

**LITERATURE REVIEW****Indications of the Caldwell-Luc procedure in the era of endoscopic sinus surgery****Andreea Bajan<sup>1</sup>, Codrut Sarafoleanu<sup>1,2,3</sup>, Violeta-Gabriela Melinte<sup>1,2,3</sup>, Roxana Decuseara<sup>1,2,3</sup>**<sup>1</sup>ENT&HNS Department, "Sfanta Maria" Clinical Hospital, Bucharest, Romania<sup>2</sup>"Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania<sup>3</sup>CESITO Centre, "Sfanta Maria" Clinical Hospital, Bucharest, Romania**ABSTRACT**

Surgical treatment of chronic rhinosinusitis is indicated after failure of correctly conducted maximal drug therapy or the occurrence of complications. Radical maxillary sinus surgery has been abandoned nowadays, to the detriment of endoscopic sinus surgery, for several reasons, such as: increased incidence of complications, decreased healing rate compared to the endoscopic technique. The literature cites many situations in which the Caldwell-Luc procedure is used as a first-line surgical technique: recurrent chronic rhinosinusitis, malignant tumors of the maxillary sinus extending to the lateral wall of the nasal fossa and the pterygomaxillary space, the cases where an extensive approach to the pterygopalatine fossa is required – for ligation of the internal maxillary artery or the approach of the vidian canal in vidian neurectomy.

The authors highlight the use of Caldwell-Luc procedure in endoscopic sinus surgery era, by reviewing the complications rates, indications and long-term effectiveness of the two surgical techniques.

**KEYWORDS:** Caldwell-Luc surgery, endoscopic sinus surgery, rhinosinusitis, bleeding, sinusoscopy, histopathological score.

**INTRODUCTION**

The Caldwell-Luc procedure was first described in 1893. The American surgeon George Caldwell associates the surgical approach of the anterior wall of the maxillary sinus through a gingival-labial incision with the inferior meatotomy, while Henry Luc, French surgeon, describes the same procedure, but combined with middle meatotomy<sup>1</sup>. It was widely used until 3 decades ago as a standard surgical procedure to solve various rhinosinusal pathological cases, today with very limited indications due to the development of endoscopic surgical techniques<sup>2</sup>.

Surgical treatment of chronic rhinosinusitis is indicated after failure of correctly conducted maximal drug therapy or the occurrence of complications. The Caldwell-Luc surgery involves opening the maxillary sinus at the level of its anterior wall through a gingival-labial incision, ensuring surgi-

cal drainage in the inferior meatus, in order to evacuate the pathological content<sup>3</sup>. It is an exceptional procedure, through which the endosinusal mucosa is completely removed, the patient's discomfort, both immediately and late postoperatively, being superior to endoscopic techniques.

Functional endoscopic sinus surgery (FESS) was first described in the 1970s<sup>4,5</sup>, then having a success rate (90%) similar to the Caldwell-Luc surgery in the treatment of recurrent chronic and acute maxillary rhinosinusitis<sup>6,7</sup>. Radical maxillary sinus surgery has been abandoned nowadays, to the detriment of endoscopic sinus surgery, for several reasons, such as: increased incidence of complications (10-40%)<sup>8,9</sup>, decreased healing rate compared to the endoscopic technique<sup>10</sup>.

Pentilla et al. support the effectiveness of endoscopic surgery in terms of ameliorating symptoms in chronic rhinosinusitis, compared to the Caldwell-Luc procedure<sup>9</sup>. Thus, endoscopic antros-

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tomy is recommended as the first surgical procedure used in the treatment of chronic maxillary rhinosinusitis. On the other hand, the hospitalization of the patient who underwent a Caldwell-Luc type of intervention is much longer, 5-7 days postoperatively, compared to one day postoperatively in the case of endoscopic intervention<sup>11</sup>.

## COMPLICATIONS OF CALDWELL-LUC SURGERY VERSUS FESS

In the literature, there are numerous studies highlighting the complications associated with the Caldwell-Luc procedure, which limits the use of this procedure as a technique for surgical treatment of rhinosinusal pathology. A number of complications can also occur in the case of endoscopic approach of the maxillary sinus. These can be both immediate (intraoperative and postoperative) and late.

If we refer to the intraoperative incidents and accidents in the two types of surgical interventions, bleeding is the main event described. Injury to the suborbital neuro-vascular bundle, by not identifying or not protecting it at the time of the incision in the labiogingival groove during the Caldwell-Luc approach, can cause intraoperative hemorrhage with postoperative suborbital neuralgias. In the case of classical surgery, the injury of the internal maxillary artery by breaking through the posterior wall of the sinus surgery can trigger significant bleeding. Specialist studies report an incidence of bleeding complications of about 3%<sup>10</sup>. Comparatively, functional endoscopic sinus surgery reports bleeding as part of minor (about 5%) and major (0.5 - 1 %) complications. Diffuse bleeding from the nasal mucosa during endoscopic sinus surgery is more common, compared to severe bleeding from the sphenopalatine or anterior ethmoidal artery injury (the incidence reported by some authors is between 0.1 - 0.8%)<sup>12,13</sup>. A study conducted in 1996 evaluated intraoperative bleeding in classically operated patients (Caldwell-Luc) compared to endoscopic sinus surgery, demonstrating a lower value in FESS (53.0±71.8ml, respectively 297.5±339.5ml;  $p < 0.01$ )<sup>8</sup>.

At the orbital level, in both types of interventions, trauma to the extrinsic ocular muscles may occur, with the subsequent onset of diplopia, intra-orbital hemorrhage, periorbital emphysema, eyeball trauma that can lead to blindness, tear duct injury. These accidents are rare in both types of interventions and can be avoided by intraoperative eyeball examination and by performing a correct and complete imaging evaluation preoperatively (CT and / or MRI)<sup>13-15</sup>.

In the Caldwell-Luc surgery, the damage of the dental root or of the superior alveolar nerve may occur.

The most common postoperative complications in the Caldwell-Luc approach are represented by facial swelling or numbness, facial and cheek discomfort, facial asymmetry, facial paresthesia in the suborbital region, hemorrhage, persistent suborbital neuralgias, oro-antral fistulas, gingival-labial fistulas, dental devitalization, dacryocystitis, or recurrence of rhinosinusitis.

Referring to immediate postoperative complications, the most commonly described are facial swelling reported in 62-90% of cases and the discomfort in the cheek area in up to 33% of cases<sup>10,15,16</sup>. Facial and cheek swellings can occur as a result of anaesthetic infiltration, of the tamponade of the sinus cavity or of the violent traction exerted by the retractors during the surgery. Regarding late complications, the most common are recurrent rhinosinusitis, facial paresthesias (by injuring the infraorbital nerve) and chronic dacryocystitis (stenosis of the lacrimal ducts by injury of the nasolacrimal duct)<sup>16</sup>. Very rare complications are periostitis of the orbital arch, phlegmon of the cheek, osteomyelitis of the upper jaw<sup>17</sup>.

In a study conducted on a group of 271 patients, Yaringston reported complications in 3% of cases, these being represented by hyperaesthesia of the suborbital region (by including the nerve or its emergences in the resulting scar tissue), postoperative ethmoiditis (by incomplete curettage of osteitis lesions or pathological mucosa), dental devitalization (atrophy and degeneration of dental nerve fibres) and, less often, blindness (by accidentally perforating the orbital floor). Late complications such as neuralgias or cheek paresthesias have been reported in a small number of patients<sup>16,18</sup>.

DeFreitas and Lucente highlight that other complications such as facial asymmetry (due to retraction of the cheek on the side of the operated maxillary sinus), oro-antral fistula (due to alveolar ridge osteitis, persistence of suppurations) or dental devitalization, persisted for 1 year postoperatively; in some cases, treatment is necessary, up to minor surgeries<sup>10</sup>. Increased frequency of facial tumefactions (61.9%), facial (46%) and dental or gingival (30%) pain and paresthesias was also reported by Low. In most cases, these complications received treatment, their persistence being reported in 15-20% of cases. In Low's study, rare complications such as epistaxis (0.4%), oro-antral fistula (0.4%) and epiphora (0.44%) represented a small percentage<sup>16</sup>.

Moreover, it has been demonstrated that by making a triangular incision at the gingival-labial level, patients no longer had late postoperative

complications such as paresthesias in the infraorbital region<sup>18</sup>.

Murray et al. reports postoperative complications in a study on a group of patients with malignant pathologies in the maxillary sinus and the pterygopalatine fossa including recurrent rhinosinusitis, infraorbital paresthesias, intranasal synechiae, persistent facial/cheek swelling and dental complications<sup>19</sup>.

Comparing the side effects of endoscopic sinus surgery with those of the Caldwell-Luc procedure, a randomized controlled study in Finland showed that they may be significantly more numerous and longer lasting in classical surgery<sup>20</sup>.

In the case of endoscopic rhinosinusoidal surgery, complications are reported between 2 and 17% and are primarily related to the surgeon's experience<sup>21</sup>. Postoperative complications are hemorrhages, crusts, synechiae, stenosis, epiphora, anosmia or CSF leaks, periorbital emphysema<sup>8,21,22</sup>.

### LONG-TERM EFFECTIVENESS OF THE CALDWELL-LUC PROCEDURE VERSUS ENDOSCOPIC SINUS SURGERY

In the literature, there are numerous studies comparing the long-term results of the two types of surgery. The evidence attests a superiority of endoscopic techniques in terms of efficacy and long-term evolution of local and general symptoms.

In a randomized controlled study, Jakob et al. compared the postoperative results of 40 patients diagnosed with chronic rhinosinusitis and treated with the Caldwell-Luc radical therapy with those of 40 patients treated with endoscopic sinus surgery. It should be noted that 77.5% of the patients also associated nasal polyposis<sup>23</sup>. 1 year postoperatively, 44% of the patients treated with radical surgery and 89% of those treated endoscopically showed significant improvement in symptoms, which demonstrates the superiority of the efficacy of the endoscopic technique in the treatment of chronic rhinosinusitis<sup>24</sup>.

In 1997, Pentilla et al. revealed in a group of 128 patients with chronic maxillary sinusitis a different evolution of postoperative symptoms in the two types of surgery<sup>25</sup>. The patients were followed up for a period of 5 to 9 years postoperatively. Therefore, 51% of patients treated by the Caldwell-Luc procedure, respectively 77% of those who received endoscopic sinus surgery showed a favourable evolution of symptoms one year postoperatively, while at 5-9 years, 82% of patients treated with radical surgery experienced the complete disappearance of symptoms, compared to those treated under en-

doscopy control who had a percentage of 76%. Also, a lower percentage of patients who underwent a Caldwell-Luc type of surgery required a revision surgery at 7-9 years postoperatively (18% compared to 20% of patients operated by endoscopic procedure). The authors conclude that the Caldwell-Luc surgical technique may be superior to the endoscopic technique, taking into consideration the long-term postoperative results<sup>25</sup>.

Regarding relapse, a high rate (40-80%) of local relapses of inverted papillomas treated by conservative surgical procedures was noted<sup>26</sup>.

Närkiö-Mäkelä compared the effectiveness of surgical treatment by external approach (Caldwell-Luc) with that by endoscopic approach, with significantly lower results of the need for revision surgery in the group of patients treated by external approach<sup>27</sup>.

### CURRENT INDICATIONS FOR THE CALDWELL-LUC PROCEDURE

As we can see, the above-mentioned complications can be significant and long-lasting. For this reason, the endoscopic surgical technique has priority and should be considered as the first method of surgical treatment.

On the other hand, the literature cites many situations in which the Caldwell-Luc procedure is used as a first-line surgical technique: recurrent chronic rhinosinusitis (despite endoscopic surgical treatment associated with maximal drug treatment); malignant tumors of the maxillary sinus extending to the lateral wall of the nasal fossa and the pterygomaxillary space<sup>28</sup>; the cases where an extensive approach to the pterygopalatine fossa is required – for ligation of the internal maxillary artery (in the case of a massive epistaxis)<sup>3</sup> or the approach of the vidian canal in vidian neurectomy. Some authors consider this procedure much more effective in the surgical treatment of facial trauma, in the fracture of the maxillary bone or the orbital floor<sup>29</sup>.

The choice of surgical technique must take into account several parameters, the most important being the diagnosed pathology, the local endoscopic and imaging aspects.

Clinically, Cannady et al.<sup>30</sup> recommended a classification of types of inverted papilloma according to its location and extent, information that can help assess the risk of recurrence and then choose the surgical technique:

- Type A – tumor limited to the nasal fossa, ethmoidal sinus or medial wall of the maxillary sinus.

- Type B – tumor with extension to the walls of the maxillary sinus (except for the medial one), sphenoid sinus or frontal sinus.
- Type C – tumor with extension outside the paranasal sinuses.

According to this staging, Cannady et al. demonstrated that the use of endoscopic surgery in the case of inverted papillomas can lead to a recurrence rate of 3% in type A, 19.8% for type B and 35.3% for type C. Therefore, inverted papillomas included in type B require treatment with radical surgery of the Caldwell-Luc type<sup>30</sup>.

Clinico-pathological aspects of the maxillary sinus were first described in the literature by the British surgeon Nathaniel Highmore in 1651, hence the name “Highmore’s antrum” associated with it<sup>31</sup>. In addition to research into surgical techniques discovered over time, huge leaps have been made in the study of rhinosinusal pathophysiology and histological structure. Discovery of the microscope in 1830 allows the detailed study of the structure of the rhinosinusal mucosa; thus, the pathologist Friedrich Henle was the first to describe the different types of mucosa, as well as the function of the ciliated epithelium in the upper respiratory tract<sup>32</sup>.

According to the experience of the ENT&HNS Department, “Sfanta Maria” Hospital, sinusoscopic aspects of the endosinusal mucosa may have predictive value in the treatment of chronic rhinosinusitis<sup>33</sup>. Therefore, 5 types of aspects of the maxillary sinus mucosa are recognized:

- Type 0 – normal mucosa, without secretions, with vascular pattern within normal limits;
- Type 1 – mucosa with accentuated vascular pattern, with serous secretions;
- Type 2 – thickened mucosa, with consistent secretions, accentuated vascular pattern, cystic dilatations of the submucosal glands and changes in the chorion;
- Type 3 – important changes in the mucosa, polyps, mucopurulent secretions;
- Type 4 – mucosal hyperplasia and metaplasia, polyps, fungosities and caseum – they denote structural and functional impairment of the endosinusal mucosa.

Based on these findings, we adapted the treatment method according to the appearance of the mucosa revealed by the sinusoscopy. Thus, in type 1, a drug treatment with a role in restoring mucociliary and ostial functions is indicated. Type 2 responds to drug treatment or endoscopic surgery for the repermeabilization of the ostium transition zones. Type 3 requires endoscopic surgical treatment to restore rhinosinusal ventilation, followed by adjuvant drug treatments. In type 4,

characterized by structural and functional compromise of the sinus mucosa, classic Caldwell-Luc surgery is indicated.

Because the evaluation of the endoscopic aspect can be subjective, in the ENT&HNS Department, “Sfanta Maria” Hospital, a correlation was made between the endoscopic score and a histopathological score, which objectively assesses the structural changes in the mucosa taking into account the following parameters: density and distribution of the inflammatory infiltrate, the presence of eosinophils, the presence of edema in the nasal mucosa, the presence of neoformation vessels (formed by neoangiogenesis) and the presence of fibrosis. After the histopathological examination of mucosal fragments collected during sinusoscopy, a score is awarded for each of the above-mentioned parameters, thus obtaining the histopathological score<sup>34</sup> (Table 1). The score obtained was used in the decision of therapeutic approach. A score of 0-3, grade 0 fibrosis, benefit from conservative treatment with endoscopic monitoring. In case of a 3-7 score, corresponding to a grade 1 fibrosis, endoscopic sinus surgery is indicated. Extensive rhinosinusal endoscopic surgery is the intervention of choice in cases with grade 2 fibrosis, histopathological score between 7 and 10. Grade 3 fibrosis, a score equal to 11, requires classic surgery – radical Caldwell-Luc procedure<sup>35</sup>.

Becker et al., in a comparative study performed in 2011, demonstrated that the sinus mucosa removed after the Caldwell-Luc procedure shows necrotic bone debris, compared to the mucosa removed by endoscopic antrostomy, which is relatively normal<sup>36,37</sup>. Moreover, postoperatively regenerated mucosa of the maxillary sinus after the Caldwell-Luc procedure has been shown to have a degree of ciliary dysfunction.

## PERSONAL EXPERIENCE

To exemplify the usefulness of the classical Caldwell-Luc type of intervention in the rhinosinusal pathology in the era of endoscopic sinus surgery, we present the case of a 19-year-old patient, who presented to the ENT&HNS Department, “Sfanta Maria” Hospital, in April 2019 accusing frontal headache, pressure sensation at the projection of the left maxillary sinus, bilateral antero-posterior mucopurulent rhinorrhea, chronic bilateral nasal obstruction. Symptoms had started 6 weeks before and had not yielded to the correctly recommended and followed drug treatment.

The ENT clinical examination and nasal endo-

**Table 1. Rhinosinusal histopathological score<sup>34</sup>**

Histopathological parameter	Score
1. Density and distribution of the inflammatory infiltrate	- 1 point – rare lymphatic elements, diffusely distributed
	- 2 points – frequent lymphatic elements, diffusely distributed
	- 3 points – frequent lymphatic elements, subepithelial +/- perivascular densifications or the presence of lymphocyte aggregates
2. Presence of eosinophils	- 0 points – absent
	- 1 point – rare
	- 2 points – frequent
3. Intramucosal oedema presence	- 0 points – without oedema
	- 1 point – minimum subepithelial oedema
	- 2 points – moderate oedema
4. The presence of neoformation vessels	- 3 points – severe oedema
	- 1 point – a minimum of neoformed vessels
	- 2 points – frequent neoformed vessels
5. Fibrosis – independent parameter	- 3 points – frequent neoformed vessels with thickened walls due to fibrosis (in the walls and perivascularly)
	- 0 points – absent fibrosis
	- 1 point – minimal fibrosis, periglandular +/- intramucosal
	- 2 points – moderate, with cystic glandular dilatations
	- 3 points – marked, with irreversible mucosal hyperplasia

scopic examination showed hypertrophied inferior nasal turbinates, heavily congested nasal mucosa, and quantitatively important mucopurulent secretions in the left middle nasal meatus (Figure 1).

The native cranio-facial CT examination revealed a heterodense tissue mass that completely occupied the left maxillary sinus, extending into the nasal fossa, the ethmoid cells and frontal sinus



**Figure 1.** Nasal endoscopic examination – mucopurulent secretions in the left middle nasal meatus.



**Figure 2.** Cranio-facial CT scan, coronal section – heterodense tissue mass completely occupying the left maxillary sinus, areas of osteolysis in the medial wall of the left maxillary sinus.

on the same side, areas of osteolysis in the medial wall of the left maxillary sinus; hypertrophy of the mucosa of the inferior nasal turbinates (Figure 2).

Following these examinations, the diagnosis of chronic suppurative left maxillo-ethmoid rhinosinusitis and chronic hypertrophic rhinitis was established.

The treatment was surgical, consisting in left antrostomy and left anterior ethmoidectomy, with drainage of purulent secretions from the left maxillary sinus and ethmoid cells on the same side. Antibiotic drug treatment has been associated (Amoxicillin 1,2gx2/day), steroidal anti-inflammatory, analgic, both intraoperatively and 7 days postoperatively.

In May 2019, the patient returns with the same symptoms.

The bacteriological examination of the nasal exudate revealed intranasal infection with *Pseudomonas aeruginosa*, and the complete blood count showed an inflammatory syndrome (mild leukocytosis and increased C-reactive protein).

Left maxillary sinus puncture was performed (for 3 consecutive days) associated with antibiotic (levofloxacin), corticosteroid antiinflammatory drugs, the evolution being slowly favourable.

In June 2019, the patient returned with bilateral purulent antero-posterior rhinorrhea and bilateral nasal obstruction. The ENT clinical examination together with the nasal endoscopic examination established the diagnosis of recurrent suppurative left maxillary chronic rhinosinusitis. The radical left maxillary sinus surgery was performed by the Caldwell-Luc procedure with a favourable postop-

erative evolution, without the relapse of symptoms.

This case supports the indication and efficiency of the Caldwell-Luc type radical surgery in the treatment of recurrent maxillary rhinosinusitis despite previously correctly established and performed endoscopic drug and / or surgical treatment.

## CONCLUSIONS

Although the endoscopic technique is the standard approach for the maxillary sinus pathology, certain areas of the sinus (anterior wall and floor) are more difficult to approach.

The Caldwell-Luc procedure must mandatorily remain in the surgical repertoire of an otorhinolaryngologist, for exceptional cases<sup>38</sup>.

**Conflict of interest:** The authors declare that there is no conflict of interest.

**Contribution of authors:** All authors have equally contributed to this work.

## REFERENCES

1. McBeth R. Caldwell, Luc, and their operation. *Laryngoscope*. 1971;81(10):1652–7. DOI: 10.1288/00005537-197110000-00011.
2. Theissing J, Rettinger G, Werner JA. *ENT – Head and neck surgery: essential procedures*. Thieme; 2010, p.126-39.
3. Gleeson M, Browning GG, Burton MJ, Clarke R, John H, Jones NC, et al. *Scott-Brown's otorhinolaryngology, head and neck surgery*, 7th edn. Hodder Arnold: London; 2008.
4. Draf W. *Endoscopy of the paranasal sinuses*. Springer-Verlag, Berlin; 1983.
5. Stammberger H. Endoscopic surgery for mycotic and chronic recurring sinusitis. *Ann Otol Rhinol Laryngol Suppl*. 1985;119:1–11. DOI: 10.1177/00034894850940s501.
6. Lund VJ. Inferior meatal antrostomy: fundamental considerations of design and function. *J Laryngol Otol Suppl*. 1988;15:1–18.
7. Kennedy DW. Functional endoscopic sinus surgery. *Technique. Arch Otolaryngol*. 1985;111(10):643–9. DOI: 10.1001/archotol.1985.00800120037003.
8. Ikeda K, Hirano K, Oshima T, Shimomura A, Suzuki H, Sunose H, et al. Comparison of complications between endoscopic sinus surgery and Caldwell-Luc operation. *Tohoku J Experim Med*. 1996;180(1):27–31. DOI: 10.1620/tjem.180.27.
9. Penttila MA, Rautiainen ME, Pukander JS, Karma PH. Endoscopic versus Caldwell-Luc approach in chronic maxillary sinusitis: comparison of symptoms at one-year follow-up. *Rhinology*. 1994;32(4):161–5.
10. DeFreitas J, Lucente FE. The Caldwell-Luc procedure: institutional review of 670 cases: 1975–1985. *Laryngoscope*. 1988;98(12):1297–1300. DOI: 10.1288/00005537-198812000-00004.
11. Ciuchi V. *Otorinolaringologie: curs postuniversitar*. Ed. Sylvi; 2000, p.63-73.
12. Amadei EM. Functional endoscopic sinus surgery (FESS): Is it always a safe procedure? *Otorhinolaryngol Head Neck Surg*. 2019;4:1-5. DOI: 10.15761/OHNS.1000199.

13. Shi GG, Li XG, Wang ZD. Severe complications in the treatment of chronic rhinosinusitis and nasal polyps with endoscopic sinus surgery. *Zhonghua Er Bi Yan Hou Tou Jing Ke Za Zhi*. 2007;42(1):19-22.
14. Buus DR, Tse DT, Farris BK. Ophthalmic complications of sinus surgery. *Ophthalmology*. 1990;97(5):612-9. DOI: 10.1016/S0161-6420(90)32535-6.
15. Stankiewicz JA. Complications of sinus surgery. In: Bailey BJ, Johnson JT, Newlands SD (eds). *Head and Neck Surgery – Otolaryngology*. Fourth Edition. Lippincott Williams & Wilkins, Philadelphia; 2006, p.477-91.
16. Low WK. Complications of the Caldwell-Luc operation and how to avoid them. *Aust N Z J Surg*. 1995;65(8):582-4. DOI: 10.1111/j.1445-2197.1995.tb01700.x.
17. Bhattacharyya N. Surgical treatment of chronic recurrent rhinosinusitis: a preliminary report. *Laryngoscope*. 2006;116(10):1805-8. DOI: 10.1097/01.mlg.0000231786.10969.3f.
18. Yarington CT. The Caldwell-Luc operation revisited. *Ann Otol Rhinol Laryngol*. 1984;93(4):380-5. DOI: 10.1177/000348948409300419.
19. Murray JP. Complications after treatment of chronic maxillary sinus disease with Caldwell-Luc procedure. *Laryngoscope*. 1983;93(3):282-4. DOI: 10.1288/00005537-198303000-00006.
20. Penttilä M, Rautiainen J, Punkander J. Functional endoscopic and radical Sinus surgery in relation to allergy and ASA intolerance. Abstract Book XIV Congress European Rhinologic Society, Rome. 1992;10:145-145.
21. Suzuki S, Yasunaga H, Matsui H, Fushimi K, Kondo K, Yamasoba T. Complication rates after functional endoscopic sinus surgery: analysis of 50,734 Japanese patients. *Laryngoscope*. 2015;125:1785-91.
22. Tan BK, Chandra RK. Postoperative prevention and treatment of complications after sinus surgery. *Otolaryngol Clin North Am*. 2010;43(4):769-79. DOI: 10.1016/j.otc.2010.04.004.
23. Jacob KJ, George S, Preethi S, Arunraj VS. A comparative study between endoscopic middle meatal antrostomy and Caldwell-Luc surgery in the treatment of chronic maxillary sinusitis. *Indian J Otolaryngol Head Neck Surg*. 2011;63(3):214-9.
24. Jonnalagadda S. In reference to the article a comparative study between endoscopic middle meatal antrostomy and Caldwell-Luc surgery in the treatment of chronic maxillary sinusitis: by k. Joe Jacob, Shibu George, S. Preethi, V.S. Arunraj. *Indian J Otolaryngol Head Neck Surg*. 2011;63:412.
25. Penttilä M, Rautiainen M, Pukander J, Kataja M. Functional vs. radical maxillary surgery. Failures after functional endoscopic sinus surgery. *Acta Otolaryngol Suppl*. 1997;529:173-6. DOI: 10.3109/00016489709124114.
26. Manea CM, Sarafoleanu C, Beuran M. Patologia infecto-inflamatorie rinosinusala. In: Popescu I, Ciuce C, Sarafoleanu C (ccord). *Tratat de chirurgie*. Vol. 1: Otorinolaringologie si chirurgie cervico-faciala. Editura Academiei Române, Bucuresti; 2012, p.15-82.
27. Narkio-Makela M, Qvarnberg Y. Endoscopic sinus surgery or Caldwell-Luc operation in the treatment of chronic and recurrent maxillary sinusitis. *Acta Otolaryngol Suppl*. 1997;529:177-80. DOI: 10.3109/00016489709124115.
28. Dong J, Lu M, Zhou H, Zhang W, Li Y, Dong W. Clinical analysis of primary nasal sinus osteoma. *Zhonghua Er Bi Yan Hou Tou Jing Wai Ke Za Zhi*. 2015;50(1):8-13.
29. Xu W, Zhao C, Jin L, Ge R. Clinical analysis of simple orbital blow-out fracture. *Lin Chuang Er Bi Yan Hou Tou Jing Wai Ke Za Zhi*. 2015;29(5):418-21.
30. Cannady SB, Batra PS, Sautter NB, Roh HJ, Citardi MJ. New staging system for sinonasal inverted papilloma in the endoscopic era. *Laryngoscope*. 2007;117(7):1283-7. DOI: 10.1097/MLG.0b013e31803330f1.
31. Fallopius G. *Abstract Anatomica*, Frankfurt 1600, 367. Quoted in Jeanty JM. *De l'empyeme latent de l'antra d'Higmore*, Bordeaux; 1891.
32. Stammberger H. History of rhinology: anatomy of the paranasal sinuses. *Rhinology*. 1989;27(3):197-210.
33. Sarafoleanu C. Metode de explorare paraclinică și funcțională utilizate în suferințele rino-sinusale. In: Sarafoleanu C (ed). *Rinologie*. Editura Medicală, Bucuresti; 2003, p.83-127.
34. Manea C, Iosif C, Sarafoleanu D. The value of histopathologic score as predictive factor in choosing the optimal surgical treatment for chronic rhinosinusitis. *Romanian Journal of Rhinology*. 2012;2(6):90-95.
35. Neagu A, Sarafoleanu C. The value of histopathologic score as predictive factor in choosing the optimal surgical treatment for chronic rhinosinusitis. *Romanian Journal of Rhinology*. 2015;5(18):115-9. DOI: 10.1515/rjr-2015-0014.
36. Becker SS, Roberts DM, Beddow PA, Russell PT, Duncavage JA. Comparison of maxillary sinus specimens removed during Caldwell-Luc procedures and traditional maxillary sinus antrostomies. *Ear Nose Throat J*. 2011;90(6):262-6.
37. Caldwell GW. Diseases of the accessory sinuses of the nose, and an improved method of treatment of suppuration of the maxillary antrum. *NY Med J*. 1893;58:526-8.
38. Lal D, Stankiewicz JA. Primary sinus surgery. In: Flint PW, Haughey BH, Robbins KT, Lund VJ, Thomas JR, Niparko JK, et al. (eds). *Cummings Otolaryngology–Head and Neck Surgery*. 5th Edition. Elsevier Saunders; 2010, p.739-58.