

IS THE CALDWELL-LUC OPERATION AND ITS MODIFICATIONS STILL USEFUL IN THE ERA OF ENDOSCOPIC SINUS SURGERY? FINDINGS FROM A RESOURCE-LIMITED SETTING

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ABSTRACT

INTRODUCTION: Despite the advent of endoscopic sinus surgery, an external approach to the maxillary sinus may be ideal in certain situations.

OBJECTIVES: This retrospective study reviews the relevance of, and the indications for, an external approach to the maxillary sinus via Caldwell-Luc operation or its modifications in a health resource-limited setting.

MATERIAL AND METHODS: Data from case notes and operating records of patients who had the Caldwell-Luc operation or its modifications between January 2004 and June 2018 at the Department of Maxillofacial Surgery of a University Teaching Hospital were retrospectively studied. Findings from descriptive statistics are represented in the form of tables and charts.

RESULTS: A total of 26 patients had the Caldwell-Luc operation within the period reviewed, and this consisted of 16 (61.5%) males and 10 (38.5%) females, giving a male to female ratio of 1.6 : 1. Patients' ages ranged from 10 to 45 years with a mean of 31.0 ± 8.8 years. The paediatric age group accounted for only 11.5% of cases. The main indication for performing the Caldwell-Luc operation was chronic maxillary sinusitis ($n = 14$; 53.8%), and occipitomental radiograph ($n = 24$; 92.3%) was the main imaging modality used for assessment. Compliance with follow-up review was poor.

CONCLUSIONS: Despite the advent of functional endoscopic sinus surgery, an external approach to the maxillary sinus using the Caldwell-Luc operation is still relevant, especially in health resource-limited settings.

KEY WORDS: maxillary sinus, sinusitis, health resources, external approach.

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INTRODUCTION

The paired maxillary sinus in an adult is a pyramidal shaped, air-filled cavity located within the maxilla, in the middle-third of the facial skeleton. It has medial,

superior (roof), lateral, anterior, posterior, and inferior (floor) walls with an apex that is directed towards the zygoma. Embryologically, the maxillary sinus develops in the third month of foetal development as invaginations of the nasal mucosa of the middle meatus into the max-

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illary bones [23]. It is rudimentary at birth and reaches adult size at puberty following the eruption of permanent teeth, with a mean volume of 12.5 ml [8]. It may occasionally be absent or hypoplastic [3]. The functions of the maxillary sinus are controversial, but it is said to include reduction in weight of the craniofacial bones, acts as a shock absorber to traumatic forces, thermal insulation, humidification, and warming of inspired air, and influences facial growth [25]. It receives blood supply mostly from the facial, maxillary, infraorbital, and greater palatine arteries, while venous drainage is to the facial vein and pterygoid plexus. Lymphatic drainage is to the submandibular nodes and its nerve supply is by the maxillary nerve via its superior alveolar, the greater palatine, and infraorbital nerves [15].

The maxillary sinus is related to important structures such as the orbit, roots of teeth and their supplying neurovascular bundle, the nasal cavity, the palate, maxillary/zygomatic bone, infraorbital nerve, lacrimal duct, etc. Therefore, pathologies affecting the maxillary antrum may involve these related structures. Similarly, pathologies affecting these associated structures may eventually involve the maxillary antrum. Pathologies involving the maxillary sinus may be infective (odontogenic and non-odontogenic), neoplastic, cystic, or foreign body lodgement such as teeth and bullets/pellets [2].

The maxillary antrum may be accessed surgically using several approaches for the purpose of treatment of antral pathologies or pathologies outside the maxillary antrum such as in the transantral approach to the sphenoid, infratemporal/pterygopalatine fossae, etc. Approaches to the maxillary antrum are generally classified as external, endoscopic, or a combination of both. External approaches include canine fossa puncture, transalveolar approach, Caldwell-Luc operation and its modifications, lateral antrotomy approach with or without bone flap, lateral rhinotomy approach, and intranasal approach [4, 10]. The external and endoscopic approaches have their respective indications and contraindications with varying advantages/disadvantages [2, 4].

OBJECTIVES

Despite advances in sinus surgery using the endoscopic approach, this technique is not widely available in health resource-limited settings due to limited facilities and expertise. Hence, the external approach has enabled patients to receive treatment. This retrospective study reviews the indications for an external approach to the maxillary sinus via the Caldwell-Luc operation or its modifications (CLOM) in a health resource-challenged setting.

MATERIAL AND METHODS

Data from case notes and operating records of patients who had Caldwell-Luc operation or its modifications

between January 2004 and June 2018 at the Department of Maxillofacial Surgery of a regional University Teaching Hospital were retrospectively studied. To use this data, the institutional Ethics Committee approval was not required. Patient's demographics, indication for procedure, preoperative imaging technique used, and nature of surgical procedure were retrieved and analysed using Microsoft Excel 2007 (Microsoft, Redmond, WA, USA) and Statistical Product Service Solutions (SPSS) version 16 (SPSS Inc., Chicago, IL, USA). Findings from descriptive statistics were represented in the form of tables and charts.

SURGICAL PROCEDURE FOR THE CALDWELL-LUC OPERATION

Under general anaesthesia and with the patient in a supine position, the mucogingival tissues from the central incisor to the second molar on the same side are infiltrated with diluted adrenaline solution to aid in haemorrhage control. An incision is then made using a number 15 blade from the lateral incisor to the second premolar above the root of the canine, and the mucoperiosteal tissues are reflected superiorly and inferiorly using a periosteal elevator to expose the anterior surface of the maxilla. With a round bur on a slow handpiece (or using a small chisel with a mallet), an opening is created into the maxillary antrum via the anterior surface of the maxilla superiolaterally to the canine (between the canine and the first premolar). The space is gradually widened using a bone rongeur until the antrum can be visualised or the required instruments admitted. In maxillary sinusitis, all diseased mucosa are removed and the cavity irrigated with sterile normal saline solution, packed with ribbon gauze impregnated with antibiotic, and exited via an inferior nasal antrostomy performed at a point posterior-inferior to the natural ostium to avoid damage to the nasolacrimal duct, which lies approximately 1 cm anterior-inferior to the natural ostium. For foreign body removal, a similar procedure is performed with/without removal of sinus mucosa or nasal antrostomy, depending on findings. Following completion of the procedure, the oral mucoperiosteal flap is sutured using 3/0 resorbable suture.

RESULTS

AGE AND SEX DISTRIBUTION

A total of 26 patients had the CLOM performed within the period reviewed, and this consisted of 16 (61.5%) males and 10 (38.5%) females, giving a male to female ratio of 1.6 : 1. Patients' ages ranged from 10 to 45 years with a mean of 31.0 ± 8.8 years. Adults constituted 88.5% of patients, while the paediatric age group accounted for 11.5% of cases.

IMAGING AND INDICATIONS FOR SURGERY

The main indication for CLOM was chronic maxillary sinusitis ($n = 14$; 53.8%), followed by maxillary tumour ($n = 6$; 23.1%) (Table 1). Only a single case of maxillary cyst was treated using modified Caldwell-Luc operation (Figure 1). In one of the two cases of foreign body impaction (Figure 2) treated, the procedure was undertaken to allow for possible haemorrhage control on extrication of the impaled foreign body. Plain radiography (Figure 3) in the form of occipitontal radiograph ($n = 24$; 92.3%) was the commonest imaging modality used for preoperative assessment.

ANAESTHESIA, SURGICAL PROCEDURE, AND FOLLOW-UP

Local anaesthetic technique was used in two (7.7%) cases of foreign body (tooth in antrum), while the remaining 24 (92.3%) cases were performed under general

anaesthesia. Unilateral CLOM ($n = 18$; 69.2%) was more frequently performed than bilateral procedure ($n = 6$; 27.1%). In two cases the site of the procedure was not documented. Intranasal antrostomy was additionally required in 16 (61.5%) patients, and these were mainly in cases with chronic maxillary sinusitis. One patient with histological diagnosis of benign fibrous histiocytoma following biopsy was referred to another centre on request. Although 10 (38.5%) patients presented for review, only two (7.7%) patients had follow-up review up to a period of 2-3 years, and within this period one patient who had foreign body (shrapnel) (Figure 4) removal developed chronic maxillary sinusitis requiring surgical intervention.

DISCUSSION

Following the description of an access to the maxillary antrum by George Caldwell and Henri Luc more

TABLE 1. Patients characteristics and treatment

Age	Sex	Indication	Procedure
16	M	Chronic maxillary sinusitis	Bilateral CLA with nasal antrostomy
38	M	Chronic maxillary sinusitis	Unilateral (RT) CLA with nasal antrostomy
28	M	Chronic maxillary sinusitis	Bilateral CLA with nasal antrostomy
35	F	Chronic maxillary sinusitis	Bilateral CLA with nasal antrostomy
41	M	Chronic maxillary sinusitis	Unilateral (LT) CLA with nasal antrostomy
20	M	Maxillary Tumour	Biopsy via Unilateral CLA
32	M	Chronic maxillary sinusitis	Bilateral CLA with nasal antrostomy
35	M	Chronic maxillary sinusitis	CLA with nasal antrostomy
30	F	Chronic maxillary sinusitis	Bilateral CLA with nasal antrostomy
16	F	Maxillary Tumour	Biopsy via Unilateral CLA
31	F	Chronic maxillary sinusitis	Bilateral CLA with nasal antrostomy
38	F	Chronic maxillary sinusitis	CLA with nasal antrostomy
20	M	Foreign body (Shrapnel)	Unilateral (RT) CLA
37	M	Maxillary Tumour	Biopsy via Unilateral (LT) CLA
35	F	Maxillary Tumour	Biopsy via Unilateral CLA
36	M	Maxillary Tumour	Biopsy via Unilateral CLA
10	F	Cystic maxillary lesion	Enucleation via RT CLA with nasal antrostomy
35	M	Foreign body (Knife edge)	Unilateral (RT) CLA
27	M	Displaced tooth into antrum	Unilateral (LT) CLA
35	F	Displaced tooth into antrum	Unilateral (RT) CLA
42	M	Foreign body (shrapnel)	Unilateral CLA with nasal antrostomy
27	M	Chronic maxillary sinusitis	Unilateral CLA with nasal antrostomy
25	M	Chronic maxillary sinusitis	Unilateral CLA with nasal antrostomy
45	F	Chronic maxillary sinusitis	Unilateral CLA with nasal antrostomy
34	M	Chronic maxillary sinusitis	Unilateral CLA with nasal antrostomy
37	F	Maxillary tumour	Biopsy via unilateral CLA

OMV – occipitontal view, LT – left, CLA – Caldwell-Luc antrostomy, CT – computed tomography, RT – right



FIGURE 1. A) Facial swelling from a maxillary cyst. B) Intraoperative exposure via Caldwell-Luc approach. C) Removal of cystic lining. D) Patient review at 2 years

than 100 years ago [2], this procedure is still valuable despite the introduction of functional endoscopic sinus surgery. It is performed by oral/maxillofacial surgeons, otorhinolaryngologists, and other head/neck surgeons for various indications. The Caldwell-Luc operation in its classical form involves making an opening in the anterior wall of the maxilla, superolaterally to the canine bulge with stripping from the inner antral wall of any diseased mucosa, combined with an opening in the lateral wall of the nose inferior to the inferior turbinates. Therefore, it is essentially an intraoral antrostomy with an inferior meatal antrostomy. However, in certain cases such as in the immediate removal of a dislodged tooth in the antrum, a modified Caldwell-Luc operation is used and may involve only an intraoral antrostomy without

an inferior meatal antrostomy or stripping of antral mucosa [11].

In this retrospective analysis, more males than females had CLOM, similarly to previous findings [2, 7]. However, females accounted for the major population of patients who had the Caldwell-Luc operation performed in the report by Defrietas and Lucente [6]. The male to female ratio appears to be influenced by the surgical indication for CLOM because some disease conditions usually have gender predilection. However, most antral pathologies generally appear to be more common in males [7].

The patients' ages showed an adult predominance over the paediatric population, and this is consistent with previous findings [2, 6]. Although endonasal sinus



FIGURE 2. A) Impaled foreign body following assault. B) Computed tomography scanogram showing impaled foreign body extending to the right antrum. C) Removed foreign body following Caldwell-Luc approach for haemorrhage control

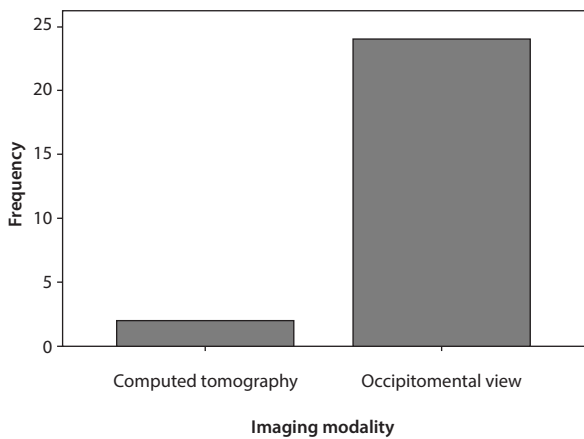


FIGURE 3. Imaging modalities used in assessing patients



FIGURE 4. Impaled foreign body in the maxillary antrum secondary to blast injury from an improvised explosive device

surgery has been advocated as the preferred option in the surgical treatment of chronic maxillary sinusitis in children, the Caldwell-Luc operation has been shown also to be beneficial and associated with less injury to the erupting dentition [20].

The main indication for CLOM was maxillary sinusitis followed by maxillary neoplastic lesions. This dominance of maxillary sinusitis over the other surgical indications is consistent with previous studies [2, 6]. Over the years, the main indications for CLOM have differed among studies and include treatment of orbital floor fractures, treatment of upper jaw cystic lesions (such as dentigerous cyst) with antral extensions, foreign body removal, maxillary antral tumour biopsy, sinus augmentation, control of severe haemorrhage following facial trauma, endoscopic treatment of antral tumours, and as an access to the sphenoid and pterygomaxillary fossa [6, 9, 11]. In the present study, modified Caldwell-Luc operation was carried out in one of the patients as a ready access for haemorrhage control in the event of withdrawal of an impaled assault weapon (knife), which extended into the maxillary antrum via its posteromedial wall on computed tomography scan. On withdrawal of the impaled object, bleeding was controlled using an antral pack (ribbon gauze impregnated with antibiotic paste) and exited through an inferior meatal antrostomy.

Sinusitis, the inflammation of one or more of the paranasal sinuses, may be classified as acute (infection of the paranasal sinuses, with accompanying symptoms present for more than 10 days and less than four weeks), subacute (symptoms lasting four to eight weeks), chronic (symptoms lasting longer than eight weeks), and recurrent (presence of three or more acute episodes a year). Both acute and chronic sinusitis may require surgical treatment [16]. No patient in this study had CLOM for acute maxillary sinusitis. Maxillary sinusitis may be of odontogenic or non-odontogenic causes, with the latter accounting for 30-40% of cases in a study [21]. Odontogenic maxillary sinusitis differs in its pathophysiology, diagnosis, and management from sinusitis of other causes [26] and may arise from upper lateral or apical periodontal infections, infected odontogenic cysts, oro-antral communications/fistula, dental/zygomatic implant placement, dislodged tooth or tooth fragment into the antrum, and maxillary fractures. The aetiological basis for maxillary sinusitis in the patients studied was not clearly highlighted, and therefore the role of odontogenic infection could not be established.

Various accesses to the maxillary antrum exist, and these include endoscopic, external, and combined approaches. External approaches include canine fossa puncture (which may be used in maxillary sinus lavage or combined with endoscopic approach), transalveolar approach (useful for removal of a dislodged tooth, and for sinus augmentation), Caldwell-Luc approach and its modifications, lateral antrotomy approach with or without bone flap (useful in zygoma implant placement),

lateral rhinotomy approach (useful in medial maxillectomy), and intranasal approach [4, 10, 18]. The approach used will be influenced by the indication, site of the lesion, surgeon's skills, availability of equipment, etc. The endoscopic approach to the maxillary sinus commonly involves the use of rigid endoscopes (diameter 2.7 mm for paediatric and 4 mm for adults) with varying angles of vision ranging from 0 to 120 degrees [22]. Combined external and endoscopic approaches have also been used [29]. Studies comparing the Caldwell-Luc operation and endoscopic approach have shown better cure rates of sinusitis as well as markedly reduced post-operative sequelae, blood loss, operating time, and hospital stay in patients treated using functional endoscopic sinus surgery (FESS), although the Caldwell-Luc operation was associated with improved symptoms [12]. However, a higher reoperation rate has been observed in patients treated with FESS compared to those treated with Caldwell-Luc operation [19]. Despite the superior results reported with FESS, CLOM still has its indications, which include failed endoscopic middle meatal antrostomy and irreversible mucosal changes [5]. In addition, CLOM may be indicated where facilities or skills for FESS are not available, such as in resource-limited settings.

Imaging for maxillary sinus pathologies may involve the use of ultrasonography, plain radiography, or more advanced imaging techniques such as computed tomography. Ultrasonography has the advantage of being devoid of ionising radiation, it is cheap, easy to use, and can be performed by the bedside. When compared to CT in the diagnosis of paranasal diseases, ultrasonography has a sensitivity of 66.7% and a specificity of 94.9%, while its sensitivity and specificity in comparison to magnetic resonance imaging (MRI) are 64% and 95%, respectively [14, 24]. Commonly used plain radiographs include panoramic and Waters' view. For inflammatory disease of the maxillary sinus, plain radiographs have a sensitivity of 80% [1]. Although panoramic radiographs provide information on the maxillary sinus, there is a moderate risk of false diagnosis when used in isolation. Therefore, computed tomography is recommended and considered the standard for a more precise evaluation of the maxillary sinus [17]. MRI is useful in assessing extension of paranasal sinus disease into adjacent soft tissues. Generally, three-dimensional imaging techniques compared to two-dimensional techniques have been shown to be significantly more reliable in detecting pathologies within the maxillary sinus [28]. Most of the patients in this study were evaluated using plain radiography (Water's view), only two patients had a CT scan done. The common use of plain radiography is primarily related to the inability of patients in this setting to afford the cost of a CT scan because most of them pay out of pocket for most procedures due to a poorly implemented national health insurance scheme.

CLOM may be performed under local or general anaesthesia [13], the choice of anaesthesia being dependent on patient age and tolerance, extent of proce-

ture, surgeon's preference, and presence of co-morbid conditions, among other factors. Most of the patients in the present study had their procedure done under general anaesthesia, and this may be due to the extent of the procedures. General anaesthesia permits adequate retraction of tissues, which may not be tolerated under local anaesthesia, and permits additional procedures to be undertaken intraoperatively when the need arises.

The follow-up review of patients treated was generally poor, and therefore objective assessment of outcome was difficult. Poor response to follow-up review has consistently remained a challenge in this environment, and factors such as poverty, feeling of wellbeing, and cultural influences play a significant role. However, two patients were reviewed over 2-3 years, and of these, one patient who had foreign body (shrapnel) removal developed chronic sinusitis requiring surgical intervention. CLOM has commonly been associated with facial oedema, pain, and/or numbness of the face, teeth, and gums. Rare complications reported include epistaxis, oroantral fistula, epiphora, and tooth discolouration.²⁷

CONCLUSIONS

Despite the advent of functional endoscopic sinus surgery, an external approach to the maxillary sinus using the Caldwell-Luc operation or its modifications is still relevant, especially in health resource-limited settings. However, poor response to follow-up in this environment does not allow for an objective assessment of outcomes relative to other studies.

CONFLICT OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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