Evaluation of Caldwell-Luc Operation in the Endoscopic Era: Experience From Past 7 Years

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Purpose: We wished to draw attention to the changes in the surgical method and indications for the Caldwell-Luc (CL) operation in the endoscopic era.

Patients and Methods: The patients who had undergone the CL operation in the previous 7 years were included in the present study. All operations had been performed by otolaryngologists. The CL operation was performed as 2 types of antrostomy: radical canine fossa antrostomy (RA) and mini-canine fossa antrostomy (MA). The surgical methods were grouped as follows: RA alone, endoscopic sinus surgery (ESS) plus RA, and ESS plus MA.

Results: RA alone, ESS plus RA, and ESS plus MA had been performed in 24 (25.5%), 6 (6.3%), and 64 (68.1%) patients, respectively. RA had been used for a total of 30 patients and had been combined with ESS for only 6 patients. The indications were categorized as mucosal sinus disease and odontogenic lesions. A statistically significant difference was found between the rates of the preferred antrostomy type for the treatment of sinus mucosal disease and odontogenic lesions ($P < .001$).

Conclusions: In otorhinolaryngology practice, the CL procedure has mostly been required to provide easy access to the maxillary sinus when ESS alone would be inadequate. However, the formal CL operation, including RA, could still be considered a main surgical technique in oral and maxillofacial surgery practice.
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The Caldwell-Luc (CL) operation has been used as a surgical approach for maxillary sinus diseases for more than 100 years. It was first described by George Caldwell in 1893 and Henri Luc in 1897.[1,2] The CL operation was the main surgical method for maxillary sinus disease until the development of functional endoscopic sinus surgery (ESS).[3] Although the CL operation has lost its validity for treating maxillary sinusitis in recent years, it is still effective in the treatment of odontogenic lesions, neoplasms, and trauma and in providing ready access to the pterygopalatine and infratemporal fossa.[4] The classic CL operation consists of 2 stages. First, the maxillary sinus is punctured through the canine fossa. Next, the diseased sinus membrane is removed. Another aperture is then created on the inferior nasal meatus to allow for intranasal counter drainage through the inferior meatus. Nevertheless, no evidence has been reported in recent years regarding the benefits of inferior meatal antrostomy (IMA). Moreover, complications, such as early loss of the opening and the risk of injury to the nasolacrimal duct, have been reported in several

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studies.[5,6] As a result of these studies showing that IMA is unnecessary and ineffective, IMA has not been performed recently. Huang and Chen[7] described a modified CL operation that does not include the IMA. Although the modified CL has been the most widely recognized method, some changes have occurred in the application method and the indications for this technique in the endoscopic era. Rather than being used alone in the treatment of maxillary sinus disease, the CL procedure has continued to be used as an assisting technique with ESS.[3,8] The aim of the present study was to analyze the data from patients who had undergone a CL operation in the past 7 years in our clinic to draw attention to the changes in the surgical method and indications for the CL operation in the endoscopic era.

Patients and Methods

We performed a retrospective study of patients who had undergone the CL operation from 2011 to 2018 at the Department of Otorhinolaryngology, Faculty of Medicine, Gazi University. All operations had been performed by otolaryngologists. Because the usage of endoscopic methods has increased in recent years, those patients who had undergone surgery in the past 7 years were included in the present study. The local ethical committee approved the present study. A total of 94 patients were included in the present study, all of whom had undergone canine fossa antrostomy. IMA had not been performed in any patient as a component of the CL procedure. Canine fossa antrostomy was performed using 2 different methods: radical antrostomy (RA) and mini-antrostomy (MA). The CL procedure was performed using 3 different combinations: RA alone, ESS plus RA, and ESS plus MA.

All the procedures that involved RA had been performed with the patient under general anesthesia. First, 1% lidocaine with 1:100,000 epinephrine was injected over the canine fossa. A 5-cm transverse mucosal incision was made in the space between the first and second molars. The incision was made 1 cm above the gingivobuccal sulcus to leave a free edge of mucosa that could be sutured at the end of the procedure. The periosteum was elevated off the maxilla superiorly to the level of the infraorbital nerve, laterally to the maxillary buttress, and medially to the nasal bone and pyriform aperture. Entry into the maxillary sinus was first performed using the maxillary sinus trocar and sheath. The trocar was placed at the junction of the midpupillary line and nasal ala. The trocar was then removed, and a Kerrison rongeur was used to remove bone from the anterior maxilla. A bone window opening at least 3 cm wide was created in the antrostomy types classified as RA (Fig 1). Care was taken to avoid removing bone from the maxillary buttress, dental roots in the maxilla, and around the infraorbital nerve.

The MA method was also used to assist with ESS. The technique was considered mini-antrostomy because a bone opening smaller than 1 cm in width was used, which allowed an endoscopic or surgical instrument to readily access the maxillary sinus (Fig 2). The trocar was inserted with a gentle twisting motion. The instrument placed through the MA was visualized in the maxillary sinus using a 30° or 70° endoscope via the middle meatal antrostomy.[8]

The indications for surgery were grouped as sinus mucosal disease and odontogenic lesions. In addition, the short- and long-term complications of the antrostomy techniques were compared.

Statistical Analysis

Statistical analysis was conducted using the SPSS, version 20.0, statistical software package (IBM Corp, Armonk, NY). Descriptive data are presented as numbers and percentages. The categorical variables were compared using the χ^2 test. $P < .05$ was considered to indicate statistical significance.

Results

The CL operation was performed using 3 different combinations: RA alone, ESS plus RA, and ESS plus MA. A total of 94 patients, with a mean age of 37 years (range, 14 to 70 years), were included in the present study. Of the 94 patients, 24 (25.5%) had undergone RA alone, 70 (74.5%) had undergone the CL procedure combined with ESS. Of these 70 patients, 6 had undergone RA plus ESS and 64 had undergone MA plus ESS (Table 1).

RA ALONE

RA alone was performed in 24 of the 94 patients (25.5%). All those patients with an odontogenic cyst, oroantral fistula, or benign odontogenic tumors of the maxilla had undergone RA alone. One patient with chronic sinusitis (osteomyelitis) and one with a fungus ball had undergone RA alone. RA alone was also used for 3 patients (3 of 5; 60%) with a foreign body (third molar tooth) in the sinus. In the patients with a maxillary sinus mass, the rate of RA alone for biopsy and excision was 8.3% (1 of 12) and 50% (4 of 8), respectively. RA alone was performed in 1 patient with an inverted papilloma (IVP) but not for any patient with an antrochoanal polyp (AP; Table 1).

ESS PLUS RA

For 6 patients, RA was combined with ESS (6.3%), which was the least used method in the present study.



FIGURE 1. Radical canine fossa antrostomy for the treatment of a benign odontogenic tumor.

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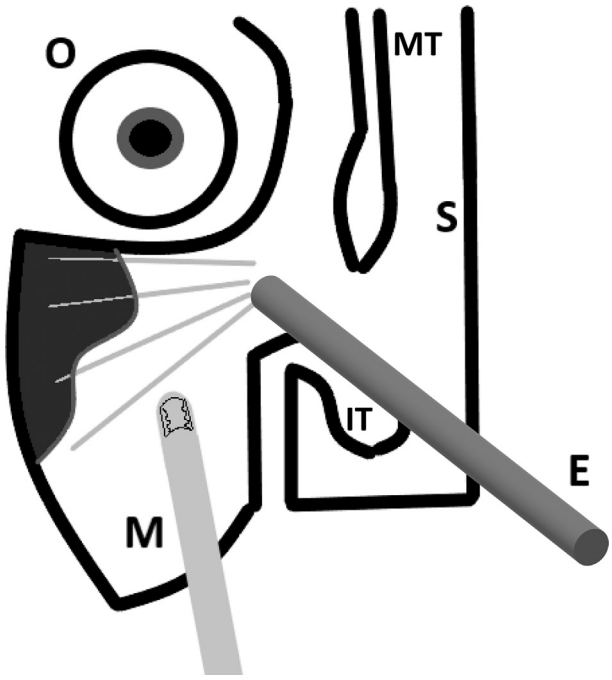


FIGURE 2. Diagram showing removal of antral pathology with an endoscope, viewed through the middle meatal antrostomy. E, endoscope; IT, inferior turbinate; M, microdebrider; MT, middle turbinate; O, right orbit; S, septum.

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ESS plus RA was used for 5 patients with recurrent IVP and 1 patient with a sinus mass (Table 1).

ESS PLUS MA

The most frequently used technique was the combination of ESS and MA (64 of 94; 68.1%) in our practice. All AP, retention cyst, nasal polyposis, and mucocele cases requiring a canine fossa approach were treated using the ESS plus MA technique. Of the 19 patients with IVP, 13 (68.4%) were treated with ESS plus MA. ESS plus MA was also performed for 1 patient with a fungal ball and 1 patient with chronic sinusitis. For the patients with a maxillary sinus mass, the rate of ESS plus MA for biopsy and excision was 91.6% (11 of 12) and 37.5% (3 of 8), respectively. This technique was used to remove foreign bodies (amalgam) in 2 patients (40%; Table 1).

DISEASE GROUPS AND ANTROSTOMY TYPES

The indications were grouped as sinus mucosal disease and odontogenic lesions. IVP, AP, sinus masses, retention cysts, nasal polyposis, mucocele, chronic sinusitis, and fungus balls were categorized as mucosal disease. Odontogenic cysts, a foreign body in the maxillary sinus, oroantral fistulas, benign odontogenic tumors of the maxilla, and bleeding control after odontogenic surgery were classified as odontogenic lesions. A statistically significant difference was found between the disease groups and antrostomy types used (Table 2; $P \leq .001$).

COMPLICATIONS OF SURGICAL TECHNIQUES

The most common short-term complications after the CL procedure were facial swelling, cheek discomfort (numbness or paresthesia), and teeth and/or gum discomfort (pain or numbness). The MA group showed significantly lower short-term complication rates compared with the RA group ($P < .001$). Severe or moderate facial swelling was observed in 19 of 30 patients in the RA group (63.3%) compared with only 2 of 64 patients in the MA group (3.12%; $P < .001$). Of the 30 patients in the RA group, 12 had experienced cheek discomfort. In contrast, the number of patients with cheek discomfort in the MA group was only 4 (6.25%; $P \leq .001$). Teeth and/or -gingival discomfort was detected in 11 and 3 patients in the RA and MA groups, respectively ($P \leq .001$). No major complications, such as tooth loss, severe hematoma, or hemorrhage, were encountered in the present study. In the RA group, wound dehiscence and periorbital edema were detected in 1 and 2 patients, respectively. Epistaxis was observed in 3 patients in the MA group.

Long-term complications developed in only 2 patients. Both patients were in the RA group. Of the 2 patients, 1 developed an oroantral fistula, and 1 experienced an infraorbital nerve injury. None of the patients in the MA group experienced long-term complications (Table 3).

Table 1. INDICATIONS AND APPLICATIONS OF CALDWELL-LUC OPERATION IN 94 PATIENTS

Pathologic Entity	RA	RA + ESS	MA + ESS	Total
Inverted papilloma	1 (5.2)	5 (26.3)	13 (68.4)	19 (20.2)
Antrochoanal polyp	0 (0)	0 (0)	12 (100)	12 (12.7)
Sinus mass biopsy	1 (8.3)	0 (0)	11 (91.6)	12 (12.7)
Retention cyst	0 (0)	0 (0)	10 (100)	10 (10.6)
Sinus mass excision	4 (50)	1 (12.5)	3 (37.5)	8 (8.5)
Nasal polyposis	0 (0)	0 (0)	7 (100)	7 (7.4)
Mucocele	0 (0)	0 (0)	3 (100)	3 (3.1)
Chronic sinusitis (osteomyelitis)	1 (50)	0 (0)	1 (50)	2 (2.1)
Fungus ball	1 (50)	0 (0)	1 (50)	2 (2.1)
Odontogenic cyst	6 (100)	0 (0)	0 (0)	6 (6.3)
Foreign body (amalgam, third molar teeth)	3 (60)	0 (0)	2 (40)	5 (5.3)
Repair of oroantral fistula	4 (100)	0 (0)	0 (0)	4 (4.2)
Benign odontogenic tumors of maxilla	3 (100)	0 (0)	0 (0)	3 (3.1)
Bleeding after odontogenic surgery	0 (0)	0 (0)	1 (100)	1 (1.06)
Total	24 (25.5)	6 (6.3)	64 (68.1)	94 (100)

Data presented as n (%).

Abbreviations: ESS, endoscopic sinus surgery; MA, mini-antrostomy; RA, radical antrostomy.

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Discussion

George Caldwell and Henri Luc described the classic CL operation more than 100 years ago.[1,2] The IMA and canine fossa approach were implemented together in the standard CL procedure for several years because IMA had been considered beneficial for sinus drainage.[9] In the experimental series by Hilding,[10] it was observed that sinus windows that had been formed too close to the natural ostium would not be well tolerated and that sinus windows created far from the natural ostium were more effective. Therefore, IMA became a widely accepted technique in the standard CL procedure. However, in subsequent studies, it was shown that the primary mucociliary flow pattern was maintained toward the natural ostium of the maxillary sinus despite the application of IMA.[6,11] An experimental study by Kennedy and Shaalan[6] confirmed that mucociliary clearance would continue toward the natural ostium after an inferior antrostomy. Subsequently, it was found that the IMA did not provide a physiologic drainage pathway. Moreover, the rate of stenosis (or complete closure) of the IMA was too great for it to be effective. The use of an IMA can also cause problems in wound healing and injuries to the nasolacrimal canal and sphenopalatine artery.[5,9,11] Because of these findings, it was accepted that the use of the IMA did not provide an advantage in the treatment of maxillary sinus disease. Thus, this procedure has substantially lost its validity. Huang and Chen[7] described the modified CL operation without IMA in a retrospective study of 50 patients. They reported that the modified CL operation could result in less complex postoperative care and fewer complications and concluded that it was not necessary to create an IMA in the classic CL operation for odontogenic sinus disease. Thus, the first modification of CL surgery began years ago with the exclusion of the IMA. Accordingly, IMA had not been performed in any patient as a component of the CL operation in our clinical practice during the past 7 years.

Table 2. FREQUENCY OF DIFFERENT ANTROSTOMY APPLICATIONS FOR CALDWELL-LUC OPERATION STRATIFIED BY DISEASE GROUP*

Antrostomy Type	Maxillary Sinus Mucosal Disease (n)	Odontogenic Lesions (n)	Total (n)
RA	14	16	30
MA	61	3	64
Total	75	19	94

Abbreviations: MA, mini-antrostomy; RA, radical antrostomy.

* $P < .001$.

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Until the development of antibiotics and ESS, the classic CL operation had been the main surgical method to treat inflammatory maxillary sinus disease. As the medical and endoscopic management of sinus lesions has improved, the indications for the CL procedure have changed substantially in recent years. The endoscopic era has largely eliminated the use of the CL operation. ESS has largely replaced the formal CL operation, especially for the treatment of maxillary sinusitis.[3,7,12] In a study by Becker et al,[13] maxillary

Table 3. COMPLICATIONS OF RADICAL ANTROSTOMY AND MINI-ANTROSTOMY

Complication	RA (n = 30)	MA (n = 64)	*P* Value
Short term			
Facial swelling (moderate or heavy)	19 (63.3)	2 (3.1)	<.001
Cheek discomfort (numbness or paresthesia)	12 (40.0)	4 (6.2)	<.001
Teeth and/or gum discomfort (pain or numbness)	11 (36.6)	3 (4.6)	<.001
Wound dehiscence	1 (3.3)	0 (0)	NA
Epistaxis	0 (0)	3 (4.6)	NA
Periorbital edema	2 (6.6)	0 (0)	
Long term			NA
Oroantral fistula	1 (3.3)	0 (0)	
Infraorbital nerve injury	1 (3.3)	0 (0)	

Data presented as n (%).

Abbreviations: MA, mini-antrostomy; NA, not applicable; RA, radical antrostomy.

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sinus specimens were removed using the CL procedure and traditional maxillary sinus antrostomy, and the 2 procedures were compared. They concluded that the CL procedure should be a treatment of last resort for patients in whom endoscopic interventions for maxillary sinus disease had failed.[13] Nevertheless, certain rare indications still exist for which the CL approach should not be entirely abandoned. The CL approach is still effective and useful for various indications, including sinusitis with irreversible mucosal damage, neoplastic lesions, oroantral fistulas, odontogenic lesions, evaluation and stabilization of orbital floor fractures after facial trauma, and removal of the orbital floor in decompression.[3,14]

The formal CL operation has been used as a fruitful and functional method in maxillofacial surgery for many years.[7,14] In the present study, we found an odontogenic problem associated with maxillary sinus problems in most of the patients who had undergone RA alone. RA was performed in combination with ESS for 6 patients, 5 of whom had recurrent IVP. However, endoscopic methods such as endoscopic medial maxillectomy, the endoscopic prelacrimal recess approach, and endoscopic CL (with MA) could also be used as an assisting technique to ESS for IVP.[15,16] These endoscopic approaches have tended to replace RA in IVP surgery.

In some cases, it might not be possible to reach the entire maxillary sinus using only ESS. Another application of the CL approach is to assist ESS in cases that cannot be managed endoscopically. In such cases, MA could be used to manipulate the endoscope and surgical instruments within the sinus (Fig 2).[8] When these 2 methods are used together, the surgical instruments and endoscopes could be used to help each other in different combinations owing to the presence of 2 openings in 2 different planes. In recent years, the application of the CL method has evolved in this direction compared with RA. In the present study, most of the patients requiring the CL operation had been treated with endoscopic CL approaches with an MA in canine fossa.

Novel studies have demonstrated that the formal CL operation is still efficient for the treatment of AP.[17] In the present study, no RA was performed for those with AP. Nevertheless, MA was added to the procedure in some patients in whom the AP could not be removed completely via ESS alone. We found that the use of RA has shown a tendency to lose its validity for the treatment of AP in the endoscopic era.

Barzilai et al[3] reviewed the indications of the CL operation in the endoscopic era. Of the 62 patients in their study, 20 had chronic sinusitis (32%), 16 had IVP (26%), 9 had nasal polyposis (15%), 4 had dentigerous cyst (6%), and 4 had a fungus ball (6%).[3] The remaining 9 patients had undergone surgery for other indications. Although the present study and the study by Barzilai et al[3] reviewed similar topics, significant differences were present between the 2 studies, especially concerning the rate of chronic sinusitis (2.1% in our study vs 32% in their study[3]) and nasal polyp (7.4% in our study vs 15% in their study[3]). Although both studies investigated the indications for the CL operation in the endoscopic era, a difference of ~10 years exists in the study periods for the 2 studies. Considering the technological developments, observations regarding the changes in the surgical techniques and indications for the CL operation could continue in the future. We found a statistically significant difference in our study between the sinus mucosal disease and odontogenic lesion groups in the rates of the antrostomy types performed. ESS procedures have largely eliminated the use of the RA in otorhinolaryngology. This change could have resulted as a part of the evolution of the CL operation during the endoscopic era.

ASPECTS AFFECTING CHOICE OF SURGERY TYPE

The location and size of the lesions are the most influential parameters that determine the antrostomy type. RA has been preferred for surgery of the large-volume odontogenic lesions that require a wide window. Because foreign bodies such as third molars require increased access to the maxillary sinus, RA was performed for such cases in our practice.

Moreover, because odontogenic masses and lesions (oroantral fistulas and cysts) are frequently associated with the anterior and inferior walls of the maxillary sinus, RA was required for such cases. It was also preferred for the management of nonodontogenic masses located below the Ohngren line. In patients with recurrent IVP requiring the CL approach for treatment, RA was used because of the possibility for malignant transformation of the disease.

When adequate access could not be achieved with ESS, MA was our primary choice for patients requiring the CL approach in otolaryngology practice. The MA was sufficient and effective for access to most of the walls of the maxillary sinus, except for anterior and inferior walls. Thus, the MA was particularly feasible in the treatment of almost all the mucosal lesions associated with the nasal cavity through the middle meatal antrostomy.

When comparing the antrostomy types in terms of the complications, both short- and long-term complications were detected more frequently in the patients who had undergone RA. Only epistaxis was encountered more frequently compared with the other complications in the patients who had undergone MA. This resulted from the combined use of MA and ESS. Although MA was always used with ESS in our study (ie, MA was not performed alone), RA and ESS were applied in combination for only 20% of the patients requiring RA. When evaluating the cost-effectiveness of the antrostomy types, the use of RA cost less than did MA, although it might seem a more comprehensive process. This was because MA was used to assist with ESS, which is a high-cost modality.

In conclusion, in the endoscopic era, rather than being the main treatment modality in otorhinolaryngology practice, the CL procedure is often used to provide easy access to the maxillary sinus when ESS alone will be insufficient. The formal CL operation, including RA, is still an operative and working method in oral and maxillofacial surgery practice despite losing its effectiveness in otorhinolaryngology. The endoscopic CL technique with MA is efficacious for maxillary sinus mucosal disease and results in fewer complications. In the near future, with the introduction of more flexible tools in line with the development of technology, the formal CL operation might become a historical technique in otorhinolaryngology practice.

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