

THOMAS VON ARX<sup>1</sup>  
JOYA VON ARX<sup>2</sup>  
MICHAEL M. BORNSTEIN<sup>3,4</sup>

<sup>1</sup> Department of Oral Surgery and Stomatology, School of Dental Medicine, University of Bern, Bern, Switzerland

<sup>2</sup> Private Practice Dr. R. Wymann, Bern, Switzerland

<sup>3</sup> Oral and Maxillofacial Radiology, Applied Oral Sciences and Community Dental Care, Faculty of Dentistry, The University of Hong Kong, Hong Kong SAR, China

<sup>4</sup> Department of Oral Health & Medicine, University Center for Dental Medicine Basel UZB, University of Basel, Basel, Switzerland

#### CORRESPONDENCE

Prof. Dr. Thomas von Arx  
Klinik für Oralchirurgie und Stomatologie  
Zahnmedizinische Kliniken der Universität Bern  
Freiburgstrasse 7  
CH-3010 Bern  
Tel. +41 31 632 25 66  
E-mail:  
thomas.vonarx@zmk.unibe.ch

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# Outcome of first-time surgical closures of oroantral communications due to tooth extractions

A retrospective analysis of 162 cases

#### KEYWORDS

Tooth extraction  
Oroantral communication  
Oroantral closure  
Retrospective analysis

#### SUMMARY

The objective of this study was to analyze the outcome of first-time surgical closures of oroantral communications (OAC) after tooth extractions. Using a billing software, all patients treated in a surgery department were filtered for interventions of the maxillary sinus indicative of OAC therapy. Out of 221 initially eligible cases, the charts of 162 cases fulfilling the inclusion criteria were retrospectively evaluated for the outcome in terms of symptom-free OAC closure as well as possibly influencing patient and treatment factors. The analyzed cohort included 98 males (60.5%) and 64 females (39.5%) with a mean age of 48.6 years (range 17 to 86 years). The maxillary 1st molar (38.3%) was the most common site requiring OAC closure. In 60.5% of the cases, surgical OAC closure was performed immediately after tooth extraction. The Rehrmann flap (72.2%) was the most frequently used tech-

nique for surgical OAC closure. 94.4% of surgical OAC closures were successful. Gender and age did not influence the outcome. In contrast, the site of OAC and the time interval from tooth extraction to OAC closure affected the results. Furthermore, the Rehrmann flap, alone or in combination with biomaterials, was superior to the mere suturing (with or without biomaterials) of the OAC site. In conclusion, the Rehrmann flap alone or in combination with biomaterials provided high success rates for first-time surgical OAC closure. With regard to the study parameters, an OAC in the 3rd molar area and an extended interval from tooth extraction to OAC closure negatively influenced the resolution of OAC. However, results must be interpreted cautiously considering the retrospective study design and the limited number of cases.

## Introduction

The maxillary sinus is the largest of the paranasal air sinuses and occupies the body of the maxillary bone (VON ARX & LOZANOFF 2017). The maxillary sinus is an important structure of the mid-face and viscerocranium, respectively, and has a number of critical functions as humidification of inspired air, resonance space for voice, weight reduction of the skull, and – to a minor extent – olfaction (VAN DEN BERGH ET AL. 2000). The main inlet and drainage site of the maxillary sinus is the maxillary ostium that connects the sinus via the crescent-shaped hiatus semilunaris to the middle nasal meatus (VON ARX ET AL. 2019; YEUNG ET AL. 2019). The growth of the maxillary sinus continues until the third decade in males and the second decade in females, respectively (JUN ET AL. 2005). Generally, there are no side differences with regard to the volume of the maxillary sinus, but the volume in males is significantly greater than in females. Also, after reaching its maximum size, the volume gradually decreases with increasing age (JUN ET AL. 2005; AKTUNA BELGIN ET AL. 2019; BORNSTEIN ET AL. 2019).

The development of the maxillary sinus in combination with centrifugal pneumatization within the maxillary bone results in several sinus recesses, i.e. expansion of the maxillary sinus into adjacent bones. The latter include the infraorbital recess (below the orbital floor), the zygomatic recess (towards the zygomatic bone), the palatonasal recess (below the nasal floor) (CHAN ET AL. 2013), and the alveolar recess (into the alveolar process of the maxillary bones) (SHARAN & MADJAR 2006, 2008).

In clinical dentistry, the topographic relationship of the maxillary premolars and molars with the floor of the maxillary sinus is of particular interest, but also a constant challenge to the clinician (TIAN ET AL. 2016). The downward extension of the maxillary sinus and the pneumatization (alveolar recesses) of the alveolar process generally result in a close proximity of the floor of the maxillary sinus to the roots of the posterior maxillary teeth. As a consequence, dentoalveolar pathologies may spread into the maxillary sinus, or removal of periapical lesions or tooth extractions may result in a perforation of the sinus membrane, i.e., in a so-called oroantral communication (OAC). When this communication fails to close spontaneously, it remains patent with subsequent formation of an epithelialized oroantral fistula (BATRA ET AL. 2010).

If an OAC (or oroantral fistula) is left untreated, acute or chronic maxillary sinusitis may develop. Therefore, numerous surgical methods have been described for OAC closure (VISSCHER ET AL. 2010). The most common techniques for surgical OAC closure include the buccal mucosal advancement flap (first described by REHRMANN in 1936) and the mobilization of the Bichat's buccal fat pad (initially described by EGYEDI in 1977).

The primary objective of this retrospective study was an analysis of the outcome of surgical closures of OAC following tooth extractions. Secondary objectives included the evaluation of patient and treatment factors possibly influencing the outcome.

## Materials and methods

Patients were included provided they had an OAC following tooth extraction, and a first-time surgical closure of the OAC was performed at the Department of Oral Surgery and Stomatology, School of Dental Medicine, University of Bern, from 2004 to 2017. The study design was approved by the institutional review board (KEK Ethic Committee Canton of Bern/Switzerland Approval #2019-02308).

Utilizing the billing software “Medsuite” (whatwedo GmbH, Bern, Switzerland), patients were filtered for interventions regarding the maxillary sinus (TP = Tarifposition SSO / identification number for treatment according to the Swiss Dental Association):

- TP 4265: irrigation of maxillary sinus via tooth socket
- TP 4267: surgical closure of OAC using a buccal flap
- TP 4268: surgical closure of OAC using a palatal flap
- TP 4269: removal of foreign body from maxillary sinus

No age limit was applied. The computer search yielded 221 cases, of which 59 were excluded from the final analysis (Tab. I). Consequently, the charts of 162 patients were evaluated for the following study parameters:

- *Patient*: gender (male, female), and age groups (<49 years, ≥49 years; cut off = mean age).
- *Site of OAC*: 1st molar, 2nd molar, 3rd molar, or others (premolar, supernumerary molar, primary molar).
- *Interval from occurrence to closure of OAC*: immediate, early (1–7 days), delayed (8 days to 4 weeks), or late (>4 weeks).
- *Technique of OAC closure*: Rehrmann flap, Rehrmann flap combined with other (bio-)materials, or technique other than Rehrmann flap.
- *Outcome of OAC closure*: success (complete and symptom-free OAC closure), or failure (recurrence of OAC).

In a subset of 118 cases, information about additional possibly influencing factors could be collected:

- *General health status*: healthy patient, patient on medication that is unlikely to affect wound healing (hypertension, hyperlipidemia, thyroid disorders, psychiatric diseases), patient on medication that may affect wound healing (diabetes, anti-coagulation, anti-aggregation, immunosuppression, anti-resorptive therapy).
- *Smoking habit*: smoker, non-smoker.
- *Presence of neighboring teeth*: mesial and distal teeth are present, mesial or distal tooth present, both neighboring teeth absent.
- *Prescription of antibiotics in conjunction with OAC closure*: yes, no.

**Tab. I** Reasons for exclusion of cases (N = 59)

Reason for exclusion	N
Removal of foreign body from maxillary sinus	15
No OAC	8
Displacement of dental implant into maxillary sinus	4
Oro-antral fistula (without previous tooth extraction)	4
Perforation of maxillary sinus with drill	2
Removal of osseointegrated dental implant	1
Previous surgery of maxillary sinus	1
Second-time surgical closure of OAC	10
Spontaneous healing of OAC	9
Unknown surgical technique	2
Treatment discontinued	3
OAC = oroantral communication	

Two different scenarios were distinguished with regard to tooth extraction and OAC closure:

- Scenario "Extern/intern": tooth extraction by referring dentist; OAC closure by surgeon of department of oral surgery.
- Scenario "Intern/intern": tooth extraction and OAC closure by surgeon of department of oral surgery.

All data was collected retrospectively, and information was stored encoded in the REDCap database (Vanderbilt University, Nashville, USA).

### Statistical analysis

Separated Fisher's exact tests were performed to evaluate potential influencing factors for the success of OAC closure. As the potential influencing factors assessed did not belong to a joint test for a single hypothesis, the significance level was not corrected. Risk ratio was also calculated. All of the tests were two-tailed tests with the 0.05 significance level performed by IBM SPSS Statistics for Windows Version 26 (IBM Corp. Armonk, NY, USA).

**Tab. II Site of OAC (N = 162)**

Site	N	%
2nd deciduous molar	1	0.6
Canine	1	0.6
1st premolar	1	0.6
2nd premolar	8	4.9
1st molar	62	38.3
2nd molar	55	34.0
3rd molar	29	17.9
Supernumerary molar	1	0.6
Unknown	4	2.5

OAC = oroantral communication

**Tab. III Surgical technique of OAC closure (N = 162)**

Surgical technique	N	%
Rehrmann	117	72.2%
Rehrmann combined (N = 36)	+ Bichat fat pad	1 0.6%
	+ Tabotamp	1 0.6%
	+ Fibrin glue	11 6.8%
	+ Collagen membrane	2 1.2%
	+ Collagen fleece	14 8.6%
	+ Collagen fleece + fibrin glue	7 4.3%
Non-Rehrmann (N = 9)	Suturing only	4 2.5%
	Collagen fleece only	1 0.6%
	Collagen fleece + suturing	3 1.9%
	Collagen fleece + fibrin glue + suturing	1 0.6%

OAC = oroantral communication

## Results

The analyzed cohort included 98 males (60.5%) and 64 females (39.5%) with a mean age of 48.6 years (range 17 to 86 years). The maxillary 1st molar (38.3%) was the most common site requiring OAC closure in this cohort (Tab. II). In 60.5% of the cases, surgical OAC closure was performed immediately after tooth extraction. The Rehrmann flap (72.2%) was the most frequently used technique for surgical OAC closure (Tab. III). With regard to the outcome, 94.4% of surgical OAC closures were successful (Tab. IV-a).

No statistically significant differences were observed comparing success rates of the subcategories of the study parameters gender, age, and scenario (Tab. V-a). With regard to the site of OAC, 3rd molars showed a higher rate of failure, but overall, there was no significant influence of the OAC site on the outcome ( $p = 0.343$ ). Immediate (96.9%) or early (100%) OAC closure after tooth extraction resulted in higher success rates compared to delayed (83.3%) or late (87%) OAC closure. When pooling data, immediate and early (97.4%) OAC closure after tooth extraction resulted in significantly higher success rates compared to delayed and late (85.4%) closure ( $p = 0.029$ ). With regard to the surgical technique of OAC closure, the Rehrmann flap alone (95.7%) or in combination with other materials (97.2%) provided significantly higher success rates ( $p = 0.010$ ) compared to non-Rehrmann closure techniques (66.7%). With regard to additional possibly influencing factors, none of these proved significant (Tab. IV-b and V-b).

The analysis of "relative risk ratios (RR)" provided markedly increased RR for the following factors (Tab. V-a): OAC site in 3rd molar (RR = 4.28), delayed or late interval from occurrence to closure of OAC (RR = 5.71), and non-Rehrmann closure techniques (RR = 7.80).

In the present study, OAC closure failed in 9 cases (5.6%). The details of the cases with OAC recurrence are presented in Table VI. Six of these cases had a prolonged interval from tooth extraction to OAC closure. In 3 out of 9 cases, no Rehrmann flap was utilized for the first intervention. Furthermore, it is interesting to note the varying time intervals ranging from 6 to 89 days between the first surgical OAC closure and the OAC recurrence. Retreatment consisted mainly in irrigation of the maxillary sinus through the site of OAC recurrence with subsequent revision using a Rehrmann flap.

## Discussion

This retrospective study evaluated the outcome of first-time surgical closures of OAC following tooth extraction. Only 5.6% of the analyzed cases failed in terms of OAC closure. Other clinical studies have also documented good to high success rates for surgical OAC closure using the Rehrmann technique (Tab. VII). The latter technique consists of the advancement of a buccal mucosal flap following horizontal releasing incision of the periosteum (Fig. 1). The drawbacks of the Rehrmann flap include reduction of vestibular depth and displacement of the mucogingival line towards the crest (GACIC ET AL. 2009; BATRA ET AL. 2010). Furthermore, the Rehrmann flap cannot be applied in cases with severely damaged gingival tissues (POESCHL ET AL. 2009). Main reasons for failure of the Rehrmann flap include its limited vascular supply and lack of tension-free wound closure.

As an alternative, a pedicled palatal mucosal flap can be rotated and advanced towards the alveolar crest to avoid the disadvantages of the Rehrmann flap mentioned above (ANAVI ET AL. 2003). The main branch of the greater palatine artery provides

**Tab. IV-a Outcome of surgical OAC closure with regard to subcategories of study parameters (N = 162)**

Parameter	Subcategory	N	%	Success		Failure	
				N	%	N	%
All	-	162	100	153	94.4	9	5.6
Gender	Male	98	60.5	93	94.9	5	5.1
	Female	64	39.5	60	93.8	4	6.3
Age group	<49 years	79	48.8	73	92.4	6	7.6
	≥49 years	83	51.2	80	96.4	3	3.6
Scenario	Extern/intern	57	35.2	53	93.0	4	7.0
	Intern/intern	105	64.8	100	95.2	5	4.8
Site of OAC	1st molar	62	38.3	60	96.8	2	3.2
	2nd molar	55	34.0	52	94.5	3	5.5
	3rd molar	29	17.9	25	86.2	4	13.8
	Other	12	7.4	12	100	0	0
	Unknown	4	2.5	4	100	0	0
Interval from occurrence to closure of OAC	Immediate	98	60.5	95	96.9	3	3.1
	Early	19	11.7	19	100	0	0
	Delayed	18	11.1	15	83.3	3	16.7
	Late	23	14.2	20	87.0	3	13.0
	Unknown	4	2.5	4	100	0	0
Surgical technique of OAC closure	Rehrmann	117	72.2	112	95.7	5	4.3
	Rehrmann combined	36	22.2	35	97.2	1	2.8
	non-Rehrmann	9	5.6	6	66.7	3	33.3

OAC = oroantral communication

**Tab. IV-b Outcome of surgical OAC closure with regard to additional parameters in a subset of patients (N = 118)**

Parameter	Subcategory	N	%	Success		Failure	
				N	%	N	%
All	-	118	100	110	93.2	8	6.8
Medical status	Healthy patient	72	61.0	67	93.1	5	6.9
	Patient on medication that is unlikely to affect wound healing <sup>1</sup>	30	25.4	29	96.7	1	3.3
	Patient on medication that may affect wound healing <sup>2</sup>	16	13.6	14	87.5	2	12.5
Smoking habit	Non-smoker	83	70.3	79	95.2	4	4.8
	Smoker	35	29.7	31	88.6	4	11.4
Presence of teeth adjacent to site of OAC	Mesial and distal tooth present	30	25.4	29	96.7	1	3.3
	Mesial or distal tooth present	57	48.3	52	91.2	5	8.8
	Mesial and distal tooth absent	31	26.3	29	93.5	2	6.5
Antibiotics	Yes	111	94.1	103	92.8	8	7.2
	No	7	5.9	7	100	0	0

OAC = oroantral communication  
<sup>1</sup> medication in conjunction with hypertension, hyperlipidemia, thyroid disorders, psychiatric diseases  
<sup>2</sup> diabetes, anti-coagulation, anti-aggregation, immunosuppression, anti-resorptive therapy

**Tab. V-a** Statistical analysis (Fisher's exact test) of potential influencing factors on the outcome of surgical OAC closure and their risk ratios (N = 162)

Influencing factor		p value	RR
Gender	Male	0.740	0.82
	Female (Ref)		1
Age group	<49 years	0.320	2.1
	≥49 years (Ref)		1
Scenario	Extern/intern	0.721	1.47
	Intern/intern (Ref)		1
Site of OAC	1st molar (Ref)	0.343	1
	2nd molar		1.69
	3rd molar		4.28
	Other		0
	Unknown		0
Interval from occurrence to closure of OAC	Immediate or early (Ref)	<b>0.029</b>	1
	Delayed or late	(immediate and early versus delayed and late)	5.71
	Unknown		0
Surgical technique of OAC closure	Rehrmann (Ref)	<b>0.010</b>	1
	Rehrmann combined	(Rehrmann and Rehrmann combined versus non-Rehrmann)	0.65
	non-Rehrmann		7.8

OAC = oroantral communication; Ref = reference; RR = risk ratio; **p value <0.05 in bold**

**Tab. V-b** Statistical analysis (Fisher's exact test) of additional potentially influencing factors on the outcome of surgical OAC closure and their risk ratios (N = 118)

Influencing factor		p-value	RR
Medical status	Healthy patient (Ref)	0.429	1
	Patient on medication that does not affect wound healing		0.48
	Patient on medication that may affect wound healing		1.80
Smoking habit	Non-smoker (Ref)	0.235	1
	Smoker		2.37
Presence of teeth adjacent to site of OAC	Mesial and distal tooth present	0.891	0.52
	Mesial or distal tooth present		1.36
	Mesial and distal tooth absent (Ref)		1
Antibiotics	Yes (Ref)	1.000	1
	No		0

OAC = oroantral communication; Ref = reference; RR = risk ratio

**Tab. VI** Detailed description of the 9 cases with failed first surgical closure of OAC

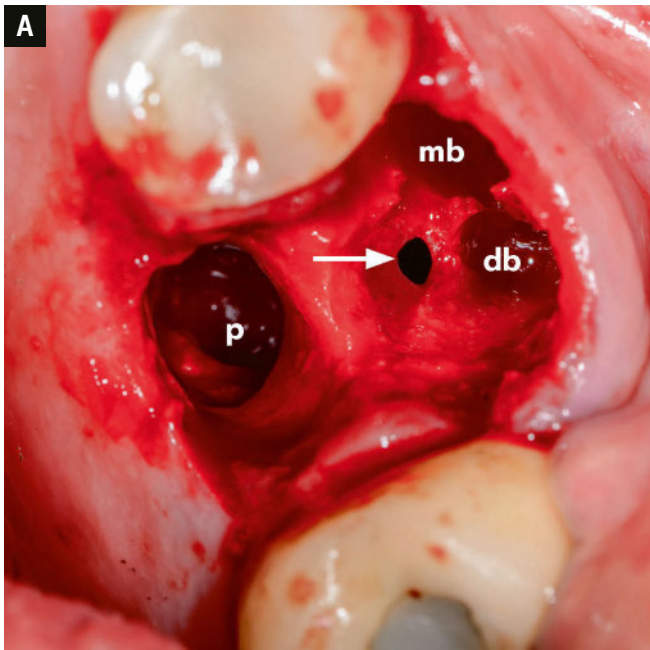
Gender	Age	Scenario	Tooth	Interval from OAC occurrence to first OAC closure	Technique of OAC closure	Interval from OAC closure to OAC recurrence	Retreatment of OAC recurrence	Outcome of retreatment
Female	45	Extern/intern	17	22 days	Rehrmann + fibrin glue	26 days	Irrigation of maxillary sinus; Rehrmann (34 days after first OAC closure)	Success
Female	27	Extern/intern	17	22 days	Rehrmann	12 days	Irrigation of maxillary sinus with subsequent spontaneous OAC closure	Success
Male	25	Intern/intern	28	Immediate	Collagen cone + suturing	6 days	Irrigation of maxillary sinus; Rehrmann (17 days after first OAC closure)	Success
Male	49	Extern/intern	26	9 days	Rehrmann	50 days	Immediate wound revision and primary closure with suturing	Success
Female	23	Intern/intern	18	Immediate	Collagen cone + suturing	10 days	Irrigation of maxillary sinus; Rehrmann + HemCon (20 days after first OAC closure)	Success
Female	62	Extern/intern	26	5 months	Rehrmann	89 days	Referral to ENT department	Unknown
Male	43	Intern/intern	18	39 days	Rehrmann	32 days	Irrigation of maxillary sinus; Rehrmann (39 days after first OAC closure)	Failure
Female	42	Intern/intern	18	58 days	Collagen fleece + suturing	38 days	Rehrmann + collagen membrane (47 days after first OAC closure)	Success
Male	57	Intern/intern	17	Immediate	Rehrmann	28 days	Irrigation of maxillary sinus; Rehrmann + collagen membrane (42 days after first OAC closure)	Success

ENT = ear, nose and throat; OAC = oroantral communication

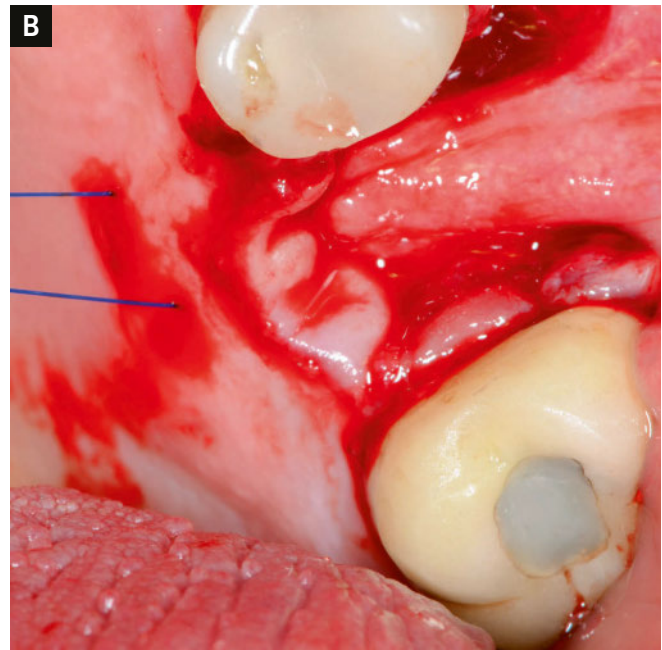
**Tab. VII** Treatment outcomes of surgical OAC closures using the Rehrmann technique (studies published after 2000)

Author(s) and year	Type of study (years of treatment)	OAC closure technique: N	Success rate	Comments
ABUABARA ET AL. 2006	Retrospective (1988–2004)	Rehrmann: 9 Palatal flap: 2 Buccal fat pad: 28 Suturing only: 61	88.9% 50% 100% 93.4%	–
GACIC ET AL. 2009	Prospective (years N/A)	Rehrmann: 10 TCP: 10 Hemostatic gauze: 10	100% 100% 100%	–
HERNANDO ET AL. 2010	Retrospective (1996–2007)	Rehrmann: 7 Palatal flap: 4 Buccal fat pad: 1	57% 100% 100%	Mean average size of OAC was 9 mm; 7.4 mm in successful cases, but 11mm in cases with OAC recurrences
BATRA ET AL. 2010	Randomized clinical trial (2005–2008)	Rehrmann: 7 Buccal fat pad: 8 Combination: 6	71% 100% 100%	2 out of 7 Rehrmann cases failed due to suture dehiscence
VISSCHER ET AL. 2011A	Retrospective (2004–2008)	Rehrmann: 187 Palatal flap: 3 Suturing only: 28	87.2% 100% 92.9%	Based on multivariate analysis, the presence of maxillary sinusitis at the follow-up appointment was associated with a 15-times higher risk of OAC recurrence
NEZAFATI ET AL. 2012	Randomized clinical trial (2006–2008)	Rehrmann: 10 Buccal fat pad: 10	100% 100%	Statistically significant less pain and swelling for Rehrmann
GHEISARI ET AL. 2019	Retrospective (past 10 years)	Rehrmann: 59 Palatal flap: 28 Buccal fat pad: 60	89.8% 85.7%* 98.3%*	*statistically significant difference
Present study	Retrospective (2004–2017)	Rehrmann: 117 Rehrmann combined: 36 Other: 9	95.7% 97.2% 66.7%	–

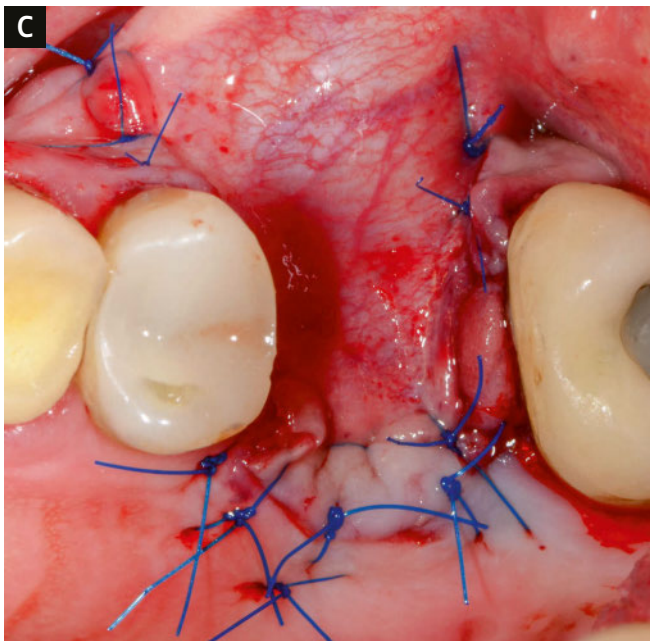
N/A = not available; OAC = oroantral communication; TCP = tricalciumphosphate



**Fig. 1a** Clinical situation following extraction of the left maxillary 1st molar in a 63-year-old male. The arrow points at the OAC. Empty root sockets: mb = mesiobuccal, db = distobuccal, p = palatal.



**Fig. 1b** A buccal mucosal flap has been advanced to cover the OAC and the root sockets following a periosteal releasing incision (Rehrmann technique). The flap is held in place with a mattress suture.



**Fig. 1c** Suturing is completed with tightening of the mattress suture and placement of multiple single interrupted sutures for water-tight closure.



**Fig. 1d** The clinical situation 2.5 months after surgical closure demonstrates uneventful and complete healing.

excellent vascular supply to this type of flap. In contrast to the buccal flap, the palatal flap is firmer and more resistant to trauma and infection (HARIRAM ET AL. 2010). However, the palatal rotational flap is highly technique sensitive and also has a number of drawbacks including denudation of palatal bone with secondary granulation, difficulty in reaching a lateral alveolus, and kinking of the flap.

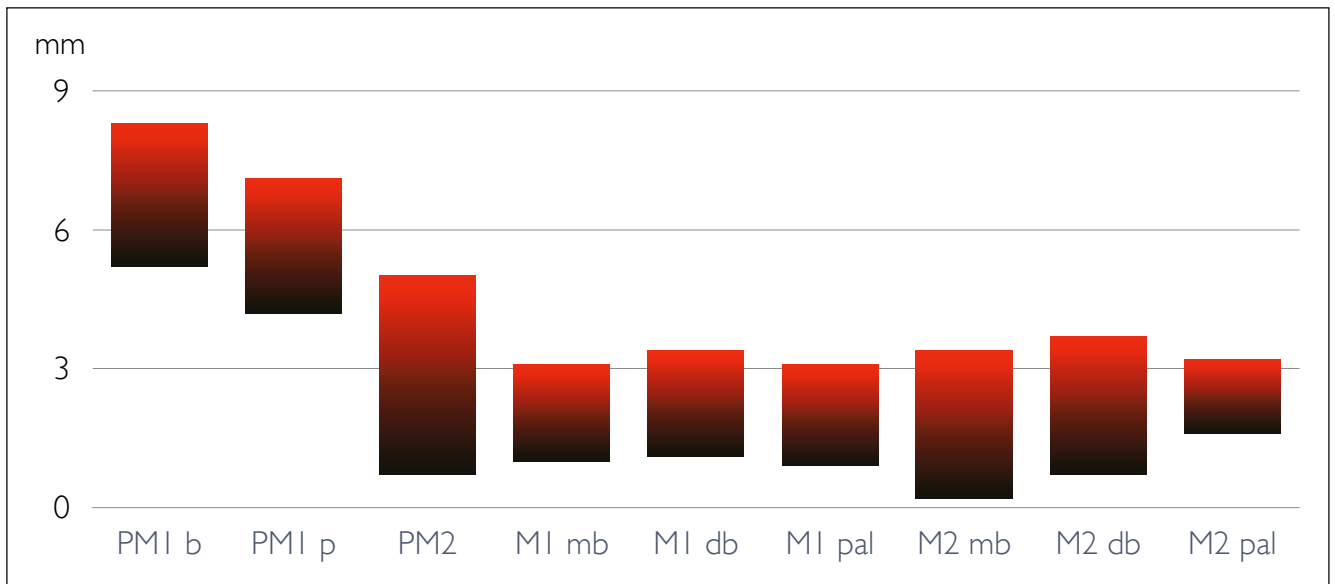
In contrast to OAC closure using mucosal flaps, a number of alternative techniques have been presented in the literature (Tab. VIII). However, none of them has gained wide acceptance among clinicians due to high cost, complexity of the procedure, or just case-base reporting.

While the Rehrmann flap is still considered the standard technique for surgical closure of an OAC (NEZAFATI ET AL. 2012), the pedicled buccal fat pad (BFP) has been well documented for closure of large, infected, recurrent, or long-standing OAC (DOLANMAZ ET AL. 2004; POESCHL ET AL. 2009). In addition, the BFP closure technique is considered a backup method if a Rehrmann flap fails (BATRA ET AL. 2010; VISSCHER ET AL. 2011A). The rich blood supply of the BFP flap may explain its generally high success rate (NEZAFATI ET AL. 2011). The quick epithelialization of the uncovered fat is a characteristic feature of the pedicled BFP and histologically proven (POESCHL ET AL. 2009). The major drawbacks of the BFP are graft contraction causing limited mouth

**Tab. VIII** Alternative techniques of surgical OAC closure (articles published after 2000)

Author(s) and year	Surgical technique
KITAGAWA ET AL. 2003	OAC closure with autotransplantation of maxillary 3rd molar (N = 2)
WATZAK ET AL. 2005	Intraorally harvested monocortical block grafts were press-fit for OAC closure + Rehrmann flap (N = 21)
THOMA ET AL. 2006	Placement of chair-side fabricated root analogues made of absorbable TCP/polylactide (N = 20)
DOOBROW ET AL. 2008	Multiple layers of collagen matrix + freeze-dried demineralized bone/calcium sulfate + dental implant (N = 1)
GACIC ET AL. 2009	Resorbable hemostatic gauze composed of reconstituted oxidized cellulose (N = 10) or root analogues made with PLGA-coated synthetic, phase-pure, porous beta-TCP granules (N = 10)
HARIRAM ET AL. 2010	Pouch made of collagen sheath filled with hydroxyapatite granules (N = 10)
VISSCHER ET AL. 2011B	Tight placement of conical biodegradable polyurethane foam, secured with a safety suture (N = 10)
BURIC ET AL. 2012	Insertion of absorbable Ethisorb® cylinders containing polyglactin/polydioxanone for OAC closure (N = 12)
ER ET AL. 2013	Autogenous bone grafts harvested intraorally were “press fit” over OAC defect + buccal flap advancement (N = 10)
SALEH & ISSA 2013	Placement of nasoseptal cartilage over OAC defect + flap repositioning (N = 11)
WEINSTEIN ET AL. 2014	Bony window from Caldwell-Luc was “press fit” over OAC defect + buccal fat pad + buccal mucosal advancement flap (N = 1)
PROCACCI ET AL. 2016	Titanium-mesh as support for mucoperiosteal flap (N = 12)
BILGINAYLAR 2018	Platelet-rich fibrin clots which were sutured to the gingiva (N = 21)
DEMETOGLU ET AL. 2018	Insertion of plasma-rich fibrin membrane in layers over OAC; membranes were fixated with sutures to the surrounding gingiva (N = 18)

OAC = oroantral communication; PLGA = polylactide-co-glycolic acid; TCP = tricalciumphosphate



**Fig. 2** Mean distances (mm) from root apices to sinus floor reported in the literature (radiographic studies using CT or CBCT for distance measurements). PMI = 1st premolar; PM2 = 2nd premolar; M1 = 1st molar; M2 = 2nd molar. b = buccal root; p = palatal root; mb = mesiobuccal root; db = distobuccal root.

opening and it can only be used once (POESCHL ET AL. 2009; GHEI-SARI ET AL. 2019).

With regard to the site of OAC, the 1st molar was the most frequent location of OAC in the present study. In other studies addressing the outcome of surgical OAC closure, the predominance of the 1st molar site has been confirmed (GACIC ET AL. 2009; HERNANDO ET AL. 2010; VISSCHER ET AL. 2011A). Recent radiographic studies using three-dimensional imaging (CT, CBCT) have documented the mean distances from root apices to the floor of the

maxillary sinus in posterior maxillary teeth (EBERHARDT ET AL. 1992; HOW 2009; GEORGESCU ET AL. 2012; VON ARX ET AL. 2014; KANG ET AL. 2015). The data presented in Figure 2 graphically show the reported mean distances. The shortest mean distance (0.18 mm) was recorded for the mesiobuccal root of the 2nd molar (KANG ET AL. 2015).

In a retrospective study comprising 27,984 tooth extractions, the total number of OAC was only 87 (= 0.31%). OAC were observed from canines through to 3rd molars. The 1st molar was



the most commonly involved tooth (OAC incidence 0.64%) with the palatal socket affected most frequently (PUNWUTIKORN ET AL. 1994). The same authors found no statistically significant difference in the incidence of OAC with regard to gender and age groups. Studies limited to the (surgical) removal of maxillary 3rd molars reported relatively high frequencies of OAC, i.e. 5.1% (DEL REY-SANTAMARIA ET AL. 2006) and 13% (ROTHAMEL ET AL. 2007). In both studies, the risk of OAC was significantly related to the depth of tooth inclusion.

With regard to predictor variables of OAC closure, only the (retrospective) study by VISSCHER ET AL. (2011A) has given a detailed insight. In the univariate model, disturbed wound healing and the presence of a maxillary sinusitis were statistically associated with failures. Although there was a large difference in failures comparing immediate OAC closure (7.3%) and delayed OAC closure (19.2%), this discrepancy did not reach statistical significance. In the multivariate analysis, the presence of maxillary sinusitis at the follow-up appointment was associated with a 15-times higher risk of recurrent OAC. In the study by HERNANDO ET AL. (2010), recurrent cases presented a mean OAC size of 11.1 mm compared to successful cases with a mean OAC size of 7.4 mm at the time of surgical OAC closure. These data point at a possible influence of the OAC size – however the sample of Hernando's study was small, and no statistics were performed. Large OAC sizes may require other closure techniques that were not evaluated in the present study. Furthermore, data about the actual OAC size could not be collected since they were hardly ever measured let alone noted in the charts.

Presence or absence of neighboring teeth may also influence the design and a tension-free advancement of the flap for OAC closure. However, data from a subset of patients with regard to this study parameter did not reach statistical significance.

The data in Table V-a suggest a possible effect on the outcome for the following study parameters: site of OAC, interval from occurrence to closure of OAC, and surgical technique of OAC closure. High risk ratios negatively influencing the treatment outcome were calculated for OAC closure other than Rehrmann technique, a delayed or late interval from occurrence to closure of OAC, and a 3rd molar site of OAC. Medically compromised patients or smokers also tended to have higher failure rates of OAC closure compared to their counterparts, but the differences were not statistically significant.

In general, the limited number of cases per subgroups in the present study is a critical issue with regard to the statistical interpretation of their effects on the healing outcome. However, some trends are still noticeable, and in the context of missing data in the literature, they could form the basis for future research about risk factors for surgical OAC closure.

According to VISSCHER ET AL. (2010), treatment of OAC should be quick, safe, straightforward, and well tolerated by patients. It should have low costs, and result in good bone and soft tissue healing with a low complication rate. However, such a treatment simply does not exist. A recent systematic review by DE BIASI ET AL. (2014) about the effectiveness of surgical OAC closure resulted in the following conclusions: (1) there are no RCTs evaluating whether an OAC should be closed or not, (2) there is weak evidence from two RCTs showing good results with five different OAC closure techniques, i.e. Rehrmann flap, BFP, hemostatic gauze, resorbable root analogue, and hydroxyapatite graft.

In conclusion of the present study, the Rehrmann flap alone or in combination with biomaterials provided high success rates

for first-time surgical OAC closure. With regard to the study parameters, an OAC in the 3rd molar area and an extended interval from occurrence to OAC closure negatively influenced the treatment outcome. However, results must be interpreted cautiously considering the retrospective study design and the limited number of analyzed cases.

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## Conflict of interest

The authors declare that there are no conflicts of interest related to this study.

## Zusammenfassung

### Einleitung

Die Kieferhöhle ist die grösste aller Nasennebenhöhlen und hat wichtige physiologische und anatomische Funktionen. Klinisch relevant ist die enge topografische Beziehung des Kieferhöhlenbodens zu den Wurzelspitzen der Oberkiefer-Seitenzähne. Periapikale Veränderungen können sich deshalb in die Kieferhöhle ausbreiten. Die Entfernung dieser Pathologien bzw. die Exaktion von Oberkiefer-(Prä)molaren können zu Perforationen des Kieferhöhlenbodens mit sogenannter Mund-Antrum-Verbindung (MAV) führen. Bei ausbleibendem Verschluss einer MAV resultiert eine akute oder chronische Sinusitis. Deshalb wird ein zeitnaher chirurgischer MAV-Verschluss empfohlen. Das Ziel dieser Studie war die retrospektive Analyse chirurgischer Erstverschlüsse von MAV nach Zahnextraktionen.

### Material und Methoden

Einschlusskriterien waren Patienten (ohne Altersbeschränkung) mit Erstverschluss einer MAV nach Zahnextraktion in den Jahren 2004 bis 2017 an der Klinik für Oralchirurgie und Stomatologie der Universität Bern. Die Suche der Fälle erfolgte mithilfe der klinikinternen Abrechnungssoftware bzw. der kieferhöhlenrelevanten SSO-Tarifpositionen 4265 bis 4269. Diese Computersuche ergab 221 Fälle, wovon 162 Fälle die Einschlusskriterien erfüllten. Folgende Daten (Studienparameter) wurden aus den Krankengeschichten gesammelt: Alter und Geschlecht, Situs der MAV, Intervall vom Auftreten bis zum Verschluss der MAV, Technik des chirurgischen MAV-Verschlusses und das Ergebnis. Bezüglich Zahnextraktion und MAV-Verschluss wurden zwei Szenarien unterschieden: (1) Exaktion durch Zuweiser, MAV-Verschluss an der Klinik; (2) Exaktion und MAV-Verschluss, beides an der Klinik. Die Statistik erfolgte bezüglich eines möglichen Einflusses der Studienparameter auf das Ergebnis des MAV-Verschlusses.

### Resultate

Die analysierten 162 Fälle (98 Männer, 64 Frauen) hatten ein Durchschnittsalter von 48,6 Jahren (17–86 Jahre). Am häufigsten erfolgte der MAV-Verschluss nach Exaktion eines ersten Oberkiefermolaren (38,3%). In 60,5% wurde der MAV-Verschluss unmittelbar nach der Exaktion durchgeführt. Der Rehrmann-Lappen war die am meisten verwendete Ver-

schlussstechnik (72,2%). Die Erfolgsrate aller 162 Fälle betrug 94,4%. Bezüglich der evaluierten Studienparameter hatten das Zeitintervall vom Auftreten bis zum Verschluss der MAV ( $p = 0,029$ ) sowie die MAV-Verschlussstechnik einen Einfluss auf das Ergebnis ( $p = 0,010$ ). Die Analyse der «relative risk ratios (RR)» ergab erhöhte Misserfolgsrisiken für eine MAV im Bereich der dritten OK-Molaren ( $RR = 4,28$ ), für einen verzögerten oder späten MAV-Verschluss ( $RR = 5,71$ ) sowie für eine «Nicht-Rehrmann»-Verschlussstechnik ( $RR = 7,80$ ).

## Diskussion

In der vorliegenden Studie kam es nur in neun Fällen (5,6%) zu einem Misserfolg nach MAV-Verschluss. Die Daten zeigen, dass das Intervall vom Auftreten bis zum Verschluss der MAV sowie die chirurgische Technik einen Einfluss auf das Ergebnis hatten. Von den neun Misserfolgen hatten sechs Fälle einen verzögerten (9 Tage) bis späten (5 Monate) chirurgischen Verschluss der MAV. Auffällig war auch das unterschiedliche Zeitintervall (6–89 Tage) vom Erstverschluss bis zum MAV-Rezidiv.

Die in der neueren Literatur (ab 2000) angegebenen Erfolgsraten der Rehrmann-Methode reichen von 57% bis 100%. Der Vorteil des Rehrmann-Lappens liegt in der relativ einfachen Operationstechnik. Als Hauptnachteil wird die Abflachung des Vestibulums genannt. Als Alternativen werden in der Literatur der palatinale Rotationslappen (technisch schwierig) und die Mobilisation des Bichat-Wangenfettkörpers beschrieben. Letztere Technik bietet sich vor allem bei sehr grossen MAV-Defekten, bei chronischen MAV-Fisteln und als Back-up-Option bei erfolglosem Rehrmann-Verschluss an.

Als Konklusion kann festgehalten werden, dass in der vorliegenden Studie sowohl der Rehrmann-Lappen allein als auch in Kombination mit (Bio-)Materialien eine sehr hohe Erfolgsrate hatte. Allerdings müssen die Resultate wegen des retrospektiven Studiendesigns mit Vorsicht interpretiert werden.

## Résumé

### Introduction

Le sinus maxillaire est la plus grande de toutes les cavités pneumatiques du crâne et il a d'importantes fonctions physiologiques et anatomiques. Le sinus maxillaire est en rapport étroit avec les dents postérieures du maxillaire supérieur qu'on appellera dents antrales ou sinusiennes. En raison de ce rapport étroit, les pathologies périapicales de ces dents peuvent s'étendre au sinus maxillaire. L'ablation de celles-ci ou de pathologies associées peut provoquer une perforation du plancher du sinus appelée communication bucco-sinusienne (CBS). Restée non traitée une telle perforation peut provoquer une sinusite aiguë ou chronique. C'est pour cette raison qu'on recommande une fermeture de ces perforations peu après leur formation. Le but de cette étude était d'analyser le résultat de l'intervention chirurgicale visant à fermer pour la première fois une communication survenue après une extraction dentaire.

### Matériels et méthodes

Tous les patients ayant été traités pour une CBS après une extraction dentaire à la Clinique de Chirurgie Orale et de Stomatologie de l'Université de Berne ont été inclus dans cette étude (sans limitation d'âge). Les cas ont été recensés à l'aide du programme de facturation interne en recherchant les positions de la SSO liées à une CBS – les positions 4265 à 4269. Cette recherche a révélé 221 cas dont 162 remplissaient les critères d'inclusion. Les paramètres suivants ont été relevés dans les dossiers: âge,

sexe, localisation de la CBS, intervalle entre l'apparition de la CBS et sa fermeture, technique chirurgicale et résultat de l'intervention. Deux scénarios ont été pris en considération concernant l'extraction de la dent et la fermeture de la CBS: (1) extraction externe (par un dentiste référent) et fermeture à la Clinique universitaire, (2) extraction et fermeture à la Clinique universitaire. L'influence statistique de ces paramètres sur le résultat de la fermeture chirurgicale de la CBS a été analysée.

## Résultats

Les 162 cas analysés (98 hommes et 64 femmes) avaient une moyenne d'âge de 48,6 ans (17 à 86 ans). La localisation la plus courante (38,3%) de la fermeture d'une CBS était la zone de la première molaire. Le lambeau de Rehrmann a été la technique chirurgicale la plus communément employée (72,2%). Le taux de réussite des différentes interventions a été de 94,4%. La durée entre l'apparition de la CBS et sa fermeture ( $p = 0,029$ ) ainsi que la technique chirurgicale employée ( $p = 0,010$ ) sont des paramètres significatifs. Le risque relatif est plus élevé dans la zone de la troisième molaire ( $RR = 4,28$ ), lors d'une fermeture chirurgicale longtemps différée ( $RR = 5,71$ ) ainsi que lors de technique chirurgicale autre que le lambeau de Rehrmann ( $RR = 7,8$ ).

## Discussion

Cette analyse n'a présenté que neuf cas d'échec. On note que le moment de la fermeture chirurgicale ainsi que la technique chirurgicale utilisée ont une influence sur le résultat du traitement. Six des neuf cas d'échecs présentaient une fermeture différée (9 jours) ou tardive (plus de 5 mois). On note aussi une discrétion importante entre le moment de l'apparition d'une récurrence de la CBS (6 à 89 jours).

La littérature actuelle (depuis 2000) parle d'un taux de succès pour le lambeau de Rehrmann d'entre 57% et 100%. Le lambeau de Rehrmann a l'avantage d'une intervention chirurgicale relativement simple. On note comme désavantage majeur le raccourcissement du vestibule à la hauteur du lambeau. On citera comme techniques alternatives la plastie par volet de rotation palatin (techniquement délicate) ou la mobilisation de la boule de Bichat. Cette technique est surtout intéressante lors de CBS très étendue, de fistule bucco-sinusienne chronique ou comme «roue de secours» lors d'échec du classique lambeau de Rehrmann.

En conclusion, on retiendra de la présente étude que le lambeau de Rehrmann seul ou en combinaison avec des (bio) matériaux montre un taux de succès très élevé. Ces résultats doivent cependant être interprétés prudemment en raison du caractère rétrospectif de cette étude.

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