Visually, BCCs are showning as a painless limited rounded shape tumor-like lesion with a smooth surface. The skin above it is not changed in color. They are not soldered with surrounding tissues. A compulsory component of the

FIGURE 2 (cont'd). Clinical view of the patients of different ages with BCCs (*arrows*) of various sizes (**E**, **F**, **G**, **H**). **(Fig 2 continued on the next page.)**

FIGURE 2. (**cont'd**) Clinical view of female with the non-infected BCC (*arrow*) (**I**).

FIGURE 3. Clinical view of female with suppurated BCC.

cyst is a lymph node at the inferior pole. Upon swallowing the tumor-like mass does not move (as opposed to thyroglossal duct cysts). Consistency of the cysts are soft-elastic or elastically tense (elastically dense). A fluctuation may be determined. The BCCs does not cause respiratory and swallowing disorders. Systemic manifestations are not present. With secondary inflammation the cyst becomes dense, slow-moving, painful, can cause pain upon swallowing, and even talking. The systemic symptoms are (malaise, weakness, fever, etc.) appearing. Puncture of the cyst can get serous-mucous or muco-purulent transparent liquid light brown or dark brown (rare) color. Upon suppuration cyst fluid becomes turbid, pus appears. The skin over the cyst in case of its suppuration becomes hyperemated (Fig 3).

Desquamated epithelial cells, erythrocytes, lymphocytes, and cholesterol crystals can be detected microscopically in a punctate. Upon bacteriological examination a microflora in the content of uncomplicated cysts usually is not found. Only in rare cases low virulent *staphylococci* or *streptococci* are founded.

PATHOLOGY

Verification of the diagnosis is provided with pathomorphological investigation. Microscopically, the wall of the BCCs consists of a dense connective (fibrous) tissue that is lined with a stratified squamous non-cornified epithelium (ectodermal cysts), and multi-layered columnar epithelium (endodermal cyst). Some BCCs contain ciliated epithelium. Inside the wall (capsule) the lymphoid tissue, often forms the follicles (germinal centers) (Fig 4) [17]. Significant development of lymphoid tissue suggests that the BCCs originate from the branchial apparatus remnants. The inner surface of the cyst may be covered with warty growths of lymphoid tissue (crypts). In its wall, the formations like Hassel's corpuscles of thymus gland are identified. Upon suppuration of the cyst the epithelium can partially die and be replaced by the connective tissue, there is a thickening of the epithelial lining and its cornification. At the inferior pole of the BCCs the lymph node is often morphologically detected.

In front of the tragus, the preauricular (branchial) fistula can be found, which comes from I branchial pocket. The fistulous tract is lined by squamous epithelium. Preauricular (tragal) fistulas are often spread deep into the soft tissue to the parotid gland, and even penetrate into it. From these fistulas develop cysts localized in the parotid gland. The morphological difference between these fistulas is that the wall of the fistula, originating from the branchial I pocket has no lymphoid tissue, which is always present in BCCs or fistulas localized in the neck.

Diagnostics of BCCs is carried out between chronic **lymphadenitis** (non-specific and specific) [18-21], **dermoid** (**epidermoid**) **cysts** [22, 23], **tumors** and **tumor-like lesions** of soft tissues of the neck, blood vessels, nerves and thyroid gland, lymphangiomas (Fig 10) [24-28], metastases of malignant tumors, etc. For more accurate diagnosis the cyst- or fistulography with the administration of radiocontrast agents, CT, MRI, ultrasound can be performed (Fig 5).

ULTRASOUND

Upon **ultrasound diagnostics** are estimated: the location of the lesion, its size, wall thickness and the presence of septations, edges, borders, internal echogenicity, presence of acoustic enhancement artifact, fistula, vascularization at Doppler ultrasound. Compression of the mass by ultrasonic transducer confirms the true cystic nature helping in differential diagnosis. BCCs at ultrasonography are visualized as cystic mass of oval or round shape with smooth surface (Figs 6-8). Ahuja A.T. et al. (2000) [19] distinguish four echogenicity patterns of BCCs content: truly ***anehoic*** (41%), predominantly homogeneously ***hypoechoic*** but

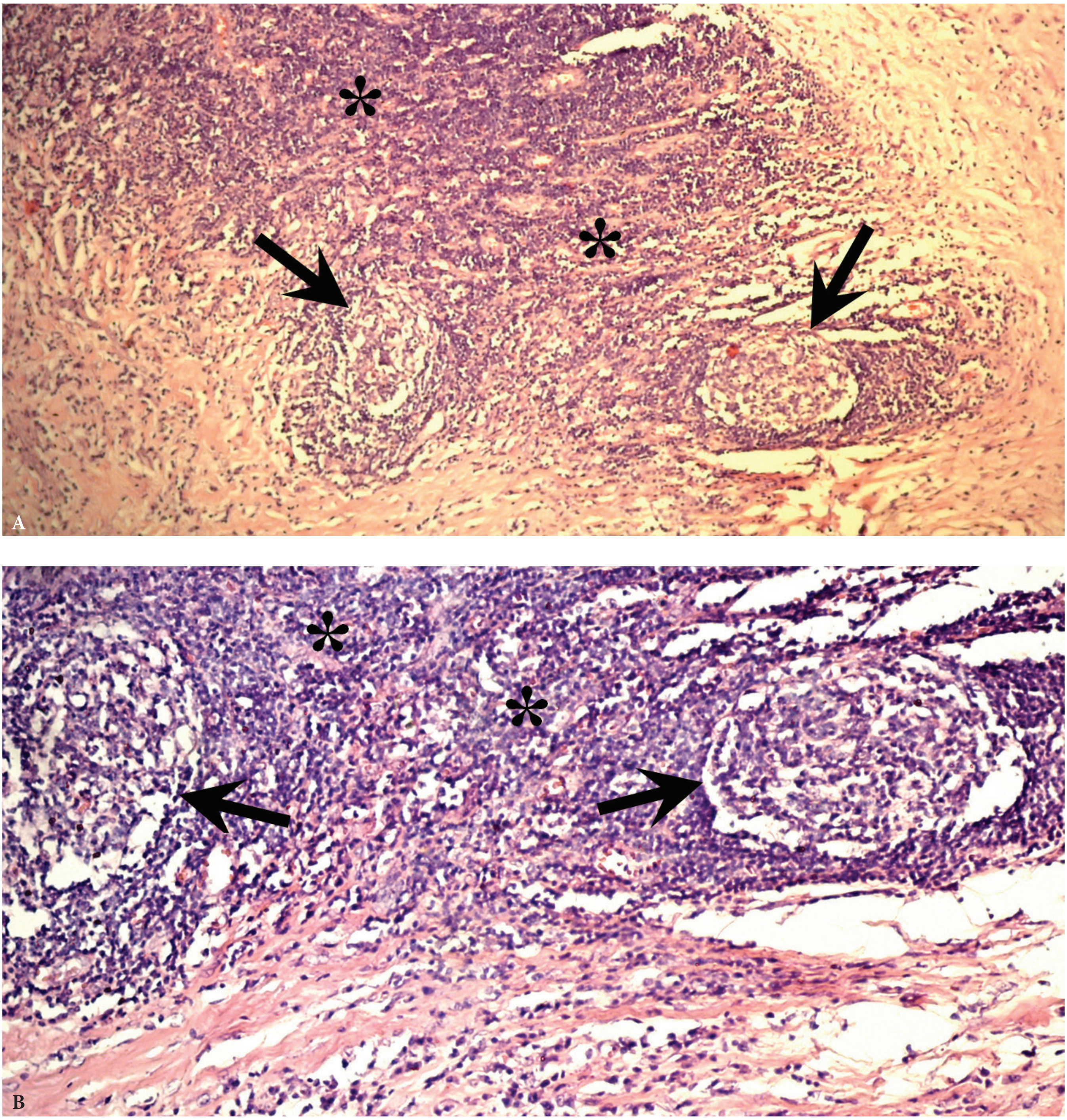

FIGURE 4. The histologic specimen of BCC of a 52-years-old female. Lymphoid formation (*asterisks*) in the thickness of the cystic wall with prominent bright breeding centers (germinal centers), which are marked by *arrows* (hematoxylin and eosin; magnification: **A** – x50, **B** – x100).

showing the presence of internal, low-amplitude, freely floating ***debris*** (diagnosed at 24%), ***hyperechoic*** with ***pseudosolid*** appearance (12%), ***heterogeneous*** internal echoes with internal debris and septa (23%). Echogenicity type is affected by the consistency of the content of the BCCs, which may vary depending on the presence of inflammatory processes (liquid-cystic, cystic-liquid with debris, pasty, suppurated). Pseudosolid appearance due to the presence of the protein content of the cysts produced by the epithelial lining [31]. On color and power Doppler ultrasound BCCs are avascular. Cyst wall appears as hyper- or isoehoic linear structure, often avascular at Doppler ultrasound. The thickness of the wall may vary in different parts of cysts and reach 1.0cm in recurrent inflammations [30,31], but also thinning is possible, i.e. the wall becomes non-differentiable [4].

CT & MRI

According to Weerakkody Y., Gaillard F. et al. on the **CT** and **MRI** images the BCCs have the following features.

For the patients with BCCs is recommended to perform magnetic resonance imaging in three modes. On **T1-weighted MR images** BCCs appears as a variable signal depending on the protein content. If their content is high – as high-intensity signal, low – as low intensity. On **T2-weighted MR images** BCCs are usually of high intensity. On **contrast-enhanced T1-weighted**

MRI, in uncomplicated cases, the BCCs have no enhancement.

On **contrast-enhanced multidetector CT images** BCCs are spherical or round shape, its walls are clearly distinguished from the surrounding tissue. The wall thickness varies from 0.1 to 1.0 cm. The cystic wall may penetrate between internal and external carotid arteries, in the region above the bifurcation of the common carotid artery (scraps symptom or beak tail) [6]. The density of the contents of the cavities (depending on the type of content and the presence of inflammation) ranges from 10 to +27,8 (± 6,0) HU, wall density is up to +102,0 (± 8,0) HU. **Hounsfield units** (HU) is a units of measure indicating the absorption of the X-rays by various tissues of the body. Remember that mostly absorbs x-rays the tooth enamel (3000 HU) and cortical bone (from 850 to 2000 HU), less of all – the blood (20-70 HU) and muscle (10-70 HU), adipose tissue (from –40 to –100 HU).

BCCs should be differentiated with esophageal diverticula. Esophageal diverticula is presented as a round shape lesion, which is located in front of sternocleidomastoid muscle. The lesion is soft or pastry to the touch, collapses on palpation and transmits peristaltic waves during swallowing. With eating it is filled, and increases in size. The pain is intensified with filling of diverticula after eating. Swallowing can be painful, especially during exacerbation of the inflammatory process.

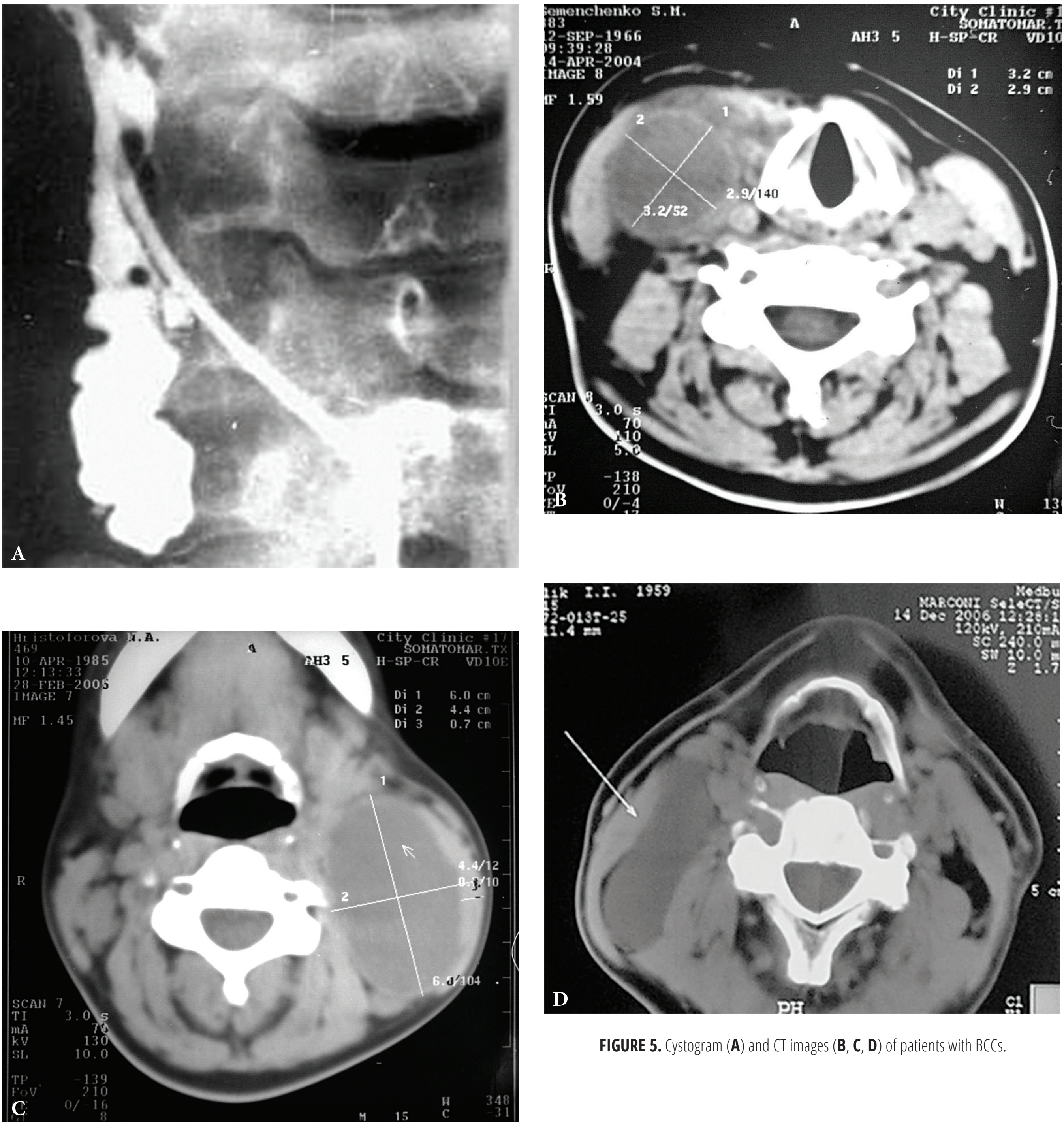

FIGURE 5. Cystogram (**A**) and CT images (**B**, **C**, **D**) of patients with BCCs.

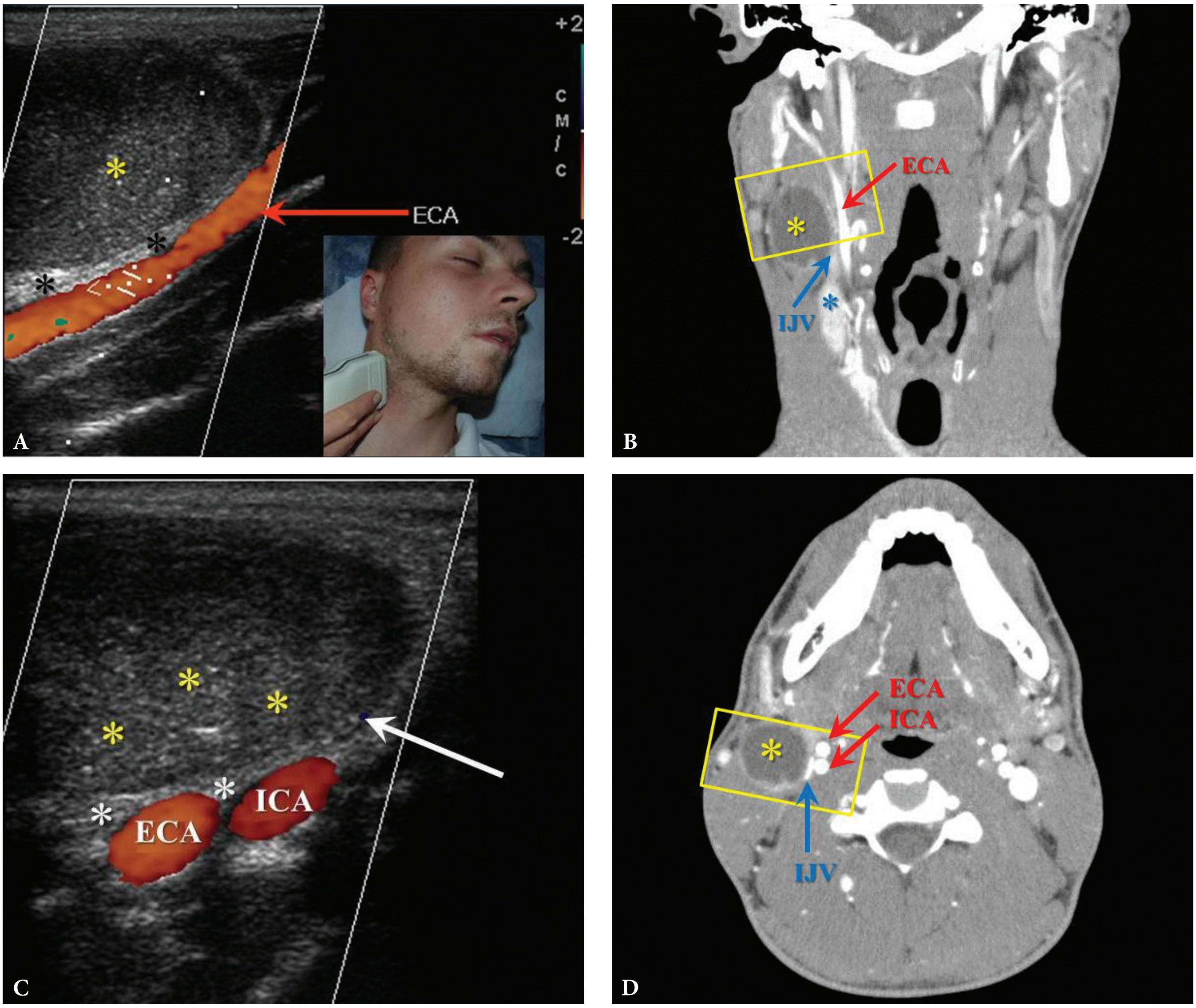

FIGURE 6. BCC in a 19-years-old patient. Longitudinal spectral Doppler sonogram (**A**) performed by linear transducer shows oval shaped cystic lesion with smooth margins, sharp edges, filled with a heterogeneous content (*yellow asterisks*) which simulate "pseudosolid" appearance. Note that cyst is adjacent to the external carotid artery (*ECA*) which is marked by a *red arrow*. Acoustic enhancement artifact (*black asterisks*) is distal to the cyst. Cyst is avascular. On contrast-enhanced CT (**B**) is confirmed the presence of cystic lesion (*yellow aterisk*) adjacent to the external carotid artery (*ECA*) and compression of the internal jugular vein (*IJV*). By *yellow frame* is marked the sonogram location performed at **Figure 6A**. Transverse spectral Doppler ultrasound (**C**) performed by linear transducer shows oval shaped cystic lesion with smooth contours, sharp edges, filled by heterogeneous content (*yellow asterisks*) which create "pseudosolid" appearance. The cyst is adjacent to the external (*ECA*) and internal carotid artery (*ICA*), and internal jugular vein (*IJV*), squeezing it (*white arrow*). Artifact of posterior acoustic enhancement (*white asterisks*) visualized distal to the cyst. Blood flow within the lesion and its wall is absent. On contrast CT image (**D**) confirmed the presence of cystic lesion (*yellow asterisk*) adjacent to the carotid arteries (*ECA, ICA*) and compression of the internal jugular vein (*IJV*). The density of the cyst content is +27,8 (± 6,0) HU. *Yellow frame* marks the position of a sonogram obtained at **Figure 6C**.

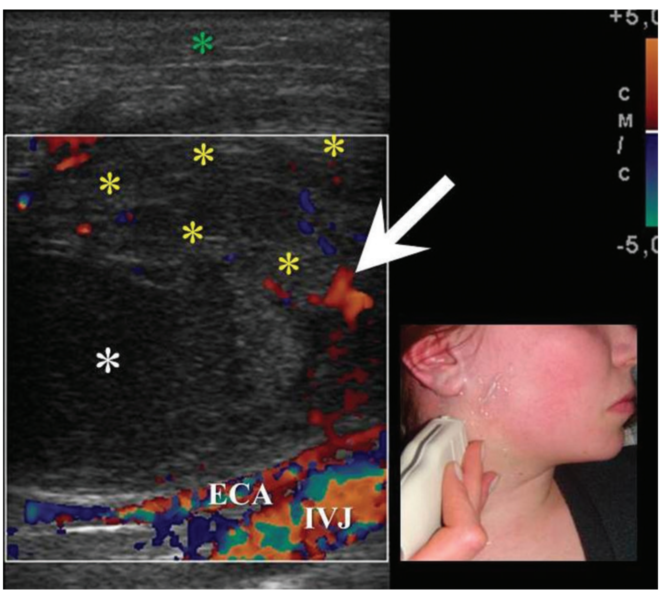

FIGURE 7. An infected BCC in a 18-years-old female. Longitudinal color Doppler ultrasound shows cystic oval shape lesion with hypoechoic content (*white asterisk*). Note inflammatory hyperemia of sternocleidomastoid muscle (*yellow asterisks*) in a form of its increased vascularity (*arrow*). Edema, decreased echogenicity of the surrounded tissues is marked by *green asterisk*. Lesion is avascular, adjacent to the neurovascular bundle of the neck. External carotid artery and internal jugular vein are marked by *ECA* and *IJV*.

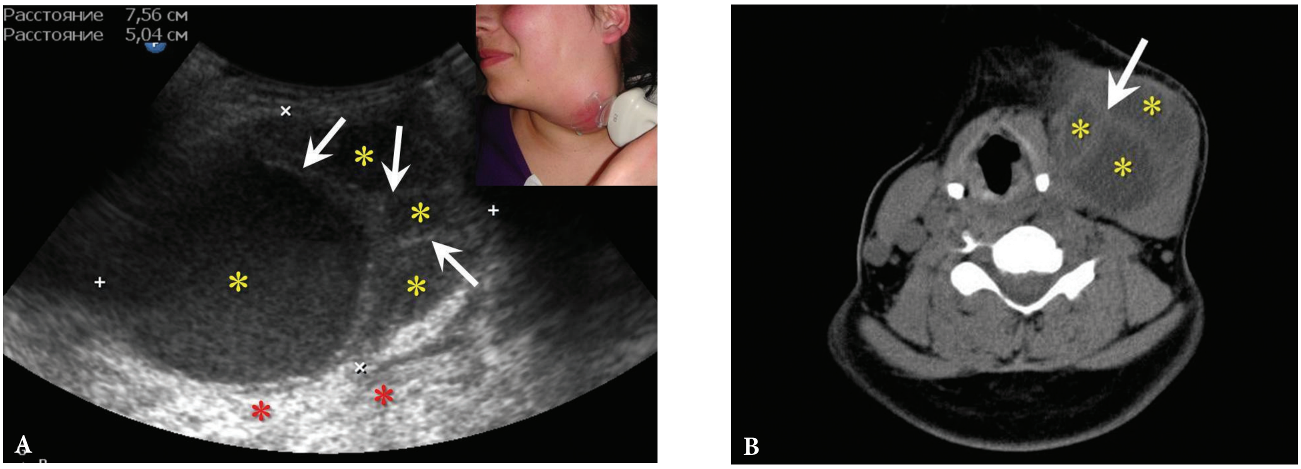

FIGURE 8. Suppurated multicameral BCC in a 33-years-old female. A sonogram (**A**) performed by convex transducer shows a cystic lesion (its size are marked with "+" and "x" are equal 7.5- x 5.0- cm) of the left neck with the presence of isoechoic septations (*arrows*). Anechoic cyst content in cameras are indicated by *yellow asterisks*, an artifact of acoustic enhancement – by *red asterisks*. An axial MDCT scan (**B**) confirms the presence of intracystic septations (*arrow*). The density of the cystic content is equal to +10, +15 HU. Cameras are marked by *asterisks*.

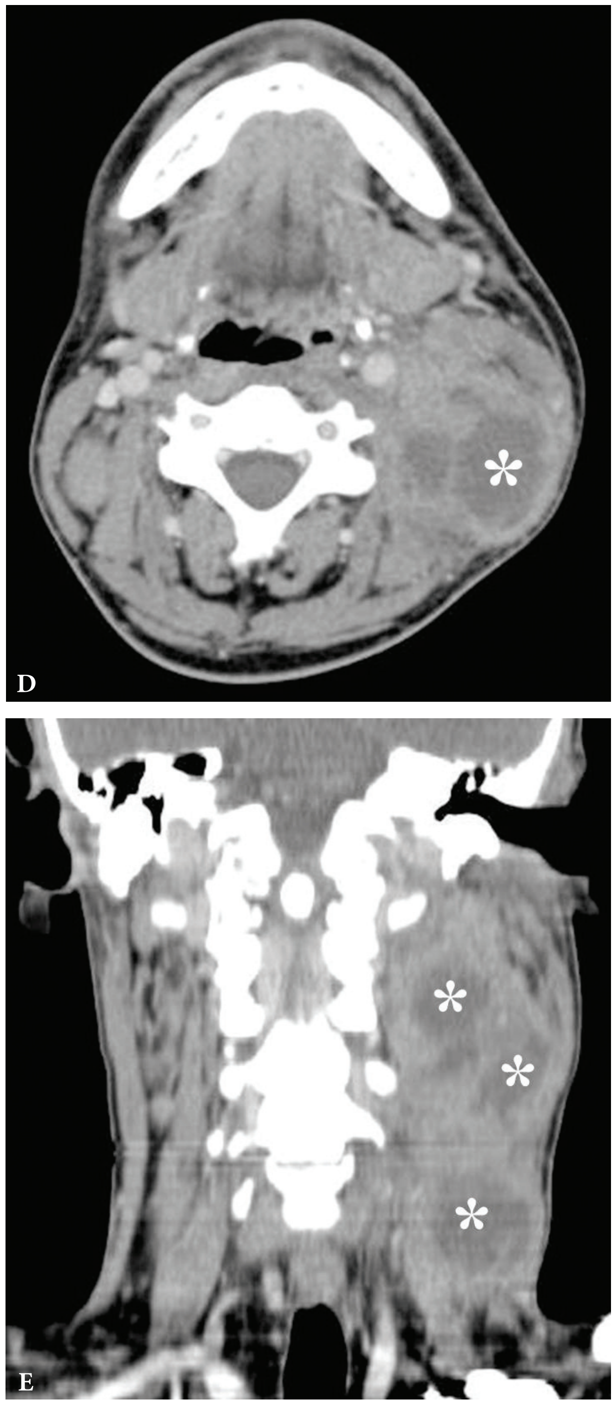

FIGURE 9. A 24-years-old man with cystic squamous cell carcinoma of the neck (poorly differentiated, which have the most aggressive behavior). Clinical photograph of the patient (**A**). Transverse gray scale ultrasound of the lower (**B**) and upper (**C**) neck shows multicameral lesion with anechoic cystic (*asterisks*) and heterogenous solid component, presented in the form of irregularly shaped intracystic growths (*arrows*). Acoustic enhancement artifact is presented. On contrast-enhanced CT images (**D**, **E**), the lesion on left side of the neck is multicameral (cameras are marked by *asterisks*) with solid component accumulating contrast. **(Fig 9 continued on the next page.)**

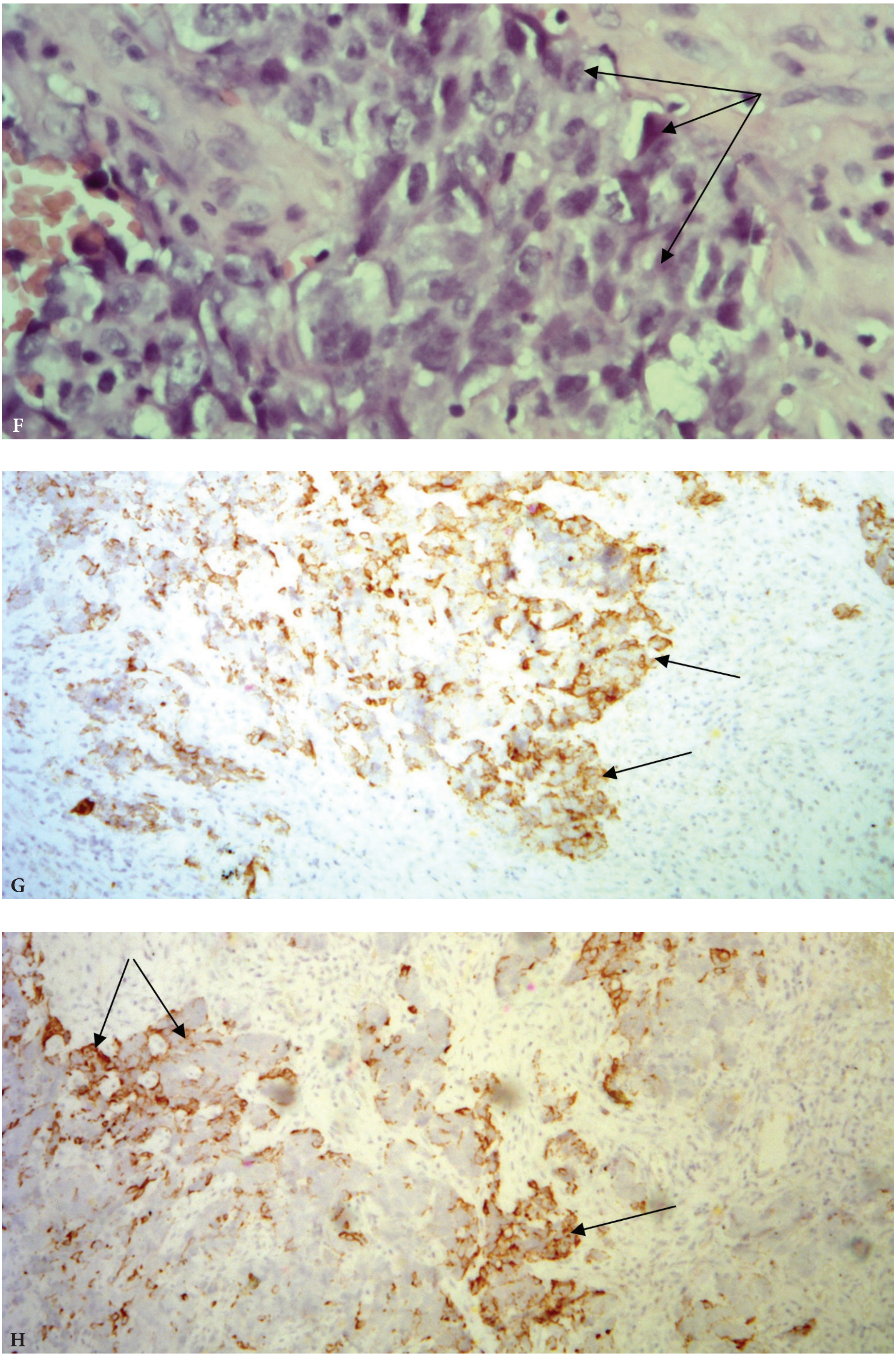

FIGURE 9 (cont'd). Trephine biopsy histology (**F**) shows, that in fragment of the lymph node tissue with presence of fibrous tissue, the growth of poorly differentiated malignant tumor (*arrows*) of epithelial nature with extensive necrosis in the tumor and lymph node tissue, hemorrhages is determined (hematoxylin and eosin; magnification x200). Immunohistochemistry (**G**, **H**) shows positive membrane reaction (*arrows*) with Cytokeratin AE1/AE3 and Cytokeratin 5/6. Reaction with CD45, S100 is negative (reaction with CD45- is determined in intact cells of the lymph node tissue). Thus, there is metastasis of poorly differentiated squamous cell carcinoma G_3 into lymphatic node tissue. (Histology and immunohistochemistry **Figure 9F**, **G**, **H** is courtesy of Dr. Antoniuk S.A., *Research Associate*, Dr. Petrenko L.I., *Junior Scientific Researcher*, Dr. Burtyn O.V., National Cancer Institute, Kyiv, Ukraine)

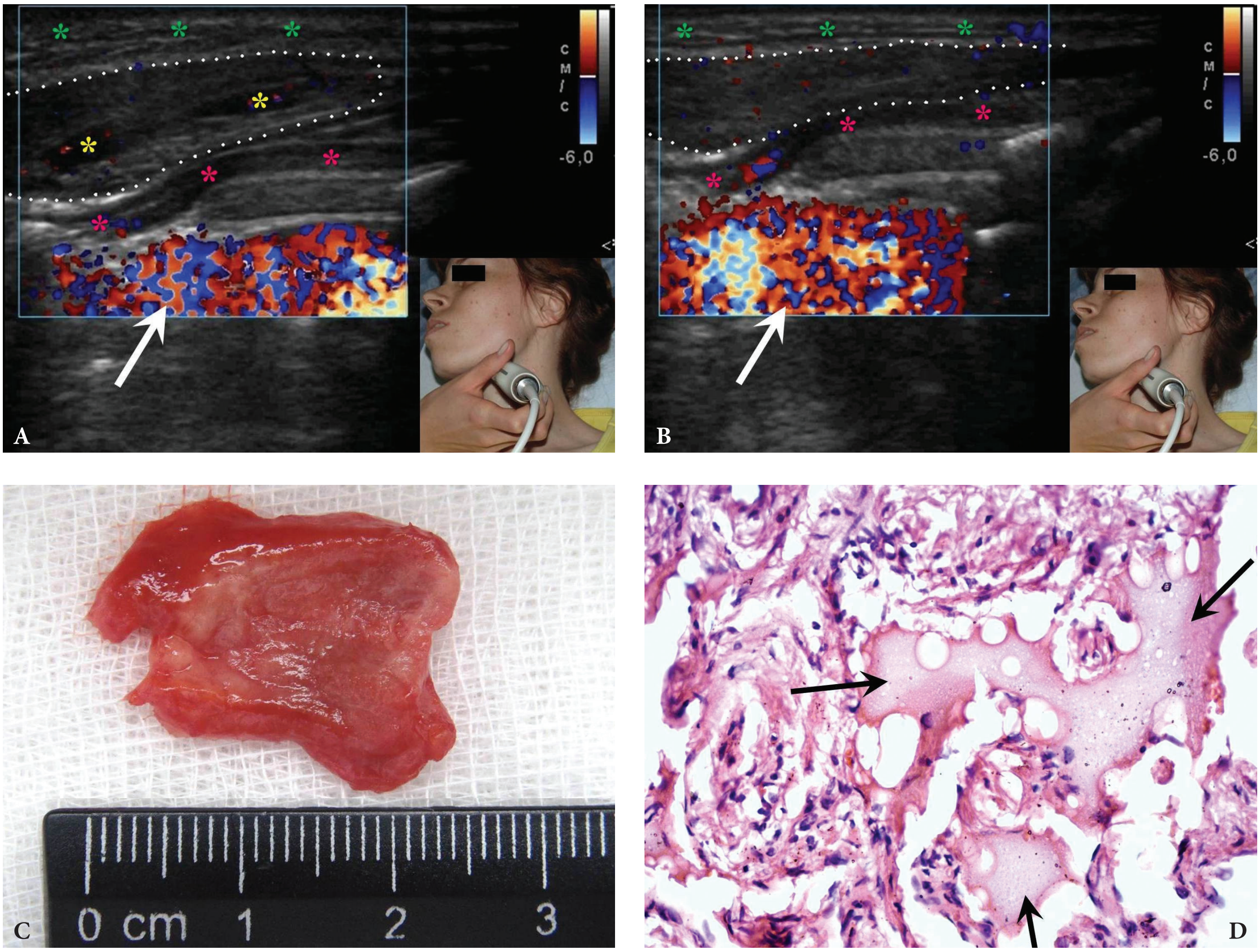

FIGURE 10. A 32-years-old female with cavernous lymphangioma of the upper neck. Oblique color Doppler ultrasound (**A**) shows well-demarcated lesion (marked by *white dots*) with a size of 3.0- × 1.0- cm elongated-oval form at the upper neck adjust to the omohyoid (*pink asterisks*) and anterior to the sternocleidomastoid muscles. Structure of the lesion is heterogeneous with presence of oval anechoic areas (cavities – *yellow asterisks*). The skin, subcutaneous tissue is marked by *green stars. White arrow* marks blooming artifact. Lesion have no arterial or venous blood flow. Oblique color Doppler ultrasound (**B**) with the compression by transducer (sonopalpation) noted the tumor shrinkage in 2-3 times, cavernous cameras are completely disappeared, indicating its spongy structure and confirmed after removal (lesion for the entire thickness was impregnated with light-gray liquid – lymph). Surgical specimen (**C**). Histology (**D**). In the lumen of the lymph vessels, lymph (*arrows*) is visualized. The inner layer is composed of endothelial cells of lymphatic vessels (oval form small inclusions with dark blue color). Hematoxylin and eosin; magnification x200.

TREATMENT

The treatment of the BCCs is only surgical (Figs 11, 12A). Surgery can be a difficult task due to the complex anatomical and topographical relations of the cysts with vessels and nerves of the neck. The surgery is performed under endotracheal anesthesia. The cut should be done on the anterior (medial) edge of the sternocleidomastoid muscle, or upper cervical crease. The first variant of incision is considered safer because in this area a large vessels and veins are located, and the second variant of cut is more cosmetic.

The surgeon may have difficulties in location place of internal pole of the BCC (Fig 1B), as in this place the internal jugular and facial veins are located. Especially need to be careful upon separating the BCC when its located nearby external and internal carotid arteries (Figs 12, 13). With the classical location of BCCs, it is more easy for the surgeon to navigate in the topographic anatomy of those vessels. However, often there are different variants for the location of the internal and external carotid arteries. This causes considerable difficulties in the intraoperative visualization of those vessels. Be especially careful in case of deep location of BCCs and the need to separate carotid arteries, i.e. topographic anatomy of the latter is not always classical (Fig 13).

COMPLICATIONS

Complications of BCCs the phlegmon of the and branchiogenic carcinoma are known. Phlegmon of the neck is more severe complication with severe intoxication in patient. Inflammatory processes can easily spread through the neurovascular bundle into the anterior mediastinum. Non-radical surgery may not only lead to recurrence, but also to the development of branchiogenic carcinoma (Figs 14, 15).

Branchiogenic carcinoma develops from the epithelium of the BCCs. Unlike cysts, tumor represents as a dense, tuberous, bad-movable (especially in the vertical direction) lesion, knitted with muscle and vascular bundle of the neck. Tumor (branchiogenic carcinoma) painless, relatively slow increases in size and can reach considerable size, quickly merges to the surrounding tissues. Tumor localization: from the submandibular region to the clavicle. Branchiogenic carcinoma merges to sternocleidomastoid muscle and vascular bundle of the neck. If the tumor has not merge into the vascular bundle, it can be separated from the vessel. Malignant tumors can merge not only in vascular bundle neck, soft tissue (muscles) of the side of the neck, but to the pharynx and larynx. Histologically branchiogenic carcinoma usually has a structure of squamous cell carcinoma (Fig 9F, G, H).

Development of branchiogenic carcinoma, according to the Maxillofacial Surgery Department of Shupyk NMAPE, is about 4.5% of patients with BCCs. A high percentage of branchiogenic cancer in these patients emphasizes the need for early and proper performed surgery (removal of the BCC). Treatment of patients with branchiogenic carcinoma is combined. Prognosis is poor, often recurs, metastases are rare.

Branchiogenic carcinoma should be differentiated from the **carotid chemodectoma** (Fig 16) and other tumors of the neck. Carotid chemodectoma *synonyms: carotid body paraganglioma, glomus tumor, endothelioma, perithelioma, pheochromocytoma, paraganglioma, potato tumor, receptoma, etc.* Chemodectoma [34, 35] develops from the carotid sinus (*synonyms*: chemoreceptoral glomus, glomus caroticum), located at the adventitia layer inwards from the bifurcation of the common carotid artery.

Carotid sinus (Greek, *karóō* to put to sleep and sinus) is an expanded portion of the common carotid artery at the site of its branching into the external and internal arteries.

In this glomus there is a cluster of chromaffin cells around capillary glomeruli, and there is lot amount of nerve endings (functions as a "chemoreceptor" – responds to changes in the level of oxygen in the blood). Making pressure on the vessel in the area of carotid glomus leads to a slowing of heart rate. There carotid sinus baroreceptors are also located, when they are stimulated the blood vessels dilate and blood pressure falls. Chemodectomas are located under the sternocleidomastoid muscle at the point of common carotid artery bifurcation.

The skin over the tumor is not changed. Tumor has spherical or elongated form, with dimensions of 3.0cm or more, smooth or slightly tuberous. *A characteristic feature of chemodectoma is its horizontal displaceability and absence of displacement in vertical direction, the inability to move aside tumor from the pulsating vessel and "transfer pulsation" over the tumor.*

Macroscopically carotid chemodectoma has a light gray or brownish-red color and is surrounded by a connective tissue capsule (Fig 16C). Treatment of chemodectoma is surgical. Postoperative mortality is very high, i.e. in the vast majority it is not possible to separate the tumor from the common or internal carotid artery.

PROGNOSIS

With timely and correct performed surgery, removing of the BCCs, the prognosis is favorable.

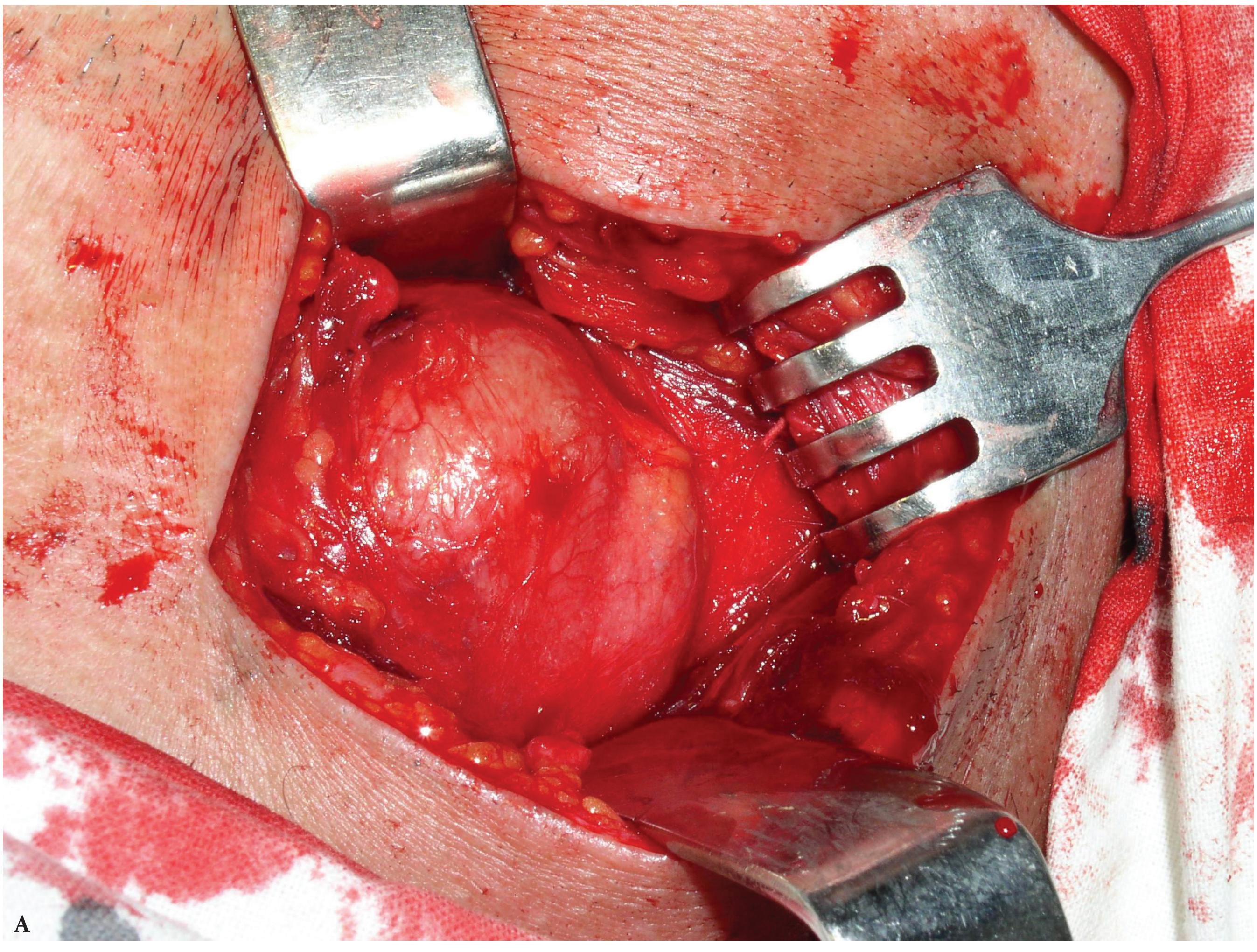

FIGURE 11. Surgical stage of BCC excision (**A**). **(Fig 11 continued on the next page.)**

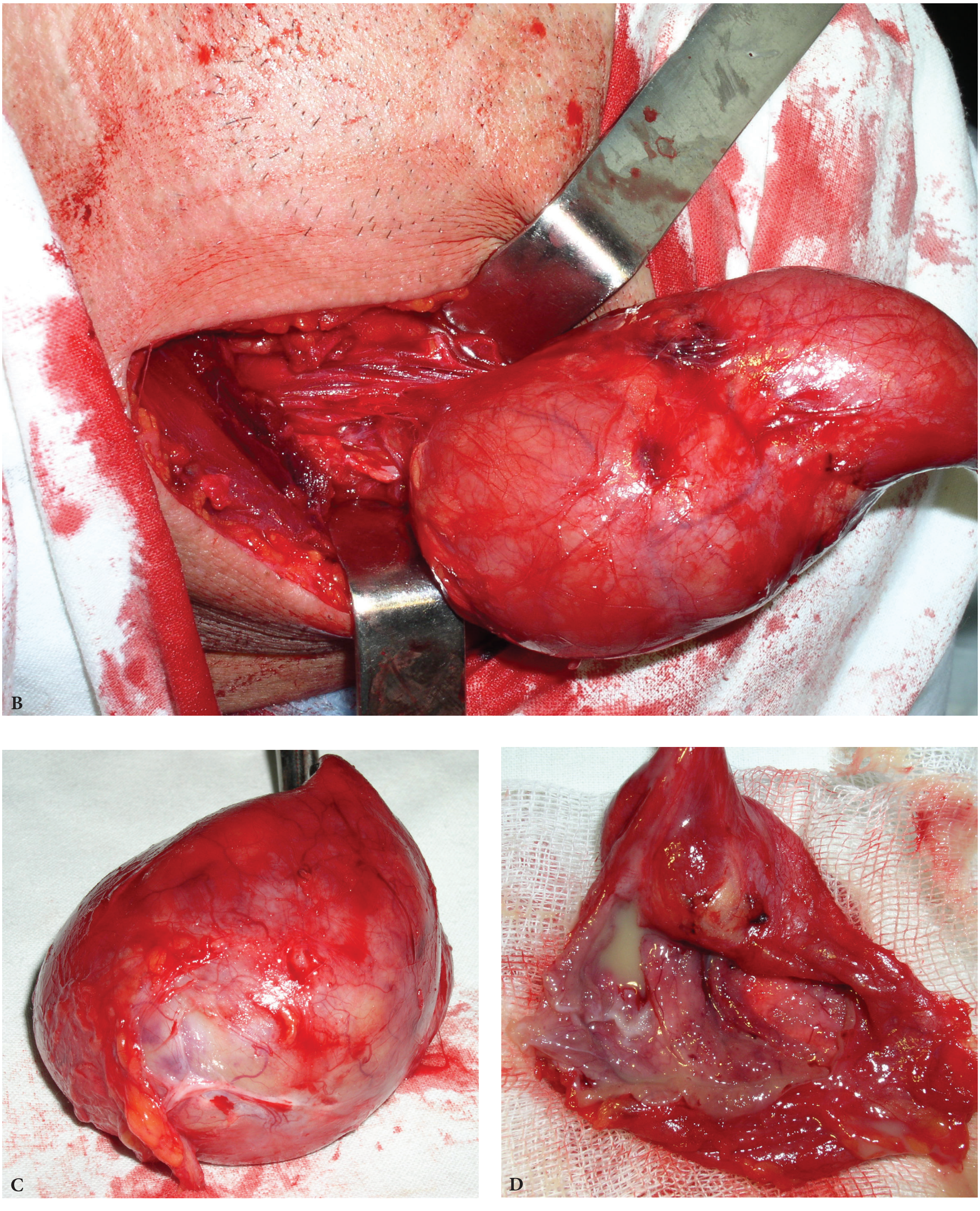

FIGURE 11 (cont'd). Surgical stage of BCC excision (**B**). View of BCC filled with content (**C**). View of the inner surface of cyst's wall (**D**) after its content evacuation.

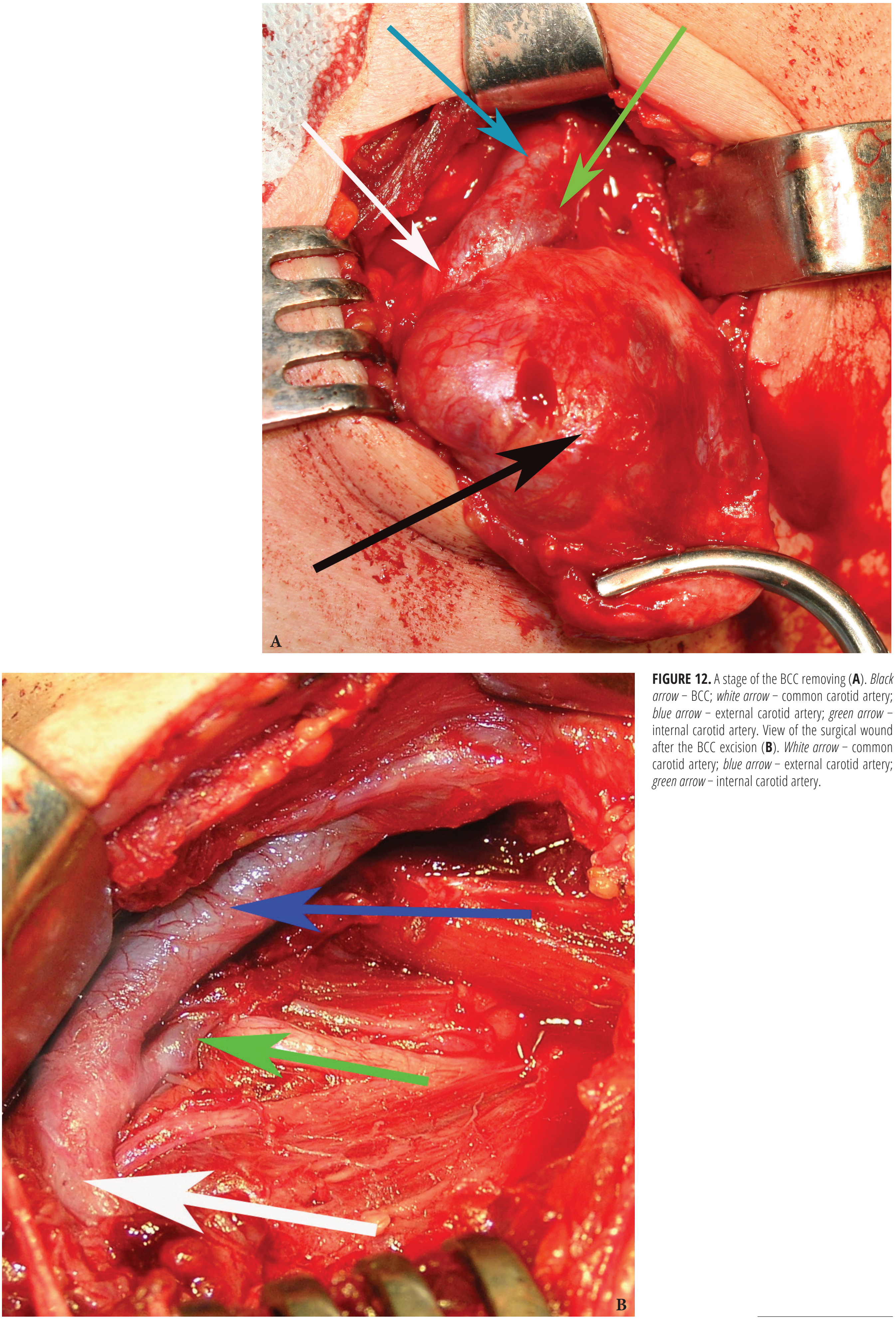

FIGURE 12. A stage of the BCC removing (**A**). *Black arrow* – BCC; *white arrow* – common carotid artery; *blue arrow* – external carotid artery; *green arrow* – internal carotid artery. View of the surgical wound after the BCC excision (**B**). *White arrow* – common carotid artery; *blue arrow* – external carotid artery; *green arrow* – internal carotid artery.

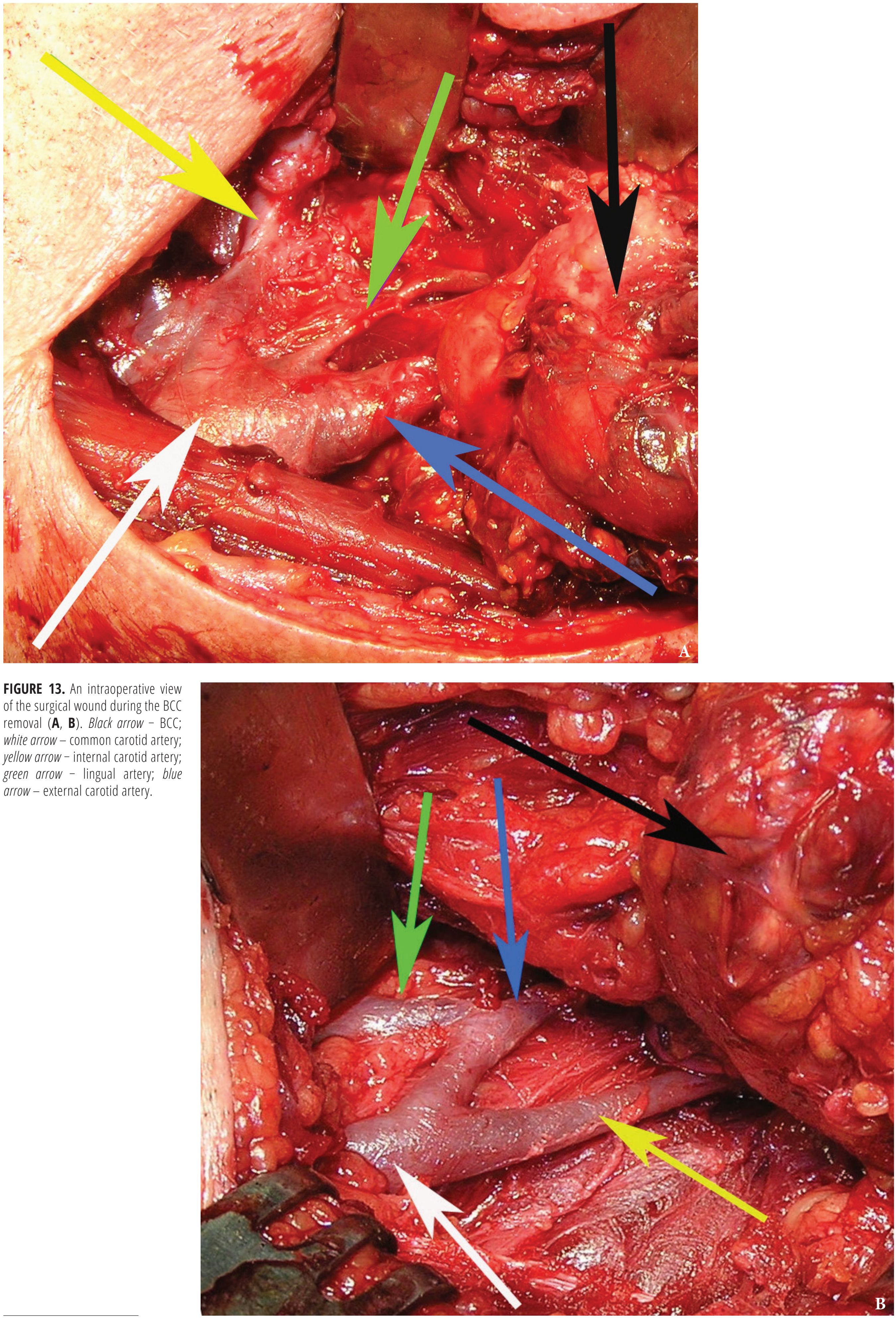

FIGURE 13. An intraoperative view of the surgical wound during the BCC removal (**A**, **B**). *Black arrow* – BCC; *white arrow* – common carotid artery; *yellow arrow* – internal carotid artery; *green arrow* – lingual artery; *blue arrow* – external carotid artery.

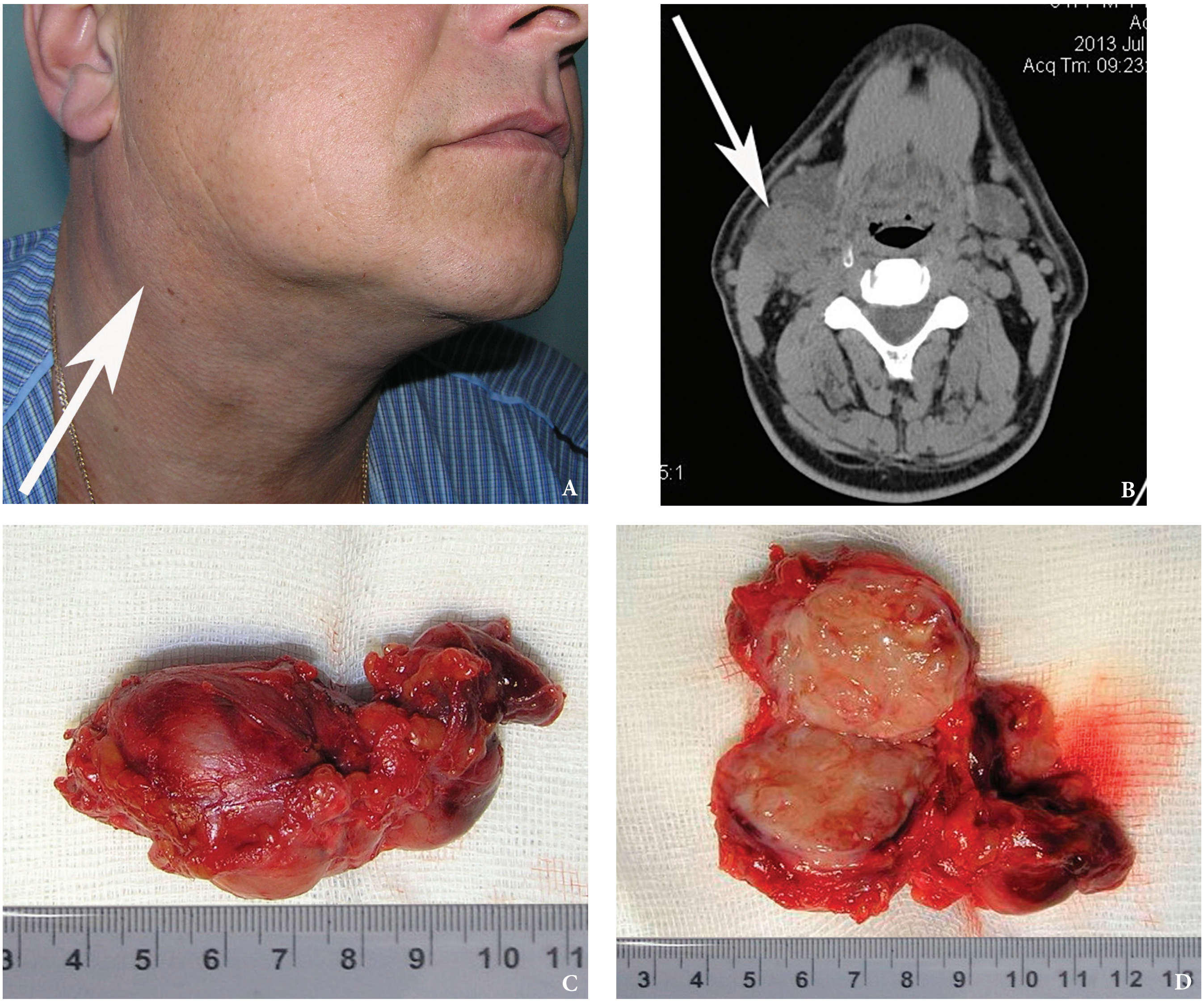

FIGURE 14. A patient with branchiogenic carcinoma (*arrow*) (**A**). Non-contrast CT image (**B**) shows the tumor (*arrow*). Tumor after its removal (**C**). Tumor on the section (**D**).

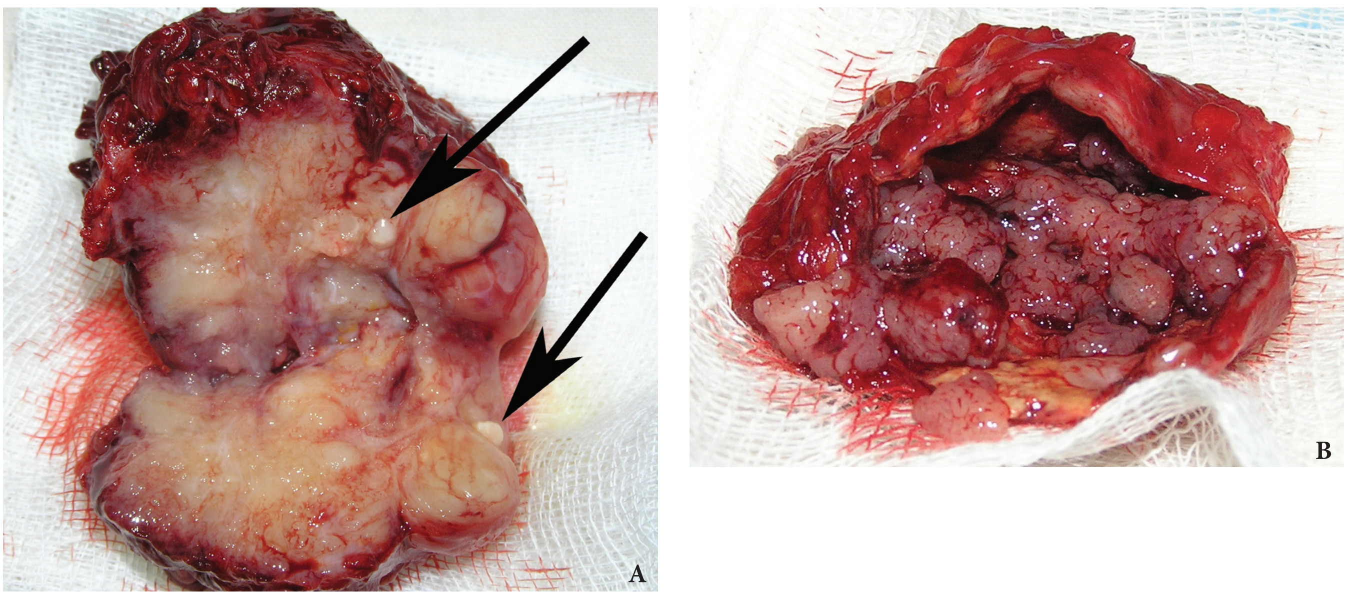

FIGURE 15. Macroscopic view of the branchiogenic carcinoma in different patients (**A**, **B**). Calcifications in malignant tumor are marked by *arrows* (**A**).

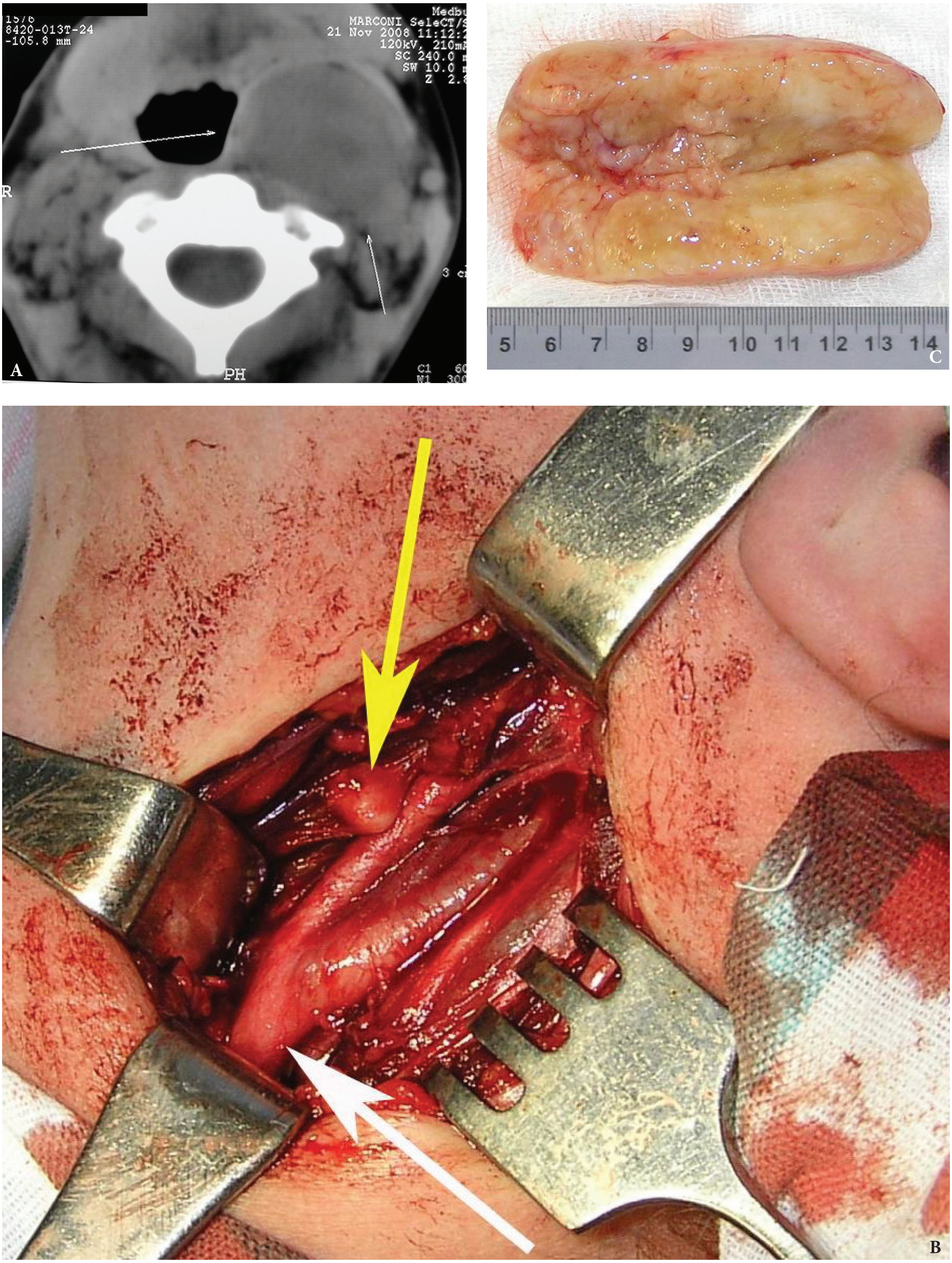

FIGURE 16. Computed tomography (**A**) of patient with carotid chemodectoma (*arrows*). Operating wound after chemodectoma removal (**B**). Common carotid artery – *white arrow*, greater horn of hyoid bone – *yellow arrow*. Macroscopic view of chemodectoma at section (**C**).

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Особливості діагностики, клінічного перебігу і лікування бранхіогенних кіст шиї

Олексій О. Тимофєєв[1], Євген І. Фесенко[2], Ольга С. Черняк[3], Валентина І. Заріцька[4]

[1] *Завідувач кафедри щелепно-лицевої хірургії Інституту стоматології Національної медичної академії післядипломної освіти імені П.Л. Шупика, д.мед.н., професор, Заслужений діяч науки і техніки України, Київ, Україна.*
[2] *Асистент кафедри хірургічної стоматології та щелепно-лицевої хірургії КМУ УАНМ, Київ, Україна.*
[3] *Завідувач відділенням ультразвукової діагностики Обласного діагностичного центру Київської обласної клінічної лікарні, Київ, Україна.*
[4] *Доцент кафедри патологічної і топографічної анатомії НМАПО імені П.Л. Шупика, к.мед.н., Київ, Україна.*

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Одиниці Хаунсфілда
МРТ
УЗД
Ехогенність
Колірне допплерівське картування
Псевдосолідність

РЕЗЮМЕ

Мета. Визначити особливості діагностики, клінічного перебігу та лікування бранхіогенних кіст шиї.
Методи. Бранхіогенні кісти шиї та їх ускладнення у пацієнтів різних вікових груп, методи їх діагностики, анатомічні особливості, етапи операції і патоморфологічне дослідження.
Результати. Доведено діагностичну цінність ехографії, МСКТ і МРТ, патоморфологічного дослідження у верифікації бранхіогенних кіст шиї та їх ускладнень. Описано методику проведення оперативних втручань.
Висновки. Описані нами методи діагностики бранхіогенних кіст шиї та їх ускладнень, варіанти клінічного перебігу та методи лікування дозволяють знизити ризик помилок на до-, інтра- і післяопераційному етапах.

Особенности диагностики, клинического течения и лечения бранхиогенных кист шеи

Алексей А. Тимофеев[1], Евгений И. Фесенко[2], Ольга С. Черняк[3], Валентина И. Зарицкая[4]

[1] *Заведующий кафедрой челюстно-лицевой хирургии Института стоматологии Национальной медицинской академии последипломного образования имени П.Л. Шупика, д.мед.н., профессор, Заслуженный деятель науки и техники Украины, Киев, Украина.*
[2] *Ассистент кафедры хирургической стоматологии и челюстно-лицевой хирургии КМУ УАНМ, Киев, Украина.*
[3] *Заведующая отделением ультразвуковой диагностики Областного диагностического центра Киевской областной клинической больницы, Киев, Украина.*
[4] *Доцент кафедры патологической и топографической анатомии НМАПО имени П.Л. Шупика, к.мед.н., Киев, Украина.*

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Бранхиогенная киста шеи
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МСКТ
Единицы Хаунсфилда
МРТ
УЗД
Эхогенность
Цветовое допплеровское картирование
Псевдосолидность

РЕЗЮМЕ

Цель. Определить особенности диагностики, клинического течения и лечения бранхиогенных кист шеи.
Методы. Бранхиогенные кисты шеи и их осложнения у пациентов разных возрастных групп, методы их диагностики, анатомические особенности, этапы операции и патоморфологическое исследование.
Результаты. Доказано диагностическую ценность эхографии, МСКТ и МРТ, патоморфологического исследования в верификации бранхиогенных кист шеи и их осложнений. Описано методику проведения оперативных вмешательств.
Выводы. Описанные нами методы диагностики бранхиогенных кист шеи и их осложнений, варианты клинического течения и методы лечения позволяют снизить риск ошибок на до-, интра- и послеоперационном этапах.

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Diagnostics of Severity of the Trigeminal Nerve Injuries During Jaws Surgeries

Oleksii O. Tymofieiev[1,*], Natalia O. Ushko[2], Olena P. Vesova[3], Mariia O. Yarifa[4]

[1] Chair of the Department of Maxillofacial Surgery, Stomatology Institute, Shupyk NMAPE, Kyiv, Ukraine (*ScD, Prof*)
[2] Department of Maxillofacial Surgery, Stomatology Institute, Shupyk NMAPE, Kyiv, Ukraine (*PhD, Assoc Prof*)
[3] Department of Maxillofacial Surgery, Stomatology Institute, Shupyk NMAPE, Kyiv, Ukraine (*ScD, Prof*)
[4] Oral and Maxillofacial Surgery Department, KMU of UAFM, Kyiv, Ukraine (*PhD, Assoc Prof*)

ABOUT ARTICLE

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ABSTRACT

Purpose.
To study the dynamics of changes in the electrophysiological parameters of II and III branches of trigeminal nerve in patients after surgeries on tumors and tumor-like lesions of jaws; to define rehabilitation therapy depending on the severity of the nerve damage.
Material and methods.
Investigation and treatment of neurological complications in 179 patients after surgeries of removal for tumors and tumor-like lesions of the upper and lower jaws, on a hardware-software complex "DIN-1".
Results.
The values of the electrophysiological parameters of conductivity, resistance and tone of the trigeminal nerve branches in patients after surgeries on tumors and tumor-like lesions of jaws can be diagnostic criteria for the severity of the sensitive nerves damage in the surgical wound.
Conclusion.
Our data can be used as an objective prognostic test in oral and maxillofacial surgery for determination the severity of neurogenic damage to soft and bone tissues innervated by the trigeminal nerve.

Introduction

The analysis of postoperative complications in patients with maxillofacial pathology identifies a significant number of neurological symptoms, the occurrence of which is associated with anatomical characteristics of the structure of the middle and lower facial zones, the proximity of the exit places of the second and third branches of the trigeminal nerve from the skull and facial bones, trauma to the blood vessels that feed the nerve and, consequently, violation of its trophic [1-4].

We performed a review of local neurological complications that occur after surgeries of removal of tumors and tumor-like lesions of jaw bones.

If the surgical intervention is associated with the removal of tumor and tumor-like lesions of the mandible (Fig 1) and

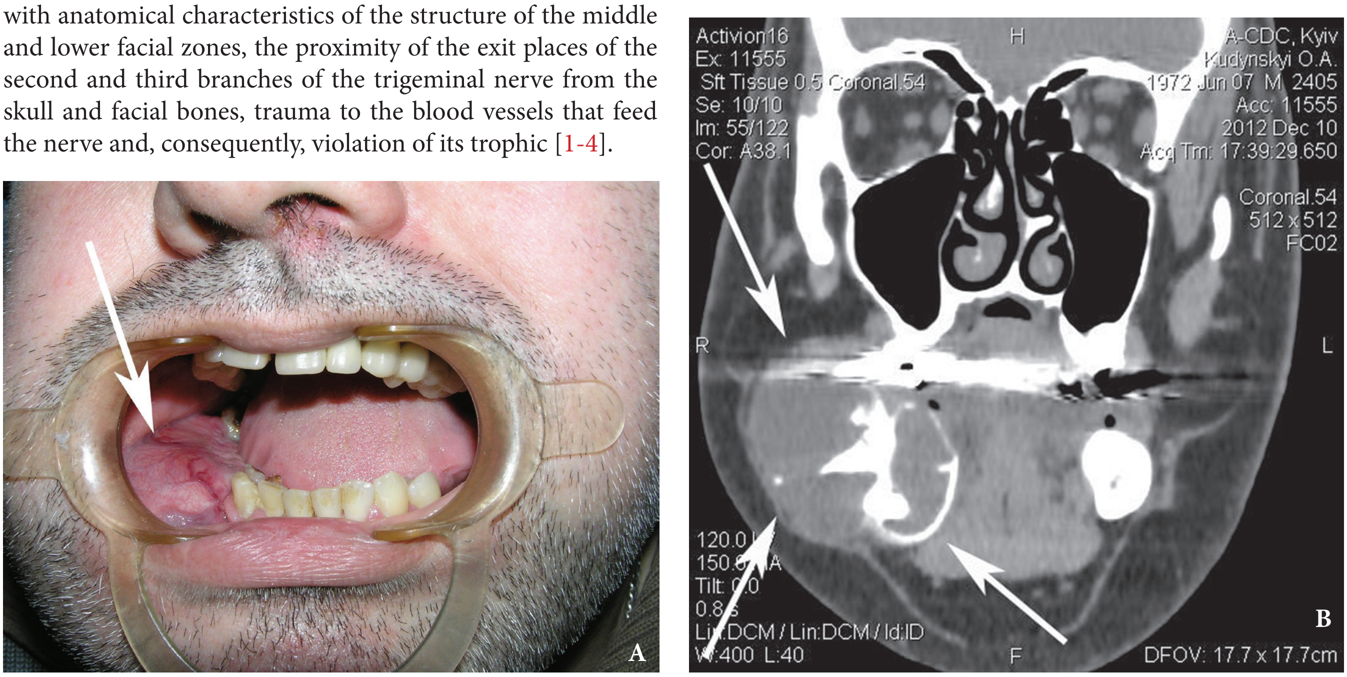


FIGURE 1. View of a 40-years-old male patient with ameloblastoma (*arrow*) of the right mandible (**A**). On coronal CT image (**B**), the tumor is marked by *arrows*.

* *Corresponding author. Department of Maxillofacial Surgery, Stomatology Institute, Shupyk NMAPE, 4-a Pidvysotskogo Street, Kyiv 01103, Ukraine. Tel., fax: +38 (044) 528 35 17. E-mail address: tymofeev@gmail.com (O.O. Tymofieiev)*

maxilla (Fig 2), the injury of the trigeminal nerve of different degrees can happen. Therefore, in the postoperative period in operated patients a neuropathy of the corresponding trigeminal nerve branches of different severity and duration is present, which require adequate treatment [5, 6].

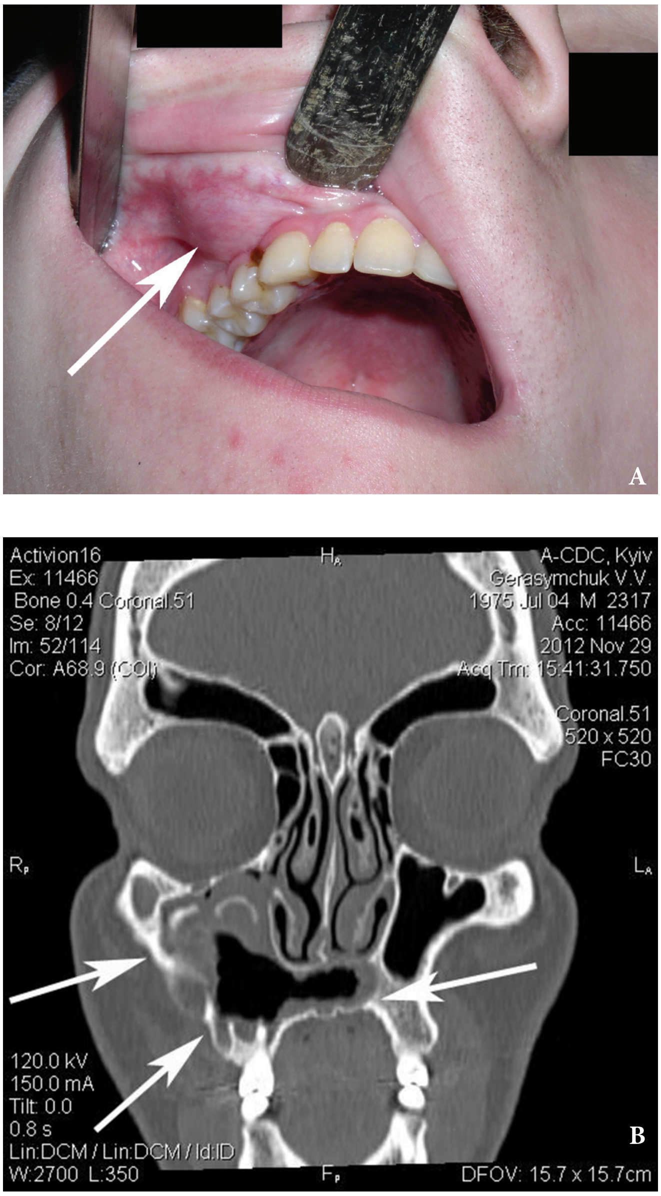


FIGURE 2. Intraoral view of 38-years-old male patient with ameloblastoma (*arrow*) of the maxilla (**A**). On coronal non-contast CT image (**B**), the tumor is indicated by *arrows*.

We believe that in cases when during the operation, a doctor separates the lesion in the jaw from the branches of the trigeminal nerve slightly shifting the nerve is causing a minimal trauma, which, in our opinion, should be regarded as **contusion** (Fig 3A). In other cases, when the tumor or tumor-like lesions are located under nerve trunk (a branch), in order to identify and remove the pathological focus we have to relocate the branches of the trigeminal nerve, stretching them. This nerve injury we name **nerve stretching** (Fig 3B). In some cases upon surgical intervention a **partial** and/or **complete rupture** (Fig 3C) of the relevant branches of the trigeminal nerve may happened.

The purpose of the study was to investigate on hardware-software complex "DIN-1" the dynamics of changes in the electrophysiological parameters of soft tissues, innervated by the II and III branches of trigeminal nerve in patients after surgical removal of tumors and tumor-like lesions of jaws depending on the severity of the nerve injury (contusion, stretching, incomplete and complete rupture of the nerve) that occurred during performance of the surgery.

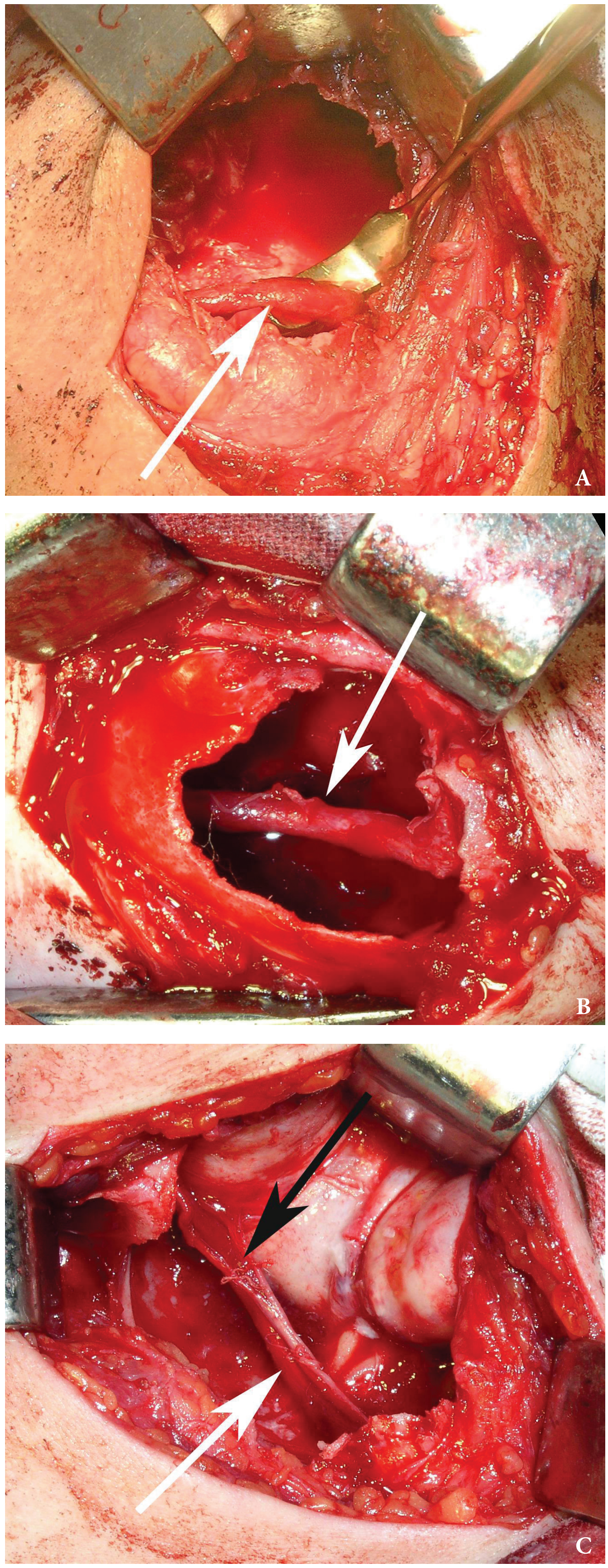
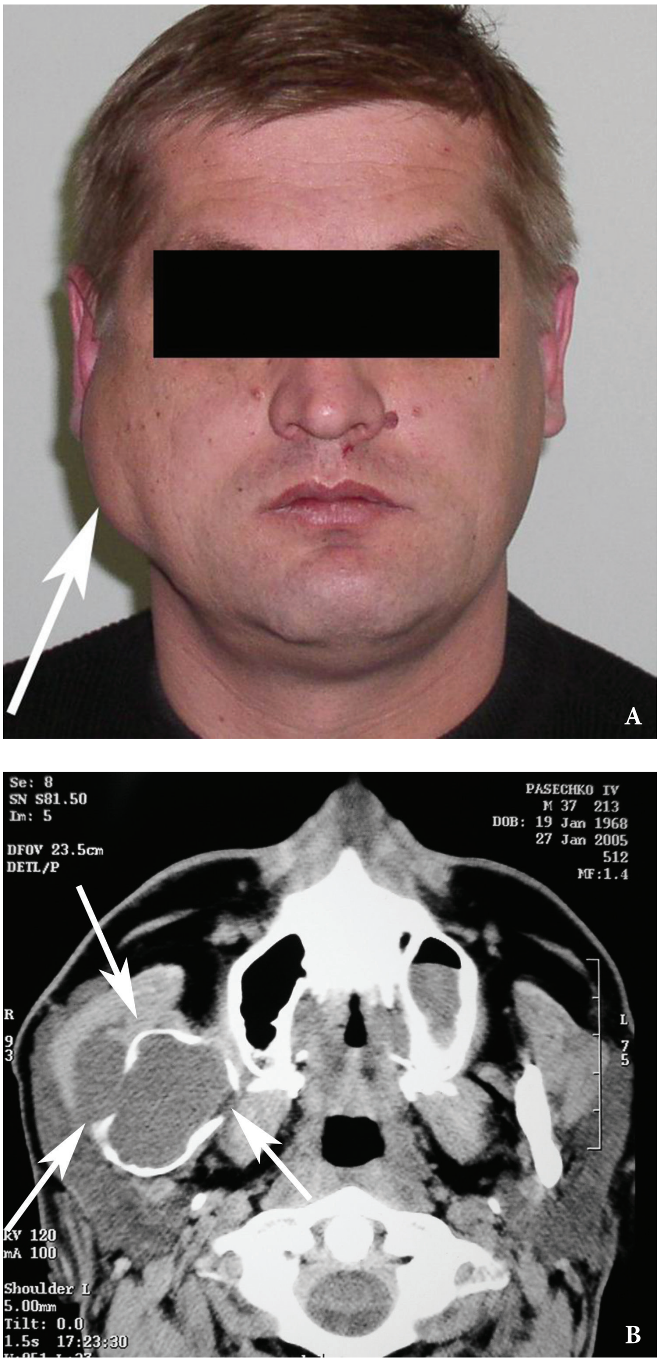


FIGURE 3. Intraoperative view of the nerve (*white arrows*): in case of contusion (**A**), in case of stretching (**B**), in case of partial rupture (**C**). *Black arrow* shows the place of incomplete nerve rupture.

Material and Methods

An investigation of neurological complications was performed in 179 patients after surgeries related to removal of tumors (ameloblastomas, osteoblastomas) (Fig 4) and tumor-like lesions (odontogenic keratocysts, radicular and follicular cysts, etc.) of upper and lower jaws. All patients received surgery and postoperative medical treatment at the Department of Maxillofacial Surgery, Shupyk National Medical Academy of Postgraduate Education.



The control group consisted of 35 persons – practically healthy people (without pathological changes in the oral and maxillofacial region). In those individuals we have identified electrophysiological parameters of soft tissues, innervated by the II and III branches of the trigeminal nerve.

All patients were divided into 4 groups: I group – 47 patients (for 23 patients surgery done on the maxilla and for 24 – on the mandible) after surgery in which there was a light injury to trigeminal nerve branches which we have described as a nerve contusion; group II – 57 patients (for 26 patients the surgery was performed on the maxilla, and for 31 people – on the mandible), in those patients was observed a stretching of the branches of the trigeminal nerve during the separation of tumors or tumor-like lesions; group III – 53 patients (for 21 the surgeries were perfomed on the maxilla and for 32 – on the mandible), in which was observed a partial (incomplete) rupture of one of the branches of the trigeminal nerve during the removal of the pathological lesion (tumor or tumor-like lesion); IV group – 32 patients (for 17 the surgery were perfomed on the maxilla, and for 15 – on the mandible) after surgery (resection of the jaw), in which there was a complete rupture of one of the branches of the trigeminal nerve during the removal of the pathological lesion (tumor or tumor-like lesions).

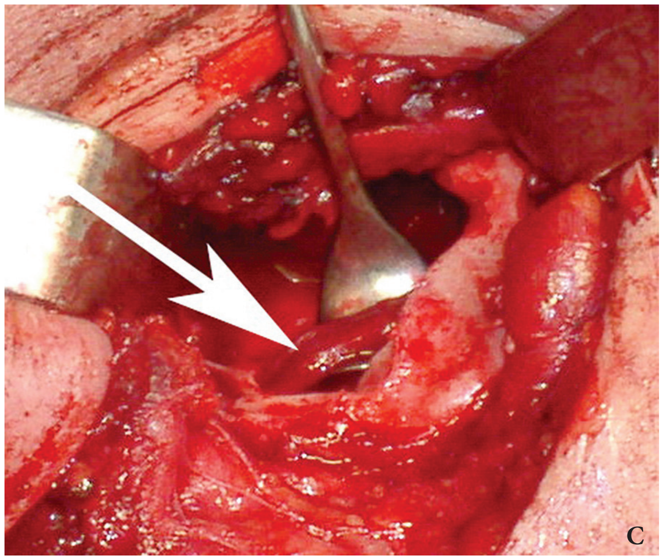


FIGURE 4. View of 37-years-old man with ameloblastoma (*arrow*) of the right mandible (**A**). The tumor on axial CT scan (**B**) is indicated by arrows. View of inferior alveolar nerve (*arrow*) during the surgery (**C**).

All patients underwent clinical examination methods, which included: general surveying, palpation, medical history, determining sensitivity (pain, tactile and thermal sensitivity) of the corresponding areas innervated by the II and III branches of the trigeminal nerve, x-rays of the jaws, etc.

After performing appropriate surgery the selection of patients with postoperative damage to the trigeminal nerve branches was carried out. To measure the static and dynamic parameters of areas of the soft tissues that are innervated by the trigeminal nerve, hardware-software complex "DIN-1" (Fig 5) was used. General surveying of patients was carried out at the following exit points of the trigeminal nerve: mental, infraorbital (was determined the conductivity, resistance and tone to the nerve). Examination was carried out on the computer and then recording the obtained data. All special methods of examination of the trigeminal nerve were performed during hospitalization and in the dynamics of the postoperative period.

All received digital data were processed by variational-statistical method with the calculation of Student's test. Changes of electrophysiological parameters in the dynamics

FIGURE 5. View of hardware-software complex "DIN-1".

of examination of patients (postoperative) were compared with the norm, i.e. indicators identified in healthy people. The indicators were considered significant at $p<0.05$.

Results and Discussion

Performing the investigation of practically healthy people (without pathology in the maxillofacial region) the static and dynamic indicators of the soft tissues, innervated by the II (in infraorbital measuring position) and III branches of the trigeminal nerve (in the mental measuring position), were determined. The indicants of resistance and tonus of the nerve have been measured. For the II branch the indicants of conductivity were 113.0±2.8 conventional units (CU), resistance – 5.0±0.7 CU and tone – 2.20±1 CU. For the III branch the indicants was 113.0±2.8 CU, resistance – 5.00±7 CU and tone – 2.2±0.1 CU. Thus, the indicants of conductivity, resistance and tonus of II and III branches of the trigeminal nerve in healthy people were almost the same.

In patients of Istudy group (**contusion of the trigeminal nerve**) in the dynamics of the investigation (postoperative), we found the loss of pain, tactile and thermal sensitivity of the skin and mucosa of the oral cavity of different severity, and these changes of sensitivity we consider in our research. In this study we present the changes in electrophysiological parameters of the branches of the trigeminal nerve in the dynamics of postoperative period. The indicants of conductivity (Fig 6) upon hospitalization (before surgery) were 115.1±3.1 CU($p>0.05$), a day after surgery 77.3±4.2 CU($p<0.001$), after 3 days – 82.4±4.5 CU ($p<0.001$), 7-8 days after surgery – 88.2±3.7 CU ($p<0.001$), after 14-15 days (two weeks) – 90.2±3.2 CU ($p<0.001$), 1 month – 109.2±5.0 CU ($p>0.05$). Resistance (Fig 7) upon the hospitalization corresponded to 5.6±2.2 CU ($p>0.05$), a day after the surgery the resistance was minus 2.5±1.7 CU ($p<0.001$), after 3 days – minus 8.6±4.1 CU ($p<0.001$), after 7-8 days after surgery – minus 2.9±0.9 CU($p<0.001$), after 14-15 days (two weeks) – 3.1±0.3 CU($p<0.05$), after 1 month 4.6±2.3 CU ($p>0.05$). The tone (Fig 8) upon the hospitalization was equal to 2.3±0.3 CU ($p>0.05$), a day after the surgery, the tone was 2.40±5 CU ($p>0.05$), after 3 days – 2.00±5 CU ($p>0.05$), after 7-8 days after surgery – 2.2±0.4 CU ($p>0.05$), after 14-15 days (two weeks) – 2.30±4 CU ($p>0.05$).

Thus, the conductivity and resistance of II and III branches of the trigeminal nerve within the first three days after the surgery reached a maximum change (decrease) of the studied parameters, and after 1 month the indicants of conductivity and resistance returned to normal. Increased tone of II and III branches of the trigeminal nerve was not significantly changed throughout the period of examination of patients ofthe I study group.

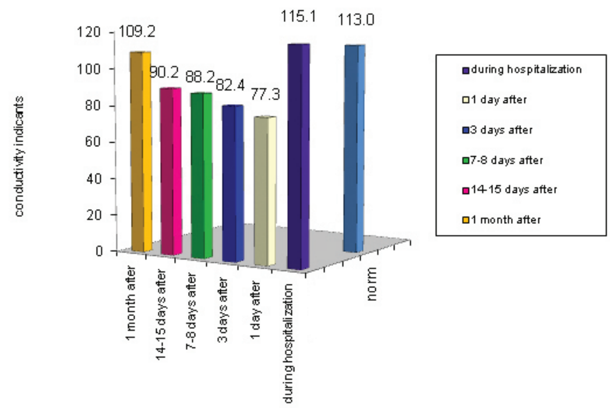


FIGURE 6. The conductivity indicants of the trigeminal nerve branches in patients of the I study group.

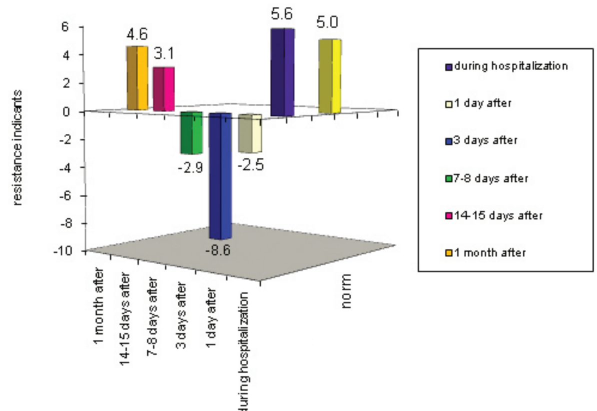


FIGURE 7. A resistance indicants of the trigeminal nerve branches in patients of I study group.

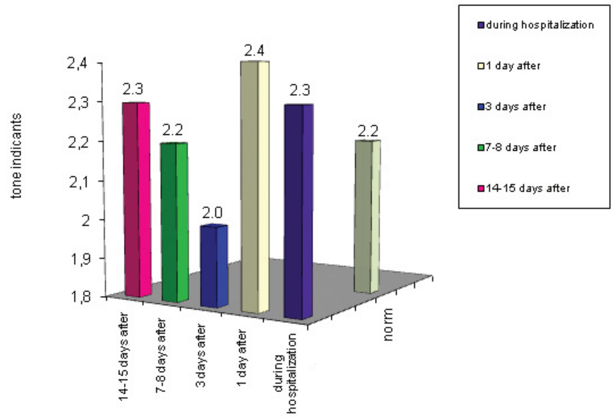


FIGURE 8. A tone indicants of the trigeminal nerve branches in patients of the I study group.

Examining patients of II study group (**stretching of the trigeminal nerve**) we also noted the change of pain, tactile and thermal sensitivity of the skin and mucosa of the oral cavity of different severity. Electrophysiological indicants of the branches of trigeminal nerve changed in the dynamics of the investigation. The conductivity (Fig 9) upon hospitalization (before surgery) was 119.4±3.1 CU (p>0.05), a day after surgery – 66.34±6 CU (p<0.001), 3 days after surgery – 78.4±4.2 CU (p<0.001), 7-8 days after surgery – 83.3±3.4 CU (p<0.001), after 3-4 weeks – 88.4±3.2 CU (p<0.001), and in 2 months – 118.5±7.9 CU (p>0.05). A resistance (Fig 10) upon hospitalization was 7.2±1.9 CU (p>0.05), a day after the surgery, the resistance was minus 6.7±2.4 CU (p<0.001), after 3 days – minus of 13.1±3.9 CU (p<0.001), after 7-8 days after surgery – minus 18.9±2.9 CU (p<0.001), after 3-4 weeks – minus 3.8±1.6 CU (p<0.001), after 2 months – 6.8±4.8 CU (p>0.05). A tone (Fig 11) upon hospitalization was 2.5±0.3 CU (p>0.05), a day after surgery, was 2.4±0.3 CU (p>0.05), after 3 days – 2.6±0.4 CU (p>0.05), 7-8 days after surgery – 2.6±0.5 CU (p>0.05), 3-4 weeks after surgery – 2.3±0.3 CU (p>0.05), 2 months after surgery was 2.4±0.5 CU (p>0.05).

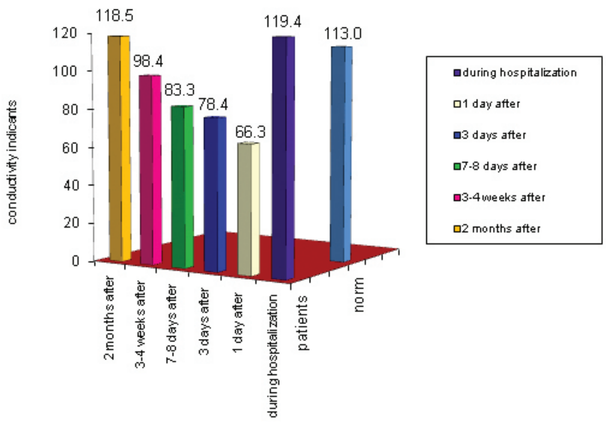


FIGURE 9. The conductivity indicants of the trigeminal nerve branches in patients of the II study group.

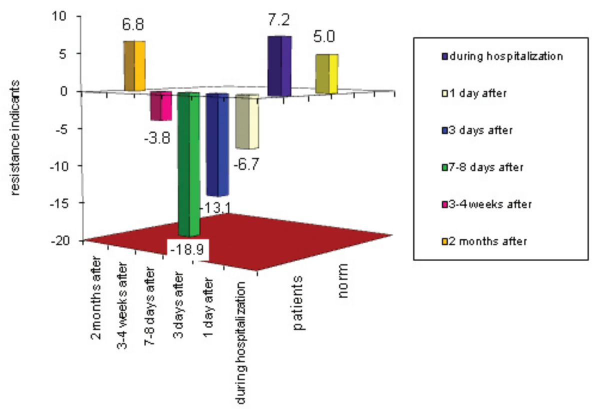


FIGURE 10. The resistance indicants of the trigeminal nerve branches in patients of II study group.

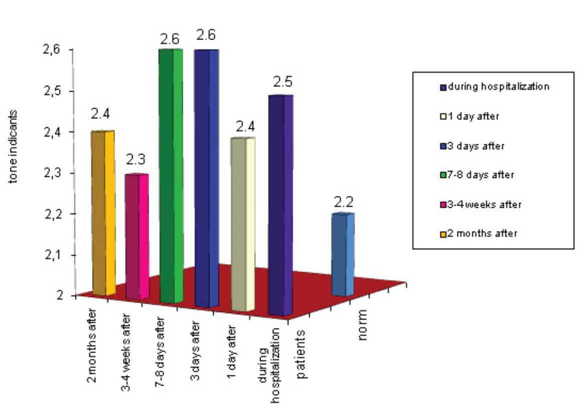


FIGURE 11. The tone indicants of the trigeminal nerve branches in patients of II study group.

Thus, the conductivity and resistance of the II and III branches of the trigeminal nerve within the first three days in patients of II study group (with the stretching of the branches of the trigeminal nerve) reached the maximum changes (reductions) in these indicants and only 2 months after the surgery indicants have been normalized. Increased tonus of II and III branches of the trigeminal nerve was not significantly changed throughout the period of examination inpatients of II study group.

Through analysis of the changes of electrophysiological parameters of II and III branches of trigeminal nerve in patients of II study group (with stretching branches of the trigeminal nerve) after surgery it was found that, the heavier the surgery was in this group, the result were neurological symptoms from trigeminal nerve and more the conductivity and resistance deviate from the norm, i.e. reduced.

During treatment of the III study group of patients (**partial or incomplete rupture of one of the trigeminal nerve branches**) we noted the change of pain, tactile and thermal sensitivity of the skin and mucosa of the oral cavity of different severity. Electrophysiological indicants of the trigeminal nerve branches changed in the dynamics of investigation. The conductivity (Fig 12) upon hospitalization (before surgery) was 120.2±5.8 CU (p>0.05), 3 days after surgery – 65.2±8.6 CU (p<0.001), after 14-15 days –73.4±9.2 CU (p<0.001), 1 month after surgery – 79.3±8.3 CU (p<0.001) after 3 months – 82.2±11.3 CU (p<0.02), 6 months – 107.5±11.2 CU (p>0.05). Resistance (Fig 13) upon hospitalization was equal to 5.9±0.8 CU (p>0.05), through 3 days after surgery the resistance was minus 9.7±4.3 CU (p<0.001), after 14-15 days – minus 10.6±4.9 CU (p<0.001), 1 month after surgery – minus 7.9±4.7 CU (p<0.001), after 3 months – minus 2.2±1.9 CU (p<0.01), after 6 months – 3.6±4.2 CU (p>0.05). The tone (Fig 14) upon hospitalization was 2.1±0.2 CU (p>0.05), through 3 days after surgery the tone was 2.9±0.2 CU (p<0.001), after 14-15 days – 3.1±0.3 CU (p<0.001), 1 month after surgery was 2.8±0.2 CU (p<0.01), after 3 months – 2.5±0.1 CU (p<0.05), after 6 month – 2.3±0.5 CU (p>0.05).

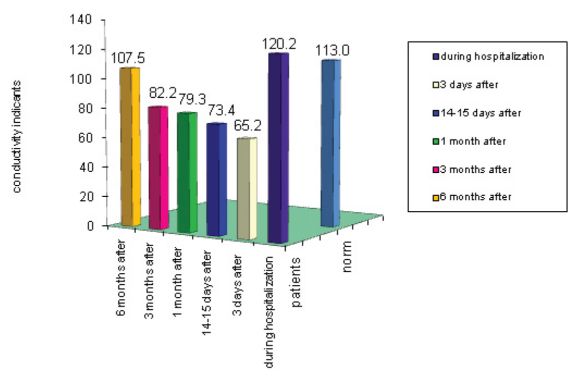


FIGURE 12. The conductivity indicants of the trigeminal nerve branches in patients of III study group.

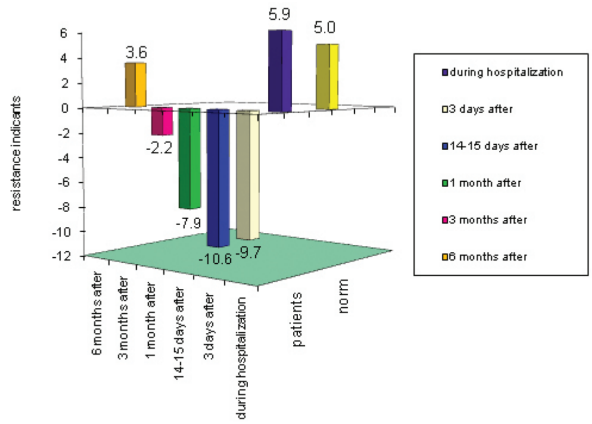


FIGURE 13. The resistance indicants of the trigeminal nerve branches in patients of III study group.

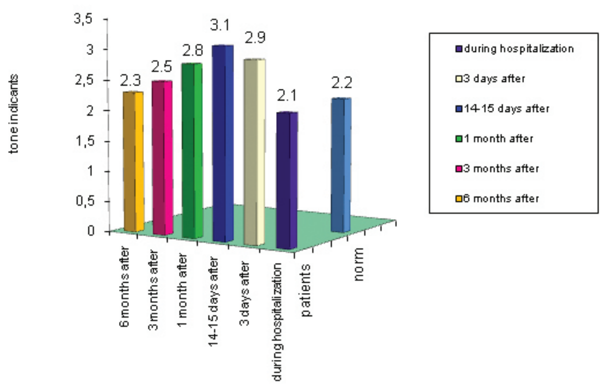


FIGURE 14. The tone indicants of the trigeminal nerve branches in patients of III study group.

Analysing the conductivity and resistance of the trigeminal nerve branches in patients of III study group (**partial rupture of any branch of the trigeminal nerve**) after surgery we found a significant decrease in these indicants. And they were very low during the first month after surgery in all patients of this study group. Then there was a slow and gradual increase of conductivity and resistance with its normalization to the 6th month after surgery. The tone of the trigeminal nerve branches was significantly increased. The highest data rates were on 14-15 days after surgery. The tone normalization occurred at the 6th month after surgery.

The heavier the surgeries were in patient of III study group (**partial or incomplete nerve rupture**), resulted in neurological symptoms from trigeminal nerve, the greater and more authentic a deviation from the norm of the conductivity, resistance and tone. Normalization of all the electrophysiological indicants was occurred only 6 months after surgery.

During examination of patients of IV study group (a complete rupture of one of the trigeminal nerve branches), we found a significant change in pain, tactile and thermal sensitivity of the skin and mucosa of the oral cavity of different severity. Electrophysiological indicants of the trigeminal nerve branches changed in the dynamics of investigation. The conductivity (Fig 15) upon hospitalization (before surgery) was 117.2±5.6 CU (p>0.05), 3 days after surgery – 58.5±6.8 CU (p<0.0±01), after 14-15 days – 44.9±8.3 CU (p<0.001), 1 month after surgery – 49.6±6.7 CU (p<0.001) after 3 months – 51.2±7.9 CU (p<0.001), after 6 months – 56.9±12.8 CU (p<0.001). Resistance (Fig 16) at hospitalization was equal to 5.6±0.9 CU (p>0.05), through 3 days after surgery the resistance was minus 23.8±3.4 CU (p<0.001), after 14-15 days – minus 29.8±5.9 CU (p<0.001), 1 month after surgery – minus 33.9±5.2 CU (p<0.001), after 3 months – minus 34.4±6.3 CU (p<0.001), after 6 months – minus 31.5±11.9 CU (p<0.001).

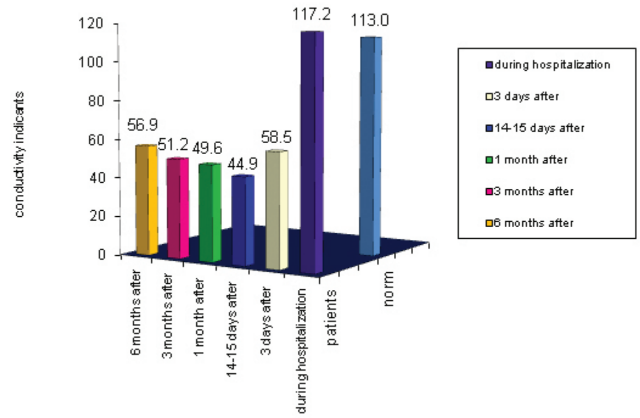


FIGURE 15. The conductivity indicants of the trigeminal nerve branches in patients of IV study group.

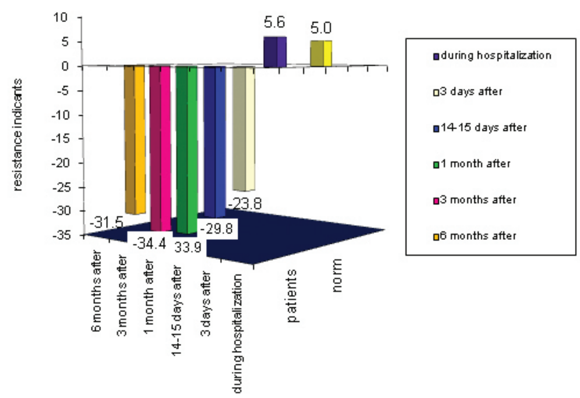


FIGURE 16. The resistance indicants of the trigeminal nerve branches in patients of IV study group.

Indicants of tonus (Fig 17) upon hospitalization was equal to 2.2±0.1 CU (p>0.05), through 3 days after surgery the tone was 2.9±0.3 CU (p<0.001), after 14-15 days – 3.5±0.2 CU (p<0.001), 1 month after surgery – 3.8±0.3 CU (p<0.001), after 3 months – 3.6±0.3 CU (p<0.001), after 6 months – 3.3±0.2 CU (p<0.001).

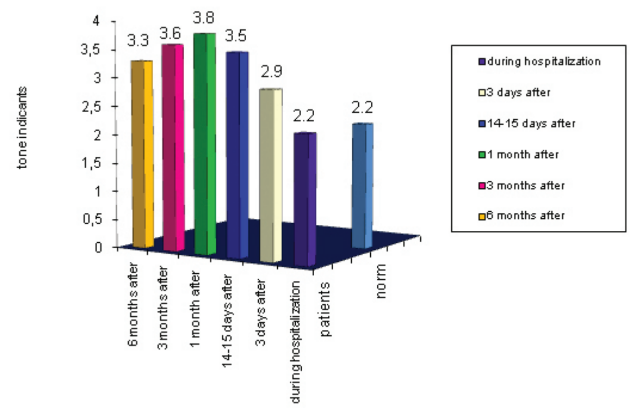


FIGURE 17. The tone indicants of the trigeminal nerve branches in patients of IV study group.

Analysing the conductivity and resistance of the trigeminal nerve branches in patients of IV study group (with complete rupture of II or III branch of the trigeminal nerve) after surgery we noted that on the 3rd day after surgery a significant decrease of these indicants occurred, which remained significantly low at 3-6 months after surgery. Increased tone of the trigeminal nerve branches was significantly increased and the highest data rates were 1 month after surgery. Normalization of conductivity, resistance and tone were not occurred within 6 months after surgery.

Research of heavier proceeded surgery of patient IV study group (nerve damage) the resulted in a clinical neurological symptoms from trigeminal nerve and the greater was deviation from the norm of the conductivity, resistance and tone. According to our observations, the normalization of electrophysiological indicants of conductivity, resistance and tone does not occur even at 8-12 months after surgery.

Summarizing conclusions, we found that upon the injury II and III branches of the trigeminal nerve (I study group) after surgery the conductivity and resistance were significantly decreased (in comparison with healthy people) and during the first three days after surgery they had reached the maximum of their changes. Significantly low conductivity and resistance were noted within 14-15 days after surgery. An investigation on hardware-software complex "DIN-1" set the normalization of conductivity and resistance at 1 month after surgery. Increased toneupon the injury of II and III branches of the trigeminal nerve was not significantly changed throughout the postoperative period in patients of I study group.

Upon stretching of II and III branches of the trigeminal nerve (II study group) the conductivity and resistance was significantly decreased (compared to the norm, i.e., healthy people) for the first three days after surgery. Significantly low conductivity and resistance were noted during 1-1.5 months after surgery. The investigation with the use of a hardware-software complex "DIN-1" set the normalization of conductivity and resistance after 2 months after surgery. Increased tonus upon the stretching of the II and III branches of the trigeminal nerve was not significantly changed throughout the period of examination of patients of II study group. It should be noted that the sensitivity recovery of the skin and mucous membranes of the oral cavity in the region of surgery also occurred in the specified time, i.e. 2 months after operation.

When partial (incomplete) rupture II and III branches of the trigeminal nerve (III study group) occurs, a significant decrease of conductivity and resistance after surgery were noted. On 14-15 days after surgery noticed a maximum reduction in the incidence of resistance and conductivity.

Further, it was observed a slow and gradual increase of these indicants, but they remained significantly low for 3 months. The tonus indicants upon the incomplete (partial) rupture of the trigeminal nerve branches were significantly increased. The highest data rates were also at 14-15 days after surgery. An investigation on hardware-software complex "DIN-1" set the normalization of all studied indicants just 6 months after the surgery. Changes of all types of sensitivity of skin and mucous membranes of the oral cavity in the field of surgery within a specified time, i.e. 6 months after the surgery, has not recovered despite the normalization of electrophysiological indicants. Complete recovery of all types of sensitivity in case of partial (incomplete) rupture of branches of the trigeminal nerve was occurred not earlier than after 8-9 months after surgery.

In a complete rupture the II and III branches of the trigeminal nerve (IV study group) in the postoperative period there was a simultaneous significant decrease of conductivity and resistance, and the rate of the tonus – on the contrary – was significantly increased compared with healthy people (norm). The lowest possible (conductivity and resistance) and the highest (tone), these figures were not just for 14-15 days after surgery, but in the following months surveys. The normalization of electrophysiological indicants (according to the hardware-software complex "DIN-1") conductivity, resistance and tonus of the soft tissues, innervated by the affected branches of the trigeminal nerve, was observed even for 6-8-12 months after surgery. It is established that the heavier the proceeded operation associated with removal of a tumor or tumor-like lesions of the jaws from the surveyed of this study group was, the result was a neurological clinical symptoms from the relevant branches of the trigeminal nerve and highes were deviations of the conductivity, resistance and tonus. Recovery of all types of sensitivity of skin and mucosal membranes after complete rupture of the trigeminal nerve branches occurred uniformly and not for all investigated samples.

Conclusions

Based on the performed investigation it was found that the determination of soft tissues electrophysiological indicants, innervated by the II and III branches of the trigeminal nerve in patients after surgery on removal of benign tumors of the jaws, is not only a diagnostic criteria of the severity of the trigeminal nerve injury in the surgical wound, but also can serve as a prognostic index that indicants the timing of sensitivity recovery of the skin and mucous membranes in the area of surgery.

Upon contusion and stretching of the trigeminal nerve branches a significant reduction in conductivity and resistance in the first few days after surgery is observed. Recovery (normalization) of the electrophysiological parameters uponcontusion and stretching of the trigeminal nerve branches occurs in 1 or 2 months (respectively) after surgery.

If in the postoperative period a significant decreasing of conductivity and resistance, and significantly increasing of indicant tonus are observed it`s indicates the injury to the trigeminal nerve branches in form of partial or complete rupture. Recovery (normalization) of all the studied electrophysiological parameters upon incomplete (partial) rupture of the trigeminal nerve branches occurs within 6 months after surgery. Upon the complete rupture of the trigeminal nerve branches the normalization of electrophysiological parameters of the trigeminal nerve does not occur within 8-12 months after surgery.

Thus, the study of electrophysiological indicants of the trigeminal nerve (conductivity, resistance, and tone) in the postoperative period has both diagnostic and prognostic value. The results that were achieved in this study can be used in maxillofacial and oral surgery.

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Діагностика тяжкості травми трійчастого нерва при операціях на щелепах

Олексій О. Тимофєєв[1], Наталія О. Ушко[2], Олена П. Вєсова[3], Марія О. Ярифа[4]

[1] Завідувач кафедри щелепно-лицевої хірургії ІС Національної медичної академії післядипломної освіти імені П.Л. Шупика, д.мед.н., професор, Заслужений діяч науки і техніки України, Київ, Україна.
[2] Доцент кафедри щелепно-лицевої хірургії ІС Національної медичної академії післядипломної освіти імені П.Л. Шупика, к.мед.н., доцент, Київ, Україна.
[3] Професор кафедри щелепно-лицевої хірургії ІС Національної медичної академії післядипломної освіти імені П.Л. Шупика, к.мед.н., професор, Київ, Україна.
[4] Доцент кафедри хірургічної стоматології та щелепно-лицевої хірургії КМУ УАНМ, к.мед.н., доцент, Київ, Україна.

ПРО СТАТТЮ

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Ключові слова:

Електрофізіологічні показники
Трійчастий нерв
Неврологічні ускладнення
Нейропатії
Пухлини щелеп
Пухлиноподібні утворення щелеп

РЕЗЮМЕ

Мета. Вивчити динаміку змін електрофізіологічних показників II і III гілок трійчастого нерва у хворих після проведення операцій видалення пухлин і пухлиноподібних утворень щелеп; визначити реабілітаційні можливості лікаря в залежності від важкості ушкодження нерва.
Методи. Проведено обстеження та лікування неврологічних ускладнень у 179 хворих після проведення оперативних втручань, пов'язаних з видаленням пухлин і пухлиноподібних утворень верхньої та нижньої щелеп, на апаратно-програмному комплексі "ДІН-1".
Результати. На підставі проведеного обстеження встановлено, що величини електрофізіологічних показників провідності, резистентності і тонусу гілок трійчастого нерва у хворих після проведених операцій видалення пухлин і пухлиноподібних утворень щелеп можуть бути діагностичними критеріями важкості ушкодження нерва в операційній рані.
Висновки. Отримані нами дані можна використовувати як об'єктивний прогностичний тест в щелепно-лицевій хірургії та хірургічній стоматології для визначення ступеню вираженості неврогенних ушкоджень у м'яких і кісткових тканинах, що іннервуються трійчастим нервом.

Диагностика тяжести травмы тройничного нерва при операциях на челюстях

Алексей А. Тимофеев[1], Наталия А. Ушко[2], Елена П. Весова[3], Мария А. Ярифа[4]

[1] Заведующий кафедрой челюстно-лицевой хирургии ИСНМАПО имени П.Л. Шупика, д. мед.н., профессор, Заслуженный деятель науки и техники Украины, Киев, Украина.
[2] Доцент кафедры челюстно-лицевой хирургии ИС НМАПО имени П. Л. Шупика, к. мед.н., доцент, Киев, Украина.
[3] Профессор кафедры челюстно-лицевой хирургии ИС НМАПО имени П. Л. Шупика, д. мед.н., профессор, Киев, Украина.
[4] Доцент кафедры хирургической стоматологии и челюстно-лицевой хирургии КМУ УАНМ, к. мед.н., доцент, Киев, Украина.

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Нейропатии
Опухоли челюстей
Опухолеподобные образования челюстей

РЕЗЮМЕ

Цель. Изучить динамику изменений электрофизиологических показателей II и III ветвей тройничного нерва у больных после проведения операций удаления опухолей и опухолеподобных образований челюстей; определить реабилитационные возможности врача в зависимости от тяжести повреждения нерва.
Методы. Проведено обследование и лечение неврологических осложнений у 179 больных после проведения оперативных вмешательств, связанных с удалением опухолей и опухолеподобных образований верхней и нижней челюстей, на аппаратно-программном комплексе "ДИН-1".
Результаты. На основании проведенного обследования установлено, что величины электрофизиологических показателей проводимости, резистентности и тонуса ветвей тройничного нерва у больных после проведенных операций удаления опухолей и опухолеподобных образований челюстей могут являться диагностическими критериями тяжести повреждения чувствительного нерва в операционной ране.
Выводы. Полученные нами данные можно использовать как объективный прогностический тест в челюстно-лицевой хирургии и хирургической стоматологии для определения степени выраженности неврогенных повреждений в мягких и костных тканях, иннервируемых тройничным нервом.

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Two Great Founders

Editorial

In December 2016 the co-founder of the Journal Yuriy V. Voronenko was re-elected to rector position at the Shupyk National Medical Academy of Postgraduate Education! The Academy became a leading Educational Institution in the Eastern Europe under his leadership. Prof Voronenko is an author of over 400 scientific works, and also author and co-author of 11 textbooks, 25 educational and methodical manuals, 38 monographs. He mentored 12 ScD and 11 PhD.

Yuriy V. Voronenko MD, ScD, Professor, is an academician of the National Academy of Medical Sciences of Ukraine, Ukraine State Prize Winner in Science and Technology, Honored Science and Technology Worker of Ukraine. Under the rector`s Voronenko support the 40 scientific journals are developed (the Journal of Innovative Technology Medicine, the Journal of Cardiac Surgery and Interventional Cardiology etc.).

So, the Editorial of the Journal is congratulate Prof Voronenko with a re-election and wishes him to create such great opportunities for our medical colleagues as for founding our Journal!

In December 16, 2016 the other Great Founder, the Founder of the Kyiv Medical University of UAFM Victor A. Tumanov was celebrated 80 years!

Prof Tumanov was a rector of Kyiv Medical University UAFM from 1994 to 2006 and now is honorary rector of this guiding institution.

Prof Tumanov is awarded by numerous state awards and is an editorial board member of many scientific journals.

With deep respect for the titanic work and achievements of the Professor we wish him for the anniversary a strong health to lead the University to the new heights!

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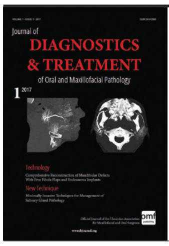

Condition of the Teeth in Fracture Gap of the Mandible

Oleksii O. Tymofieiev[1,*], Ievgen I. Fesenko[2,3], Oleksandr O. Tymofieiev[4]

[1] Chair of the Department of Maxillofacial Surgery, Stomatology Institute, Shupyk NMAPE, Kyiv, Ukraine *(ScD, Prof)*
[2] Oral and Maxillofacial Surgery Department, KMU of UAFM, Kyiv, Ukraine *(Assis Prof)*
[3] Center of Maxillofacial Surgery, Kyiv Regional Clinical Hospital, Kyiv, Ukraine (place of work at moment of article preparing)
[4] Department of Dentistry, Stomatology Institute, Shupyk NMAPE, Kyiv, Ukraine *(ScD, Assoc Prof)*

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ABSTRACT

Purpose.
The aim of the present study was to determine condition of the teeth, which are located in the fracture gap of different parts of mandible and substantiate an indications for their removing or retaining.
Material and Methods.
114 patients with 186 fractures were involved in this research.
Results.
50% or more cases of post-traumatic inflammatory complications were observed in case of contact failure of the teeth roots, that are in a gap of fracture, with the periodontium of these teeth al 1/2 or more of their length. Saving teeth in fracture gap, which have failure of contact with the surrounding periodontium 1/2 and 3/4 the length of the root causes high risk of inflammatory complications in bone and surrounding soft tissues.
Conclusions.
Based on the specified condition of teeth in the fracture gap different areas of the mandible justified indication for removal or preservation.

Introduction

In textbooks on maxillofacial and oral surgery a different attitude to the tooth, which is located in the gap of the mandible fracture, is found. Absolute indications for teeth removal from the fracture gap are: roots and fractured teeth or completely dislocated from the socket teeth; teeth periodontitis (with periapical chronic inflammatory lesions); teeth with symptoms of periodontitis or parodontosis of moderate and severe course; if exposed root is in the fracture gap or impacted tooth, thereby preventing tight (right) reposition of jaw fragments (tooth, wedged in the fracture gap); teeth, intractable to conservative treatment and supporting inflammatory manifestation [1-3]. In some cases, it is proposed to remove the tooth, which can be further potential cause of post-traumatic osteomyelitis [4]. In other cases, we have to hold it, because the tooth can keep the broken-off fragment of the mandibular bone.

The purpose of the present study was to determine condition of the teeth, which are located in the fracture gap of different parts of mandibular bone and substantiate an indications for their removing and/or retaining.

Material and Methods

We observed 114 patients with open fractures of the mandible, which were treated in the Maxillofacial Department #1 of the Kyiv City Clinical Hospital №12 (Center of Oral and Maxillofacial Surgery, Shupyk National Medical Academy of Postgraduate Education) and the Center of Maxillofacial Surgery of Kyiv Regional Clinical Hospital. This study examined only those victims who have a tooth from fracture line not removed upon hospitalization.

The observation period for patients was performed for one year after the injury. Age of victims was between 18 and 53 years. Of the 114 patients with mandibular fractures in 42 of examined (36.8%) were unilateral and in 72 patients (63.2%) – bilateral fractures. In 114 of victims were diagnosed 186 fractures. In all victims the damages of the mandible were obtained in household injuries. Seeking medical help, i.e. hospitalization of patients was 1-4 days after the injury.

During hospitalization all the victims were X-ray examined, namely making radiographs of the jaws (in different projections), panoramic radiography and/or CT scans. Reduction and fixation of mandibular bone fragments was performed by bimaxillary arch bars with gearing loops and intermaxillary rubber traction. Teeth from the fractures gap upon hospitalization were not removed. Surgical treatment (osteosynthesis) was used in 14 victims (12.3%). After the reduction and fixation of bone fragments of jaws, in addition to hygiene oral care, all patients with mandibular fractures got traditional medical treatment that included antibiotics, analgesics, hyposensitization drugs, and physiotherapy.

Among the special methods of the examination, we have chosen periotestometry and pulp vitality test (electric pulp test) of the tooth in the fracture gap.

Periotestometry is a method of the indirect state estimation of the tooth attachment tissues, e.g. estimation of the functional ability

* Corresponding author. Department of Maxillofacial Surgery, Stomatology Institute, Shupyk NMAPE, 4-a Pidvysotskogo Street, Kyiv 01103, Ukraine.
Tel., fax: +38 (044) 528 35 17. E-mail address: tymofeev@gmail.com (O.O. Tymofieiev)

of parodontium in the areas of interest, which is performed using *Periotest S* (Medizintechnik Gulden e.K., Modautal, Germany) desktop unit. This appliance complies with the norms EN 60601 and EN 60601-1-2 and was awarded the CE mark in accordance with the guidance document 93/42/EWG for medical devices dated on June 14, 1993. The *Periotest S* (Fig 1) evaluates the ability of the periodontal tissues to reset the tooth after it was exposed to the certain external load. The appliance consists of the instrument box, computer analyser and handpiece which are intercommunicated with each other. Working element of a handpiece is a two-mode tine which includes the piezoelectric element. Its physical working principle is to convert an electric pulse to a mechanical pulse. The examined tooth or implant with the abutment is percussed with the tine of the handpiece at regular intervals (250 msec) applying the force which is non-invasive both for the hard dental tissues and the tissues of the periodontium.

FIGURE 1. External view of the Periotest S.

During the measuring, the tip of a handpiece automatically taps on the tooth for 16 times, i.e. 4 times per second. To analyse the results, the arithmetic mean from 3 measurements performed with intervals from 10 to 15 seconds is used. When evaluating the function of individual periodontium, the teeth of the upper and lower jaws should not come in contact! During the measurement, the sleeve of handpiece should not touch any tooth. The distance between handpiece and tooth should be from 0.7 up to 2.0mm. The specifics of using the periotest method in persons with mandibular fracture was the fact that it could be performed only if there was a fraeture of the mandibular bone in the area of incisors, canines, premolars, and the first molar. The examined tooth, i.e. the tooth in the fracture gap, was not fixed with an arch bar during periotestometry, however it was fixed with a ligature wire after the procedure had been completed.

Vitality test of the tooth, i.e. the investigation of the pulp vitality, has been conducted with *Vitality Scanner 2006* (SybronEndo, Glendora, USA) (Fig 2A). During manipulations in the oral cavity, we have used only a disposable wooden spatula along with the appliance (Fig 2B). When using *Vitality Scanner*, we have also used the following sequence of actions recommended in the manual:

1. Before using the appliance, we have adjusted the deflection speed to its minimal value by turning the wheel "1" on the panel. We have also connected the earth wire of the spatula detector and inserted the handpiece into the front part of the sensitive element.
2. The clip for lips was attached to the patient's lip (the patient could hold it with his/her hands).
3. The test tooth was dried (according to the manual, we did not use chemicals (ether, alcohol) in order to prevent changes in the excitability threshold of the tooth pulp).
4. The tip of the sensitive element was immersed into a small quantity of the fluoride gel and placed on the tooth while not touching the gingiva.
5. Once a good electrical contact was achieved, the light on the sensitive element turned on. The sensitive element was kept in contact with the tooth until the patient felt the stimulation.
6. The response level was indicated on the digital display.
7. After waiting for two seconds, the next tooth was tested. The display was automatically rebooted to its home position once the tine contacted the tooth.
8. After the test was completed, *Vitality Scanner* automatically turned off in 10-15 seconds.

FIGURE 2. External view of the Pulp Vitality Scanner (**A**). Carrying out the Vitality test (**B**).

According to the device manual provided by the manufacturer, the normal range of the pulp vitality response is 10-40 units, 20-50 units, and 30-70 units for incisors, premolars, and molars, respectively. The values of Vitality Scanner exceeding these indices indicate any decline of the pulp vitality.

To control the indices of the conducted periotestometry and tooth vitality test in patients with unilateral open fractures of the mandibular bone, the teeth on the healthy side (the side opposite to the damage) have been used while in patients with bilateral open fractures the teeth of the upper jaw were used.

When carrying out this method of the patient's examination, we have always taken into account the following parameters: localization of the fracture; the displacement degree of the mandibular bone fragments; correlation between the tooth located in the fracture gap and periodontium.

Depending on the displacement degree of the mandibular bone fragments, we have divided the patients with fractures of any localization into three groups: **group 1 – the fractures without dislocation of the fragments (subperiosteal), i.e. the fracture gap was clearly visible in the X-ray images as a 'fine thread or the hairline'; group 2 – with minimal dislocation of the fragments (1 to 2 mm); group 3 – with remarkable dislocation of the fragments (more than 2 mm).**

Depending on the contact area between the root of the tooth (located in fracture gap) and periodontium, we have also divided all the patients into 4 subgroups: **subgroup 1 – the contact between the root of the tooth and periodontium is preserved along the whole length of the root; subgroup 2 – the contact between the root of the tooth and periodontium is disrupted along 1/3 of its length; subgroup 3 – the contact with periodontium is disrupted along 1/2 of its length; subgroup 4 – contact with periodontium is disrupted along 3/4 of its length.**

Digital data obtained from the laboratory examination has been processed using the standard variable-statistical approach and a PC with the statistical program SPSS 11.0 for *Windows* and *Microsoft Excel 2000*. The accuracy of the test results has been estimated using the Student's t-test. Variations have been considered significant when $p < 0.05$.

Results and Discussion

We would like to evaluate 114 patients with open mandibular fractures depending on their location. As we have previously pointed out, there were identified 186 fractures. If all previously mentioned mandibular fractures are taken as 100%, the median fractures have been diagnosed in 5.9% of cases, of those 53.2% were located in the mental area, 9.7% – in the area of the body, and 31.2% periotestometry of the teeth in the area of angle (Fig 3). 15 women (13.2%) (Fig 4) and 99 men (86.8%) were examined during the study.

During the further study course, we will carry out a

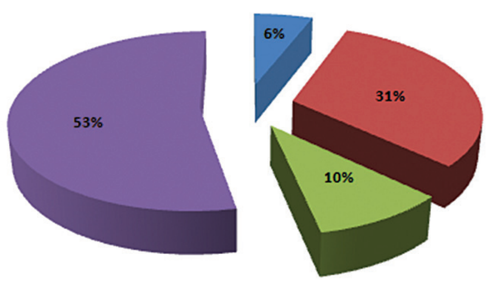


FIGURE 3. Frequency (percentage) of open mandibular fractures.

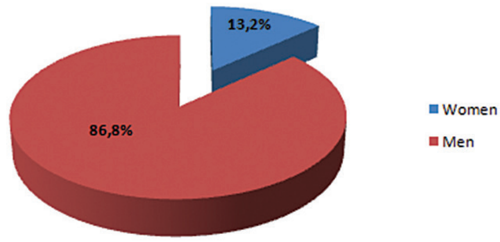


FIGURE 4. Frequency (percentage) of male and female patients with open mandibular fractures.

detailed analysis of mandibular fractures depending on their location and purpose of our examination.

The median fractures have been identified in 11 cases which make up 5.9% of all mandibular fractures. The median fractures have been diagnosed in 6 cases (1 of the patients had a single fracture and 5 patients had bilateral or segmental fractures). In median fractures, no dislocation of the fragments was found (the damage of the hard tissue was visible in the X-ray image as 'a fine thread or a hairline') in 36.4% of cases (group 1) and minimal dislocation (group 2) took place in 63.6% of cases (Fig 5).

The teeth in the median fracture gap should be assigned

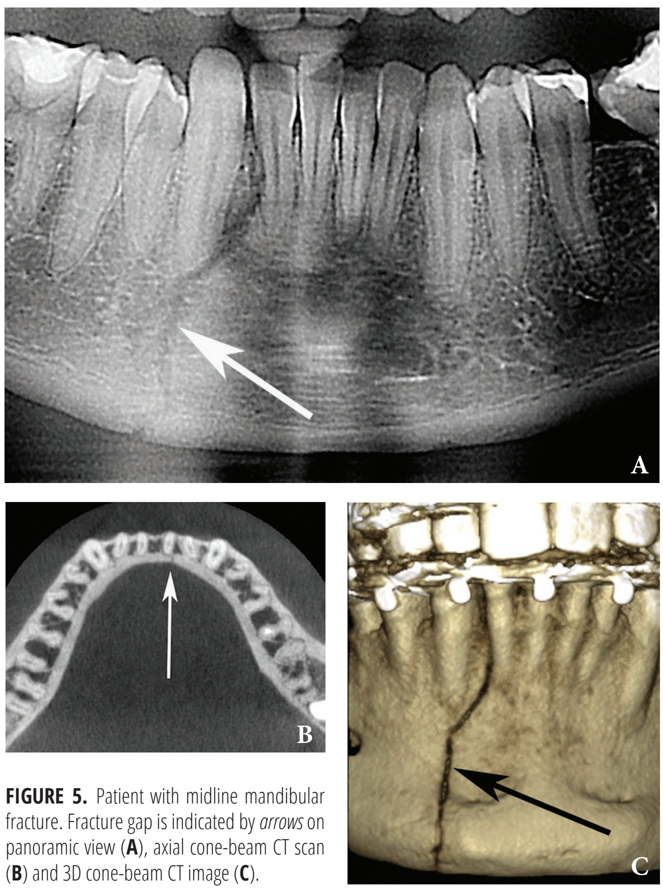


FIGURE 5. Patient with midline mandibular fracture. Fracture gap is indicated by *arrows* on panoramic view (**A**), axial cone-beam CT scan (**B**) and 3D cone-beam CT image (**C**).

to subgroup 1, i.e. the contact between the root of the tooth and periodontium has been preserved along the whole length of the root. These teeth had the following perotestometry values – 1.53 ± 0.31 units ($p > 0.05$). These figures did not differ significantly from those of healthy people (arithmetic mean upon periotestometry is 1.18 ± 0.24 units for the maxilla and

1.43 ± 0,35 units for the mandible). Almost in all patients with median mandibular fractures of the lower jaw, the contact between the teeth (in the fracture gap) and periodontium was totally preserved. The pulp vitality of these teeth was also preserved and was equal to 14.4 ± 4.7 units. During the monitoring of the patients with fractures localised in the midline (median fractures) of the lower jaw at six months and one year after the injury, it has been shown that the healing of the damaged jaw bone went smoothly, without inflammatory complications. During this period of time, there have been no clinical problems with the teeth in the fracture gap, they have not been subjected to the treatment. At six months and one year after the injury, the pulp vitality of the previously examined teeth (in the fracture gap) remained without significant changes compared both to the previous survey period (during hospitalization) and healthy people, and was 12.3 ± 3.6 units and 14.5 ± 5.9 units, respectively. The previous results of periotestometry in the same terms have also been preserved without significant changes and were 1.42 ± 0.27 units ($p > 0.05$) and 1.56 ± 0.33 units ($p > 0.05$), respectively.

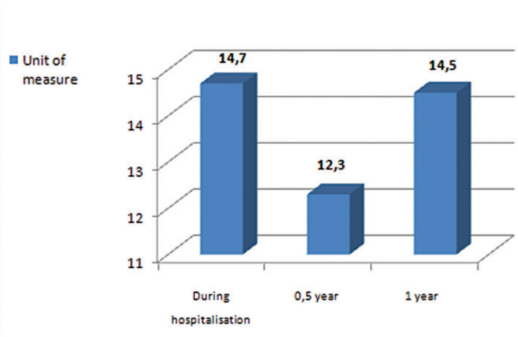


FIGURE 6. Dynamics of changes in the vitality of the teeth located in the gap of midline mandibular fracture.

In the mental section of the mandible, the fracture of the lower jaw has been diagnosed in 99 cases (53.2%). We have revealed this localisation in 54 cases (9 patients had unilateral fractions, 45 patients had bilateral fractures). In mental mandibular fractures, the dislocation degrees of the bone fragments were as follows (Fig 7): group 1 (32.3%) – damage of hard tissue which looked like 'a fine thread or hairline' could be found in the X-ray image, group 2 (43.5%) had minimum dislocation and group 3 (24.2%) had a significant dislocation.

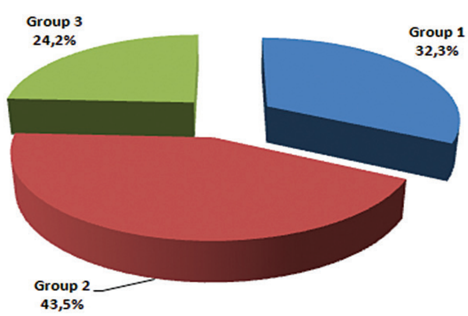


FIGURE 7. The frequence of different groups of mental fractures depending on the degree of displacement of bone fragments.

According to clinical symptoms, in all cases, in the patients with a mental mandibular fracture a contusion of the inferior alveolar nerve was diagnosed. In 45.5% of cases, the teeth in the mental fracture gap contacted with periodontium along its whole length of the root (subgroup 1). In 30.3% of cases, the teeth in the fracture gap must be assigned to subgroup 2, and 24.2% – to subgroup 3 (Fig 8).

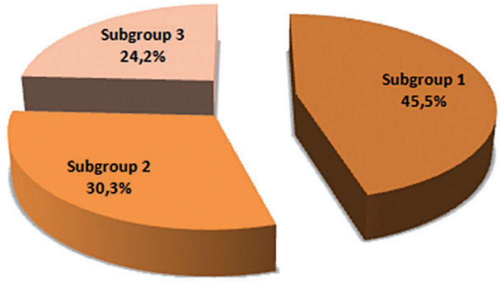


FIGURE 8. The frequency of subgroups with mental fractures (depending on the contact area between the tooth that is in the fracture gap and with the surrounding periodontium).

The panoramic images of the mental fractures with different degrees of dislocation of bone fragments are shown in Figures 9-11.

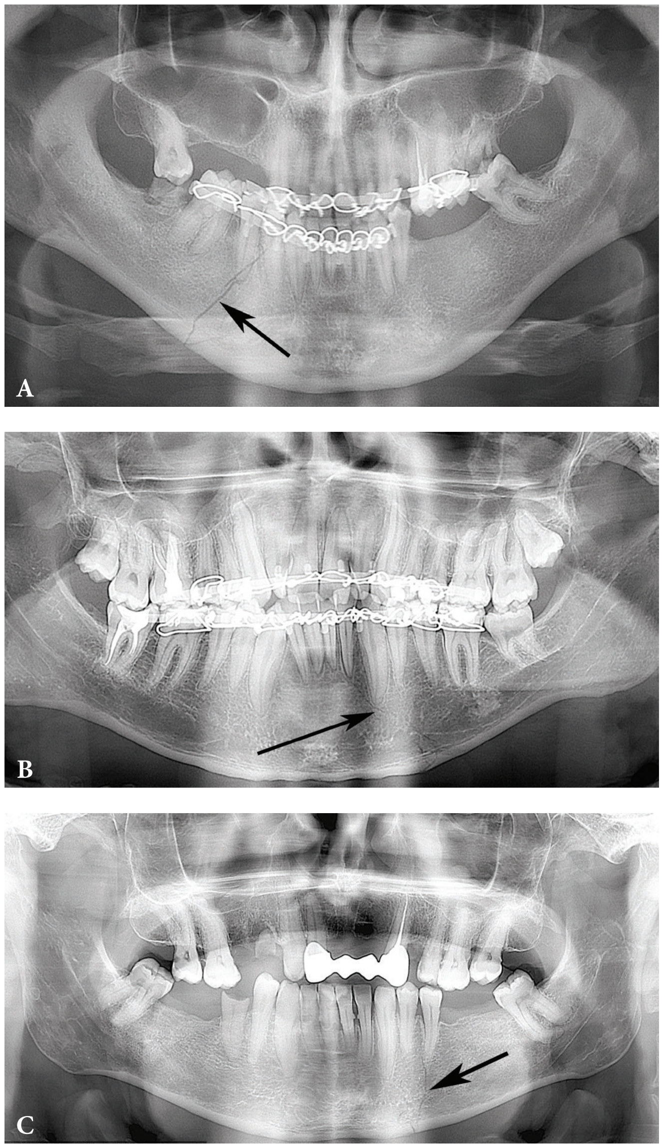


FIGURE 9. Panoramic views (**A**, **B**, **C**) of patients with unilateral mandibular fractures (*arrows*) in the mental site. **(Fig 9 continued on the next page.)**

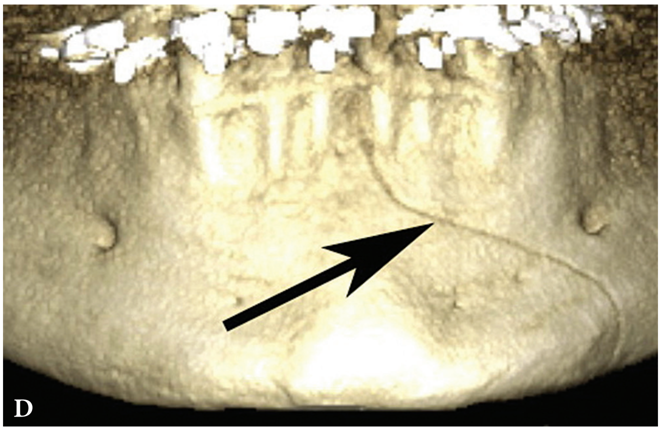


FIGURE 9 (cont'd). 3D cone-beam CT image (**D**) shows mental mandibular fracture (*arrow*).

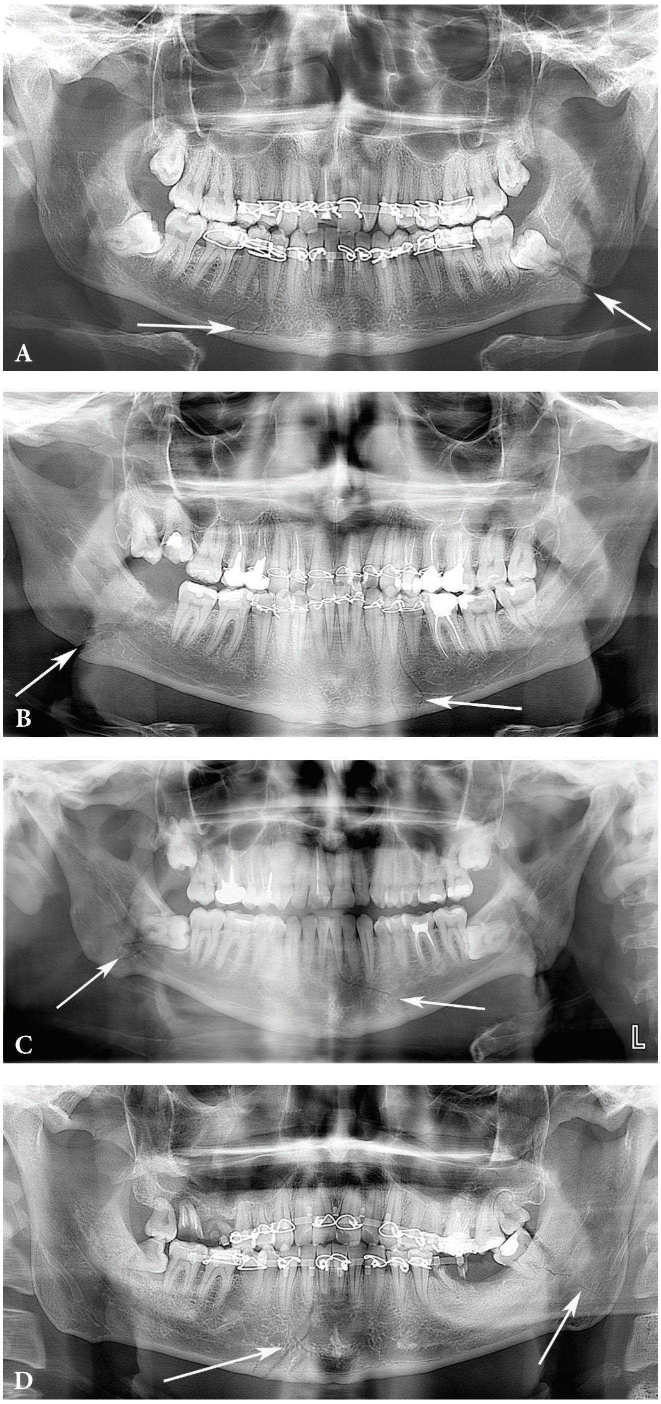


FIGURE 10. The panoramic radiographs of the patients with the bilateral mandibular fractures (*arrows*) located in the mental section and angle area (**A**, **B**, **C**, **D**).

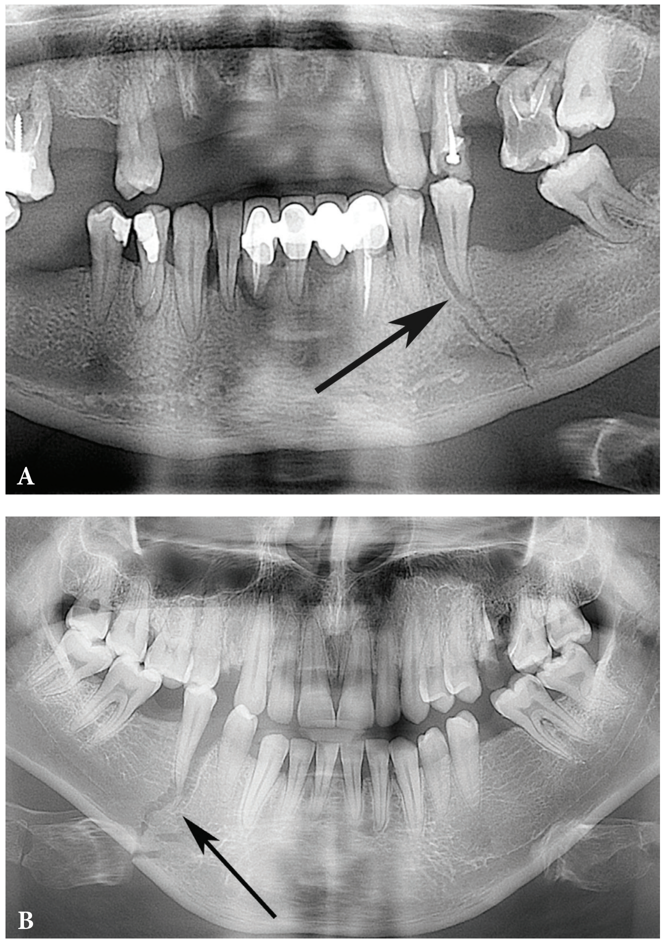


FIGURE 11. The panoramic views of the patients from group 2 (**A**) and 3 (**B**) with the mental mandibular fractures (*arrows*).

The periotestometry results for the teeth in the mental mandibular fracture gap in subgroups 1 and 2 were the following: 1.27 ± 0.42 units ($p > 0.05$) and 1.33 ± 0.51 units ($p > 0.05$). The obtained results did not differ from those in healthy people. In the 3rd examined subgroup, the results of the periotestometry were increased ($p < 0.001$) compared to the other subgroups and normal values and were equal to 7.12 ± 0.26 units (Fig 12).

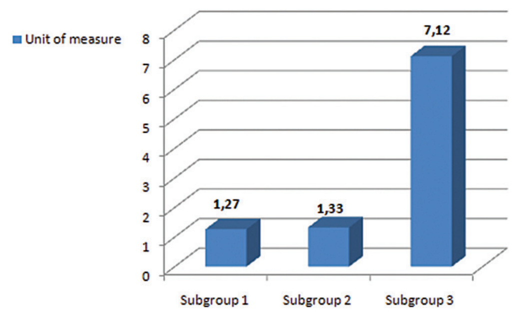


FIGURE 12. The results of the periotestometry of the teeth, that were located in the mental mandibular fracture gap in different examined subgroups.

In subgroup 1, the pulp vitality of the teeth was preserved and was equal to 17.6 ± 5.4 units. In subgroup 2, the pulp vitality of the teeth differed to some extent (there was no significant difference compared to the norm) and was equal to 27.8 ± 6.8 un. In subgroup 3, the results of the pulp vitality were within the upper margin of normal values – 52.3 ± 8.6 units (Fig 13). It should be noted that there were no pulp response in the premolar teeth located in the gap of the damaged bone in 3 patients with the mandibular fractures in the 3rd examined subgroup.

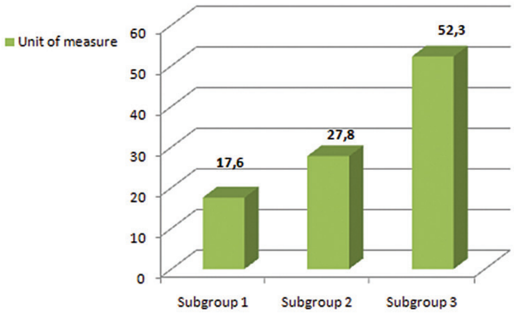


FIGURE 13. The results of the pulp vitality of the teeth located in the mental mandibular fracture gap in different examined subgroups.

At six month and one year after the received trauma, the pulp vitality of the previously examined teeth (in fracture gap) had normalised and was 28.1 ± 6.7 units ($p > 0.05$) and 25.3 ± 8.9 units ($p > 0.05$), respectively. The periotestometry results in these periods were normal and were equal to 1.22 ± 0.55 units ($p > 0.05$) and 1.57 ± 0.48 units ($p > 0.05$), respectively.

The monitoring of patients with mental mandibular fractures at six months and one year after the injury has shown that the healing of the damaged bone of the jaw did not went smoothly, i.e. there were inflammatory complications. All inflammatory complications have been observed in the 3rd examined subgroup. Two teeth in the posttraumatic period had undergone medical treatment because of exacerbation of chronic periodontitis. One patient from group 3, subgroup 3 had the suppuration of the bony wound (the causal tooth has been removed on the 5th day after the injury) and two patients removed the post-traumatic osteomyelitis of the lower jaw in the mental section after they were discharged from the hospital (Fig 14). The causal teeth were extracted after developing the post-traumatic osteomyelitis. In patients with inflammatory complications in the bone and mandibular soft tissues upon hospitalization, the pulp response of the tooth in the fracture gap was negative, i.e. the indices of the pulp vitality exceeded the maximum accepted norm for the canines and premolars in 1.5-2 times.

FIGURE 14. The appearance of the patient with post-traumatic osteomyelitis of the mandible, developed in the mental area.

The mandibular bone fracture has been diagnosed in 18 cases (9.7%). Such a location of the fracture was found in 10 cases (there were 2 unilateral fractures and 8 bilateral fractures). In cases when the mandible was injured, the fractures were classified as follows depending on the dislocation degree of the bone fragments in mandibular bone (Fig 15): group 1 (11.1%) – damage of hard tissue which looks like 'a fine thread or hairline' in the X-ray images, group 2 (33.3%) had a minimum dislocation and group 3 (55.6%) had a significant displacement.

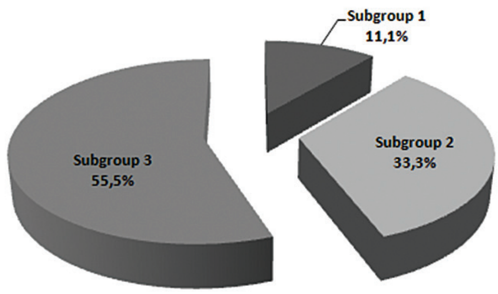


FIGURE 15. The frequency of different groups of mandible fractures depending on the degree of dislocation of bone fragments.

4 patients with the mandibular fractures underwent osteosynthesis of the mandible in the first days after their hospitalisation (Fig 16A). Depending on the clinical symptoms, there has been found a stretching of inferior alveolar nerve in the zone of the mandibular bone injury in 2 cases (Fig 16B) and the incomplete rupture of this nerve in 2 other cases (Fig 16C).

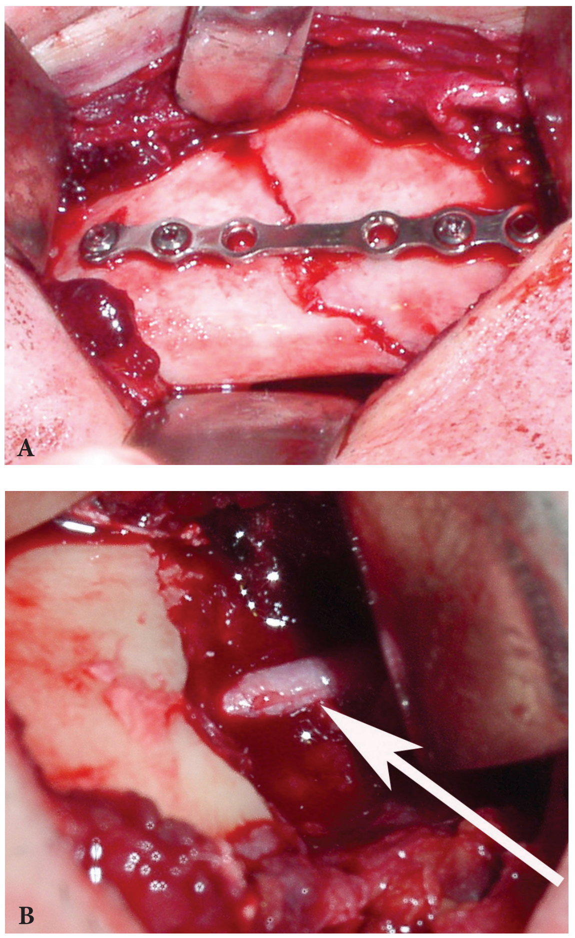


FIGURE 16. The osteosynthesis of the mandibular body using the titanium miniplate (**A**). The appearance of the inferior alveolar nerve after the stretching (**B**) at the place of mandibular fracture (inferior alveolar nerve is indicated with *arrow*). **(Fig 16 continued on next page.)**

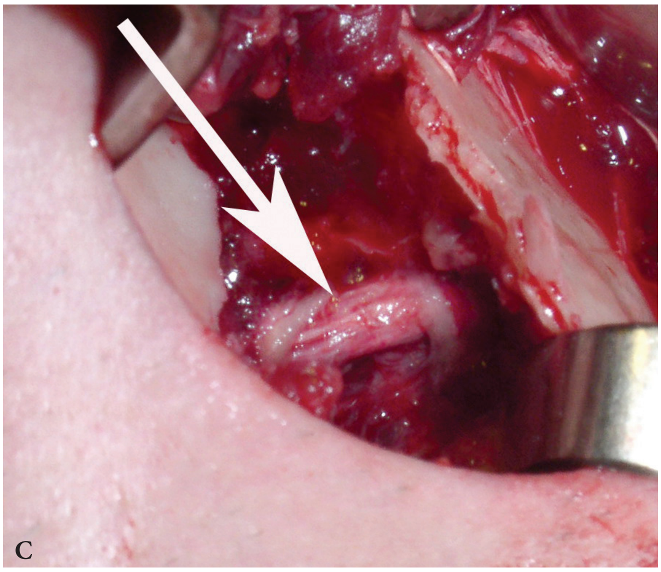


FIGURE 16 (cont'd). The appearance of the inferior alveolar nerve after the incomplete rupture (**C**) at the place of mandibular fracture (inferior alveolar nerve is indicated with *arrow*).

Depending on the contact area between the tooth in the fracture gap and periodontium, the fractures were distributed as follows: the teeth in the fracture gap contacted with the periodontium along its whole length in 11.1% of cases (subgroup 1); in 33.3% of cases, the teeth in the fracture gap should be assigned to subgroup 2, and in the 55.6% of cases to subgroup 3 (Fig 17).

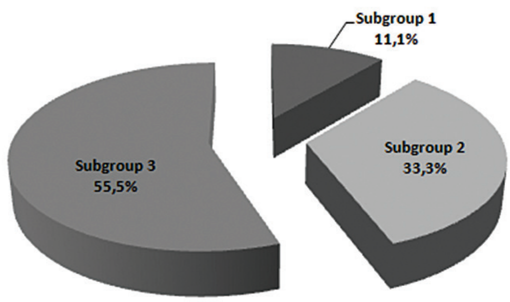
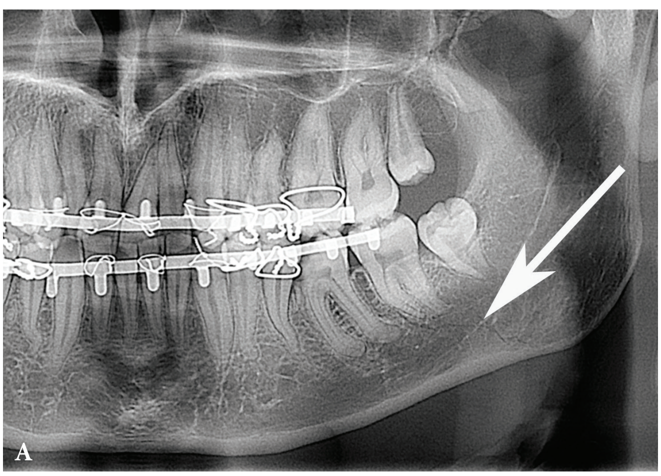


FIGURE 17. The frequency of occurrence of subgroups of mandibular fractures, depending on the tooth contact (located in the fracture gap) with the periodontitium of this tooth.

The panoramic radiographs with different degrees of fragments dislocation in the area of the lower jaw are presented in Figure 18.



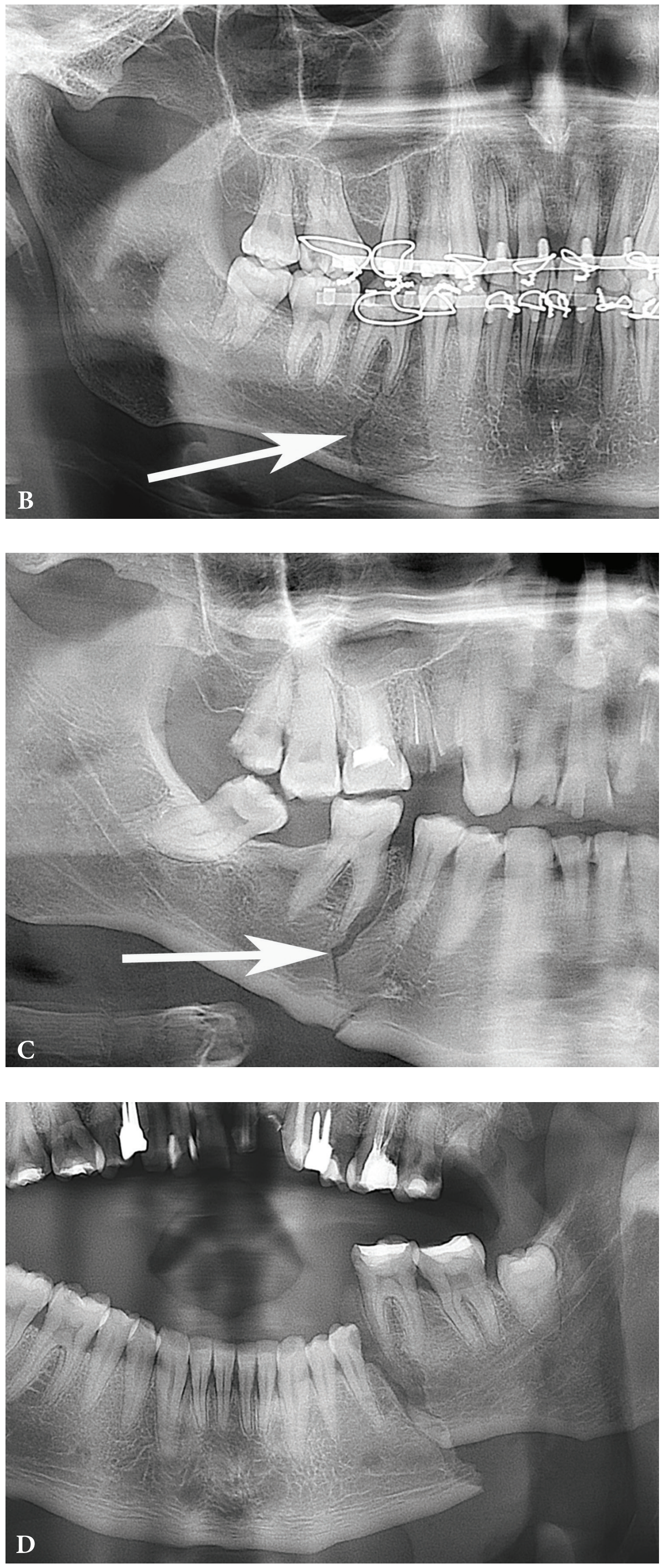


FIGURE 18. Panoramic views of the mandibular fractures in the area of the body and different dislocation degrees of fragments (**A**, **B**, **C**, **D**).

In subgroups 1 and 2, the teeth in the fracture gaps in the area of the mandible had the following periotest results: 1.66 ± 0.51 units ($p > 0.05$) and 1.53 ± 0.60 units ($p > 0.05$), respectively. These results did not differ significantly from that in healthy people (arithmetic mean periotestometry results of the teeth in the lower jaw was 1.43 ± 0.35 units). In the 3rd examined subgroup, the periotestometry results were increased ($p < 0.001$) compared to the other subgroups and normal values and were equal to 8.09 ± 0.31 units. (Fig 19).

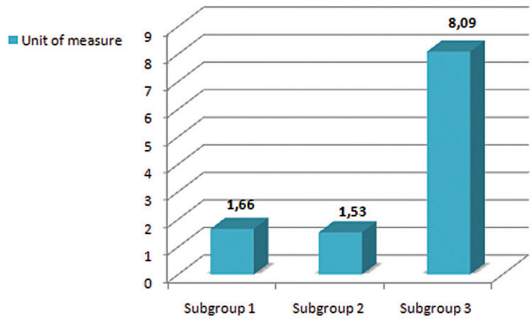


FIGURE 19. The results of periotestometry of the teeth located in the fracture gap in the area of body of the mandible in different subgroups under examination.

In subgroup 1, the pulp vitality of the teeth in the fracture gap of the jaw body was 33.7 ± 2.9 units ($p > 0,05$). In subgroup 2, the pulp vitality of these teeth was equal to 49.6 ± 7.4 units ($p > 0.05$), and in subgroup 3 ($p < 0.001$) it was increased and equal to 76.3 ± 9.1 units (Fig 20). It should be noted that there was no pulp response in molar teeth in the fracture gap in 2 patients from group 3 with the mandibular fractures. From our point of view, the negative result of the pulp vitality in these cases was due to the interruption of continuity of the inferior alveolar nerve upon incomplete ruptures of the inferior alveolar nerve.

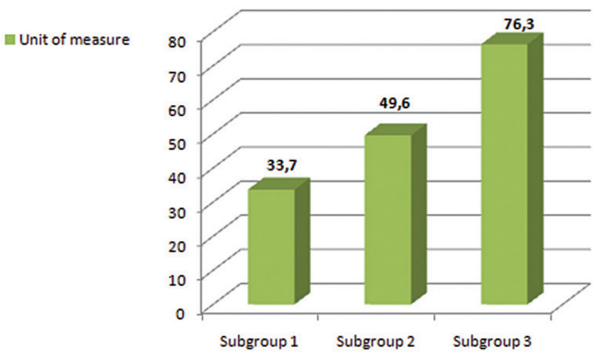


FIGURE 20. The indexes of pulp vitality of the teeth in the fracture gap of body of the mandible in different subgroups under examination.

At six months and one year after the injury, the pulp vitality of the molars (in the fracture gap) normalized and was equal to 49.8 ± 5.7 units ($p > 0.05$) and 53.2 ± 6.4 units ($p > 0.05$), respectively. The periotestometry results of the molar teeth which previously were located in the fracture gap were normal in all patients at these periods and equal to 2.07 ± 0.75 units ($p > 0.05$) and 1.89 ± 0.54 units ($p > 0.05$).

The monitoring of the patients with fractures of body of the mandible at six months and one year after the injury has shown that there were cases when the healing of the damaged bone of the jaw had inflammatory complications. All inflammatory complications developed in the 3rd examined subgroup. The exacerbation of chronic periodontitis took place in 3 cases. In two patients with mandibular fractures (group 3, subgroup 3), the bony wound suppuration was observed (the teeth in the fracture gap were extracted). In two cases of mandibular fractures, the post-traumatic osteomyelitis developed after the patients had been discharged from the hospital (Fig 21). In all patients with inflammatory complications developed in the bone and mandibular soft tissues after hospitalization, the pulp response of the molar teeth which were not located in the fracture gap was negative, i.e. the indices of the vitality of the tooth pulp exceeded the maximum accepted norm for molars in 1.5-2 times.

FIGURE 21. Appearance of the patient with the post-traumatic osteomyelitis of the mandible, complicated with the phlegmon of the cheek. The reason for the inflammatory complication was the tooth no. 3.6 in the fracture gap.

Patients with mandibular fractures who had undergone surgical treatment (osteosynthesis) with remowing of the tooth from the fracture gap had no post-surgical inflammatory complications.

In 58 cases (31.2%), the mandibular fracture in the angle area was diagnosed. We have identified this location in 44 cases (30 patients had unilateral fractures and 14 patients had bilateral fractures). In the case of the lower jaw injuries, the fractures distribution was as follows depending on the intensity of dislocation of bone fragment of mandibular angle (Fig 22): group 1 (17.3%) – damage of hard tissue which looked like a 'fine thread or hair' could be found in the X-ray images, group 2 (37.9%) had a minimal dislocation and group 3 (44.8%) had a significant dislocation.

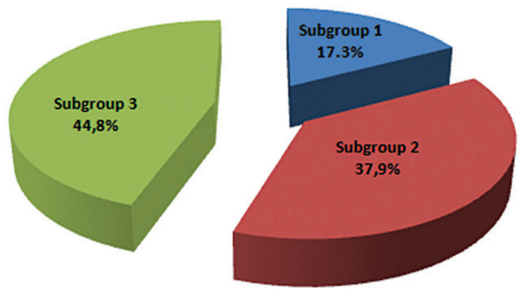


FIGURE 22. The rate of incidence of different groups of the mandibular angle fractures depending on the degree of displacement of bone fragments.

In 10 cases of the mandibular fractures, we have performed osteosynthesis of the lower jaw (Fig 16A, B). According to the clinical symptoms, in 4 of 10 patients who had been operated we found the stretching of the inferior alveolar nerve, 2 of them had the preserved vessel in the neurovascular bundle (Fig 23C) and in another 2 cases this vessel has been ruptured (Fig 23D). 5 patients with the mandibular angle fractures had the incomplete rupture (Fig 23E), and 1 patient had the complete rupture of the inferior alveolar nerve (Fig 23F).

Depending on the area of contact between the tooth and periodontium in the fracture gap, the fractures in the area of mandibular angle distributed as follows: in 20.7% of cases, the teeth in the fracture gap in the body area contacted with the periodontium along its whole length (subgroup 1); in 34.5%

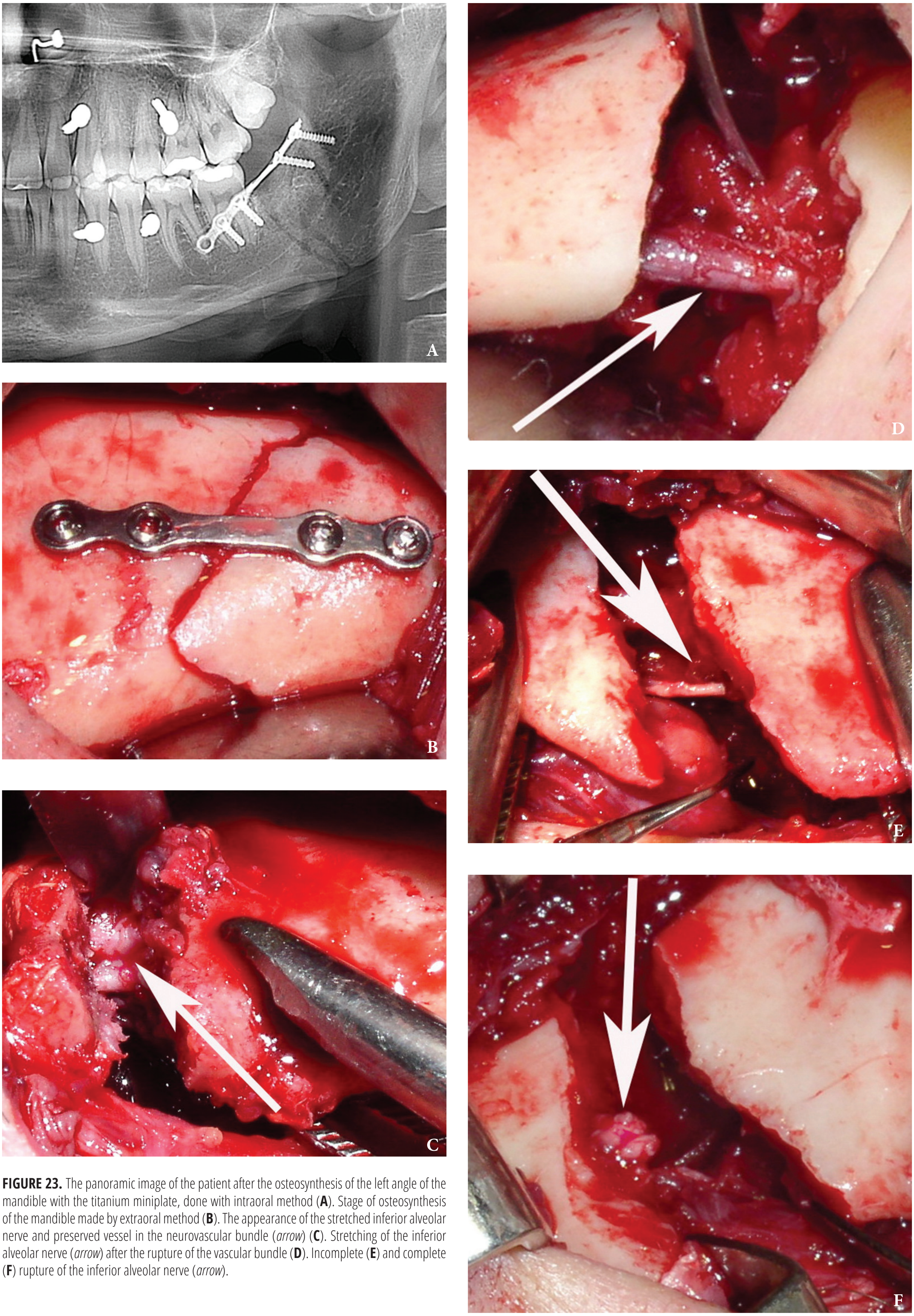


FIGURE 23. The panoramic image of the patient after the osteosynthesis of the left angle of the mandible with the titanium miniplate, done with intraoral method (**A**). Stage of osteosynthesis of the mandible made by extraoral method (**B**). The appearance of the stretched inferior alveolar nerve and preserved vessel in the neurovascular bundle (*arrow*) (**C**). Stretching of the inferior alveolar nerve (*arrow*) after the rupture of the vascular bundle (**D**). Incomplete (**E**) and complete (**F**) rupture of the inferior alveolar nerve (*arrow*).

of cases, the teeth in the fracture gap should be assigned to subgroup 2, in 22.4% – to subgroup 3, and in 22.4% – to subgroup 4 (Fig 24). Upon hospitalization, the teeth in the fracture gap were not removed.

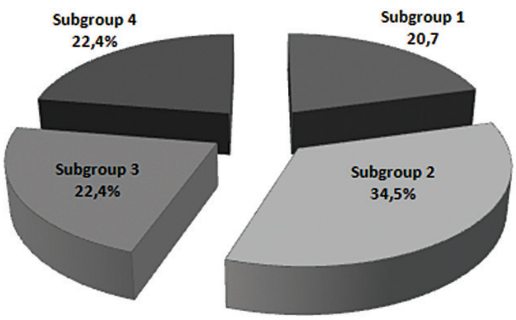
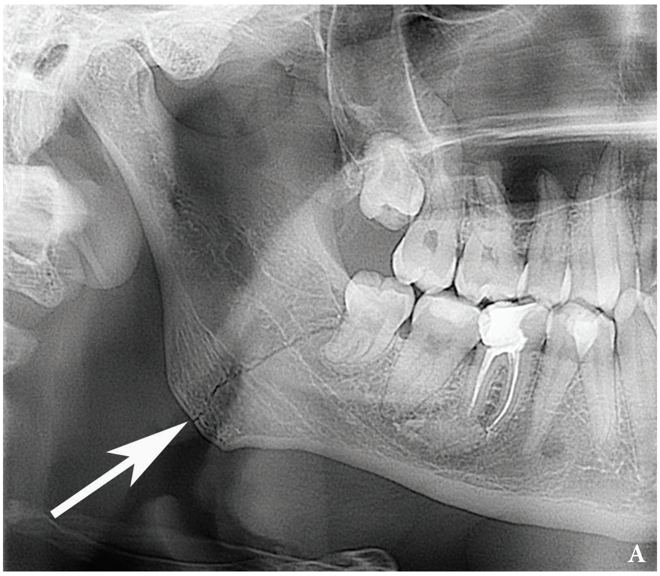
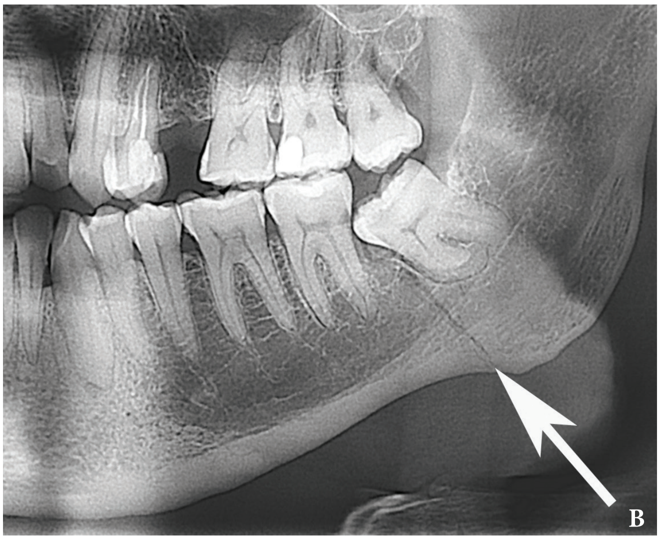
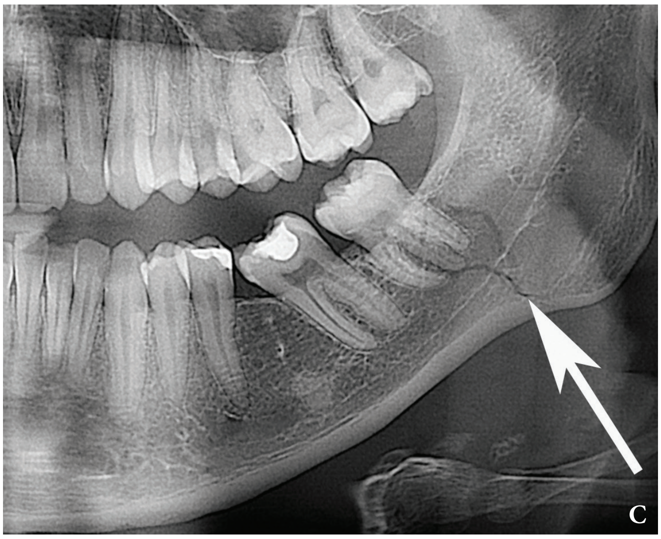


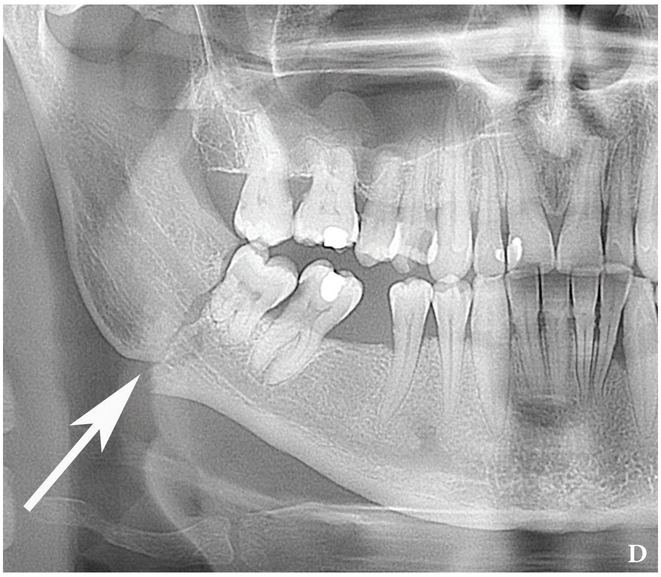
FIGURE 24. The frequency of subgroups occurrence upon the fractures of body of the mandible, depending on the degree of contact of the tooth (which is located in the fracture gap) with the periodontium of the given tooth.

The X-ray images of the fractures with the different degree of dislocation of the bone fragments in the mandibular angle are presented by the Figure 25.









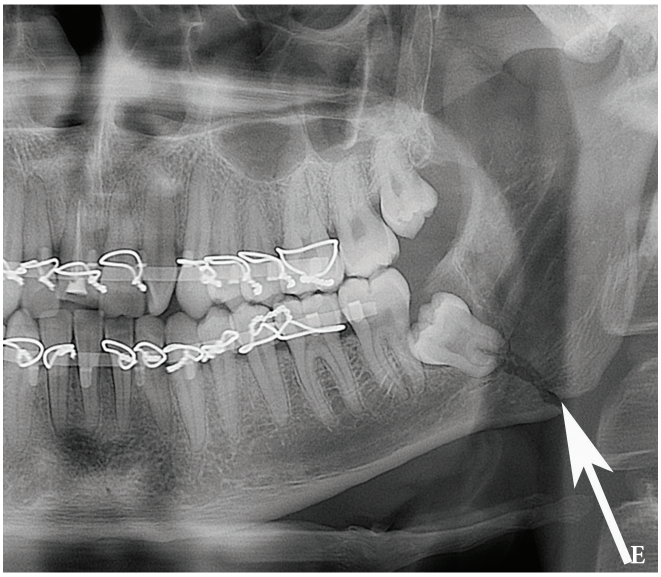


FIGURE 25. The panoramic images (**A**, **B**, **C**, **D**, **E**) of the patients with the mandibular angle fractures (*arrows*) with different degree of fragments dislocation. **(Fig 25 continued on the next page.)**

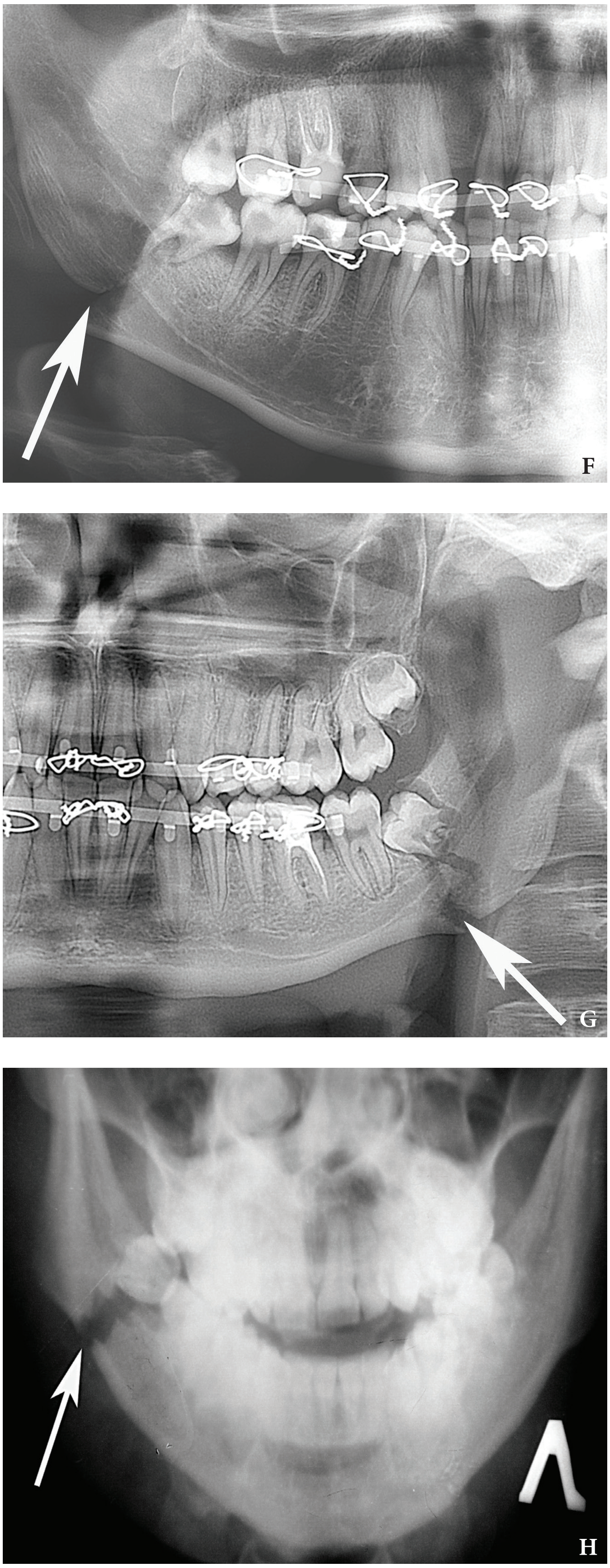


FIGURE 25 (cont'd). The panoramic images (F, G) and the posteroanterior view (H) of the patients with the mandibular angle fractures (arrows) with different degree of fragments dislocation.

In subgroup 1, the pulp vitality of the teeth in the fracture gap in the mandibular angle was equal to 52.4 ± 6.5 units ($p > 0.05$). In subgroup 2, the pulp vitality was 56.6 ± 7.1 units ($p > 0.05$), in subgroup 3 it was 78.7 ± 6.8 units ($p < 0.001$), and in subgroup 4 it was 83.8 ± 7.9 units ($p < 0.001$) (Fig 26). It should be noted that 3 patients with the mandibular fractures from group 3 had no pulp response in molar teeth in the fracture gap. In subgroup 4, more than 50% of the examined patients (7 injured) also had no pulp response of the teeth in the fracture gap, i.e. the response was negative. From our point of view, the negative results of pulp vitality in these cases was due to the injury of the inferior alveolar nerve (the stretching, incomplete and complete rupture).

The monitoring of the patients with mandibular angle fractures at six months and one year after the injury has shown that there were some cases when the healing of the damaged bony tissue of the jaw had inflammatory complications. In patients

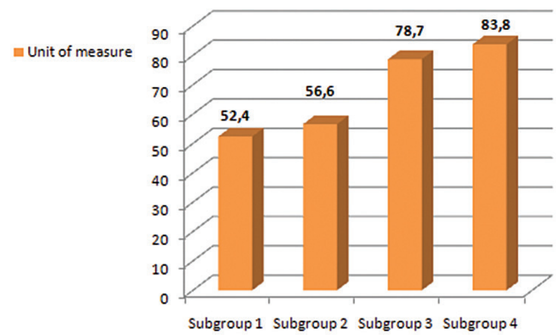


FIGURE 26. The pulp vitality of the tooth, located in the mandibular angle fracture gap in the different subgroups.

from subgroups 3 and 4, the exacerbation of chronic periodontitis of the third molars occurred in 4 cases. The five injured persons with the mandibular bone fractures (in subgroups 3 and 4) had the bony wound suppuration (these teeth in the fracture gap have been extracted as a part of the treatment). Four patients with the mandibular angle fractures (in subgroups 3 and 4) experienced the post-traumatic osteomyelitis (Fig 27). In the patients with inflammatory complications developed in the bone and premandibular soft tissues upon hospitalization, the pulp response of three molars in the fracture gap was negative, i.e. the indices of pulp vitality exceeded the maximum accepted norm for molars in 2 and more times.

In patients with the mandibular angle fracture who had undergone the surgical treatment (osteosynthesis) with the removing of the tooth in the fracture gap, the post-traumatic osteomyelitis has developed only in one case (the etiological tooth has been extracted in the post-surgical period). From our point of view, the reason for the development of this complication was the non-fulfillment of mouth cavity hygiene rules and other violations.

At six months and one year after the injury, the pulp vitality of the third molars (in the fracture gap) normalized and was 54.1 ± 7.6 un. (< 0.05) and 58.9 ± 5.9 un. (< 0.05), respectively.

Therefore, having analysed 186 cases of open mandibular fractures, we have found out that in 63 cases (33.9%) the tooth located in the fracture gap (along with the whole length of the root) fully contacted with the surrounding periodontium (group 1). In 63 cases (33.9%), there has been presented the disruption of the contact between the tooth root and periodontium in the fracture gap along the 1/3 of root length (subgroup 2). In 47 cases (25.3%), the contact between the root of the tooth in the fracture gap and periodontium was disrupted along the 1/2 of its root length (subgroup 3). In 13 cases (6.9%), the contact between the root of the tooth in the fracture gap and periodontium was disrupted along the 3/4 of its length.

FIGURE 27. The appearance of the patients with the post-traumatic osteomyelitis of the mandible (**A**, **B**). The reason for the development of the inflammatory complication were the third molars, which were located in the fracture gap.

It was found that the inflammatory complications took place only in subgroups 3 and 4. In these examined subgroups, the pulp vitality of the tooth in the fracture gap also was declined. The results of the pulp vitality of these teeth exceeded the maximum norm for the teeth of the corresponding localisation in 1.5-2 times and more. All inflammatory complications originated in the teeth with the outlined deviances. In the case of the solution of continuity of the mandibular bone in the mental divisions, subgroup 3 included 24 fractures with inflammatory complications in 5 cases (2 – the exacerbation of chronic periodontitis, 1 – suppuration of the bony wound, 2 – post-traumatic osteomyelitis), i.e. the inflammatory complications in this subgroup evolved in 20.8% of cases. Among the injuries of the lower jaw in subgroup 3, there were 10 fractures and the inflammatory complications developed in 7 cases (3 – the exacerbation of chronic periodontitis, 2 – suppuration of the bony wound, 2 – post-traumatic osteomyelitis), i.e. the inflammatory complications in this subgroup have evolved in 70.0% of cases of all injuries in this subgroup. We believe that in cases of the mandibular fractures, when the contact of the tooth in the fracture gap with the surrounding periodontium was disrupted, the increased rate of the inflammatory complications was due to the extremely rare localization of such damages. In subgroups 3 and 4, there were 26 fractures with the fracture of bone in the mandibular angle. The inflammatory complications in the mandible angle were found in 13 cases (4 – the exacerbation of chronic periodontitis, 5 – suppuration of the bony wound, 4 – post-traumatic osteomyelitis), i.e. the inflammatory complications in this subgroup have evolved in 50.0% of cases of all injuries in subgroups 3 and 4.

According to our examination of the patients with the open mandibular fractures, we have revealed that in more than 50% of cases, the post-traumatic inflammatory complications (the exacerbation of chronic periodontitis, suppuration of the bony wound, post-traumatic osteomyelitis) developed after the mandibular fractures in the molar area when the contact between the roots of the teeth in the fracture gap and periodontium of the given teeth was disrupted along 1/2 of its length and more. The preservation of the teeth in the fracture gap when the contact between the roots of the teeth in the fracture gap and the surrounding periodontium of the given teeth is disrupted along 1/2 to and 3/4 of the roots' length creates a high risk of the inflammatory complications progression in bone and surrounding mandible soft tissues.

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Стан зубів в щілині перелому нижньої щелепи

Олексій О. Тимофєєв[1], Євген І. Фесенко[2, 3], Олександр О. Тимофєєв[4]

[1] Завідувач кафедри щелепно-лицевої хірургії ІС НМАПО імені П.Л. Шупика, д.мед.н.,професор, Заслужений діяч науки і техніки України, Київ, Україна.
[2] Асистент кафедри хірургічної стоматології та щелепно-лицевої хірургії КМУ УАНМ, Київ, Україна.
[3] Центр щелепно-лицевої хірургії Київської обласної клінічної лікарні (місце роботи на момент написання статті), Київ, Україна.
[4] Доцент кафедри стоматології ІС НМАПО імені П. Л. Шупика, д.мед.н., доцент, Київ, Україна.

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Зуб в щілині перелому
Тест вітальності зуба
Періотестметрія
Нагноєння кісткової рани
Остеосинтез

РЕЗЮМЕ

Мета. Визначити стан зубів, що знаходяться в щілині перелому різних відділів нижньощелепної кістки і обгрунтувати показання для їх видалення або збереження.
Матеріали и методи. Під спостереженням перебувало 114 хворих з діагностованими 186 переломами.
Результати. В 50% і більше випадків спостерігалися посттравматичні запальні ускладнення при порушеннях дотику коренів зубів, що знаходяться в щілині перелому, з періодонтом цих зубів на 1/2 і більше їх довжини. Збереження зубів в щілини переломів, які мають порушення дотику з оточуючим його періодонтом на 1/2 і 3/4 довжини кореня призводить до високого ризику розвитку запальних ускладнень в кістці і навколощелепних м'яких тканинах.
Висновки. На основі визначеного стану зубів в щілині перелому різних відділів нижньої щелепи обгрунтовано показання для його видалення або збереження.

Состояние зубов в щели перелома нижней челюсти

Алексей А. Тимофеев [1], Евгений И. Фесенко[2, 3], Александр А. Тимофеев[4]

[1] Заведующий кафедрой челюстно-лицевой хирургии ИС НМАПО имени П.Л. Шупика, д.мед.н., профессор, Заслуженный деятель науки и техники Украины, Киев, Украина.
[2] Ассистент кафедры хирургической стоматологии и челюстно-лицевой хирургии КМУ УАНМ, Киев, Украина.
[3] Центр челюстно-лицевой хирургии Киевской областной клинической больницы (место работы на момент написания статьи), Киев, Украина.
[4] Доцент кафедры стоматологии ИС НМАПО имени П. Л. Шупика, д.мед.н., доцент, Киев, Украина.

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Тест витальности зуба
Периотестметрия
Нагноение костной раны
Остеосинтез

РЕЗЮМЕ

Цель. Определить состояние зубов, находящихся в щели перелома различных отделов нижнечелюстной кости и обосновать показания для его удаления или сохранения.
Материалы и методы. Под наблюдением находилось 114 больных с открытыми переломами нижней челюсти с диагностированными 186 переломами.
Результаты. В 50% и более случаев наблюдались посттравматические воспалительные осложнения при нарушениях соприкосновения корней зубов, находящихся в щели перелома, с периодонтом этих зубов на 1/2 и более их длины. Сохранение зубов в щели переломов, которые имеют нарушение соприкосновения с окружающим его периодонтом на 1/2 и 3/4 длины корня приводит к высокому риску развития воспалительных осложнений в кости и околочелюстных мягких тканях.
Выводы. На основании определенного состояние зубов в щели перелома различных отделов нижней челюсти обоснованно показания для его удаления или сохранения.

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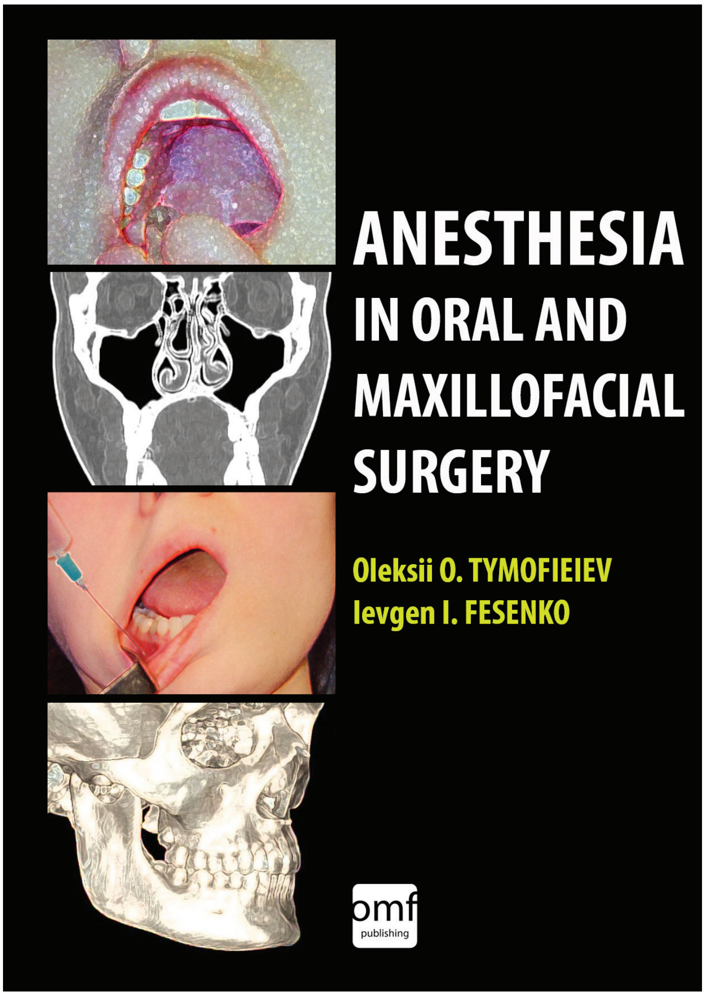

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