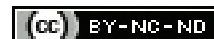


Insight to Different Approaches in Surgical Closure of Oro-antral Communication: A Literature Review

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ABSTRACT

An Oroantral Communication (OAC) is an unnatural non epithelialised continuation in between maxillary antrum and oral cavity. When it doesn't heal spontaneously or left untreated, this tract becomes epithelised and termed as oroantral fistula. Most common cause of Oro-antral communication is the extraction of maxillary posterior teeth. However there are so many other causes that can lead to development of OAC/fistula like pathologies, facial trauma, forcing a tooth/tooth root into the sinus cavity during attempted removal etc. To prevent the development of fistulas and further sinus problems, it is generally recommended that all of these defects should be closed within 24-72 hours. Various surgical techniques have been described for the closure of OAC. The aim of this literature is to review surgical treatment strategies of OAC and other treatment options along with their advantages and disadvantages, including new techniques.

Keywords: Extraction, Oroantral fistula, Surgical management

INTRODUCTION

An OAC is an unnatural non epithelialised continuation in between maxillary antrum and oral cavity [1]. When it remains open, does not close spontaneously, become epithelialised, an Oro-antral Fistula (OAF) develops. Untreated OACs may rapidly cause acute sinus disease. Oro-antral communications commonly occur after extraction of the maxillary molars teeth especially first and second molars [1,2]. Some other causes are following facial trauma, tumours, cysts, minor surgery and pathologies in the maxilla, dehiscence of floor of the sinus secondary to periapical lesions, displacement during extraction of tooth/tooth root in close proximity of sinus, chronic osteomyelitis, gumma, infected maxillary implant dentures, malignant granuloma etc., [1,3]. On the basis of location it can be classified as alveolo-sinusal, palatal-sinusal and vestibulo-sinusal [1].

Similarly an Oronasal Communication (ONC) is a pathological opening between the oral and nasal cavities, normally separated by the hard and soft palate. Its persistence or unsuccessful closure leads to epithelialisation of the tract which is called an Oronasal Fistula (ONF). The most common reason for a congenital ONC/ONF is cleft defects, whereas acquired ONC/ONF are mostly due to trauma, tumours, infections (periapical lesion, osteomyelitis, sinusitis, or any specific infection, such as actinomycosis, syphilis, tuberculosis, etc.), iatrogenic causes like surgical ablation, radiotherapy in the maxillofacial region, etc.) [4]. The main symptoms of ONC/ONF include nasal regurgitation, rhinitis, speech disorders, persistent/recurrent respiratory and ear infections [4].

Indication for surgical intervention for OAC closure depends on its size and its occurrence. The management of smaller OACs often does not require surgical repair and patients can be treated with sinus precautions and antibiotics. OACs that developed immediately post extraction and a normal blood clot forms within the socket, spontaneous closure is likely to occur if the sinus is not infected at the time. However to prevent sinusitis and development

of fistula, OACs larger than 5 mm should be closed surgically within 72 hours [1,3,5].

Many surgical procedures have been recommended for closure of OACs from simple suturing of the gingiva to various flap/graft procedure and other techniques e.g., soft-tissue flaps, autogenous bone grafts, alloplastic materials [Table/Fig-1] [1-5]. The aim of this literature is to review surgical treatment strategies of OAC and other treatment options along with their advantages and disadvantages, including new techniques.

REVIEW OF LITERATURE

A database was created primarily with PubMed by using word Oro-antral communication, OAF, oro-sinus communication were included. Further relevant articles were selected and included by using citations. The treatment strategies for OACs that the authors found in this literature search were subsequently divided into the following group as classified by the Visscher SH et al., [3]. These are autogenous soft-tissue flap/grafts, autogenous bone grafts, allogeneous materials, xenografts, synthetic materials and other new techniques. In this review apart from the existing treatment strategies for OAC, new alternatives like autogenous cartilage grafts, human amniotic membrane, and platelet rich fibrin are also described.

Autogenous Soft-tissue Flap

Buccal flap: Flap procedures can be divided into local flaps and distant flaps, as suggested by Awang MN [6]. Local flap techniques comprise various buccal flaps and palatal flap. The use of the buccal advancement flap is the most common surgical technique employed for the closure of OACs. This technique entails a broad based mucoperiosteal flap from the buccal mucosa to be advanced and sutured onto the palatal mucosa [4]. This flap provides broad base with adequate blood supply [3].

This flap is designed by Rehrmann VA [7]. Killey HC and Kay LW reported a high success rate of this procedure (94%) [8]. This flap

Autogenous soft-tissue flap				Autogenous bone/cartilage grafts		Synthetic closure	Other techniques
Buccal flap	Palatal flap	Buccal Fat Pad (BFP)	Togque flap	Cartilage grafts	Bone grafts		
60-97%	76%-93%	85-96.7%	85% to 95.5%	≥90%	90%-95.6% to 100%	90-95%,	80-95%

[Table/Fig-1]: Success rates comparing all flap types [1-5].

is technically easy to perform; however it produces a shortening of the buccal vestibule, which can require a secondary vestibuloplasty before denture fabrication [3,4].

Môczár flap is an alternative technique for closure of OACs which involves a buccal mucoperiosteal flap that is shifted one tooth width distally. Buccal vestibular depth is minimally influenced by this technique [3,9,10].

For the closure of ONC/ONF, small to moderate sized defect can be covered with buccal or palatal rotational flap, whilst the Tongue flap is indicated in large palatal defect. Palatoplasty and modified Langenbeck flap can also provide good coverage of the oro-nasal defect [4].

Palatal flap: Ashley described the full-thickness mucoperiosteal palatal flaps based on palatine artery for closure of OAFs [11]. The main advantage of this flap technique is that it is based on the large palatine vessel which ensure high vascularity and less prone to rupture than a buccal flap. In addition depth of the buccal sulcus remains unaltered. However, palatal flap creates uncovered palatal donor area which heals by secondary epithelialisation and a soft-tissue bulge at the axis of rotation [11,12].

Salin PC and Kishore SK used anteriorly based palatal flap as lateral transposition flap in closure of large OAF and achieved good results [13]. Lee JJ et al., used random palatal flaps for closure of OACs in third molar region and reported a success rate of 76% [14]. Yalçın S et al., in their study compared the two flap technique, buccal advancement flap and a palatal island flap [15].

Buccal Fat Pad (BFP): Another soft-tissue closure of OACs is the Buccal Fat Pad (BFP) flap. BFP as an anatomic element was first mentioned by Heister in 1732 and was described by Bichat in 1802. Egyedi was the first to report the application of BFP for oral reconstruction. Tideman et al., given the detail anatomy of the BFP, its vascular supply and operative technique [15,16]. The BFP is exposed by way of an incision in the periosteum posterolaterally to the maxillary tuberosity. The BFP is released, taken to the OAC defect, and sutured to the palatal mucosa [4]. Due to proximity of BFP to the recipient area make it easier for defect coverage. BFP receives its blood supply from the branches of superficial temporal, maxillary and facial arteries. As a graft material BFP is now becoming a good choice among surgeons due to its excellent blood supply, good tissue handling and minimal donor site morbidity [3,17,18].

The BFP demonstrated high success rates, even in previously operated cases, BFP allows only soft-tissue coverage, and this could not augment bone regeneration. However BFP could be used with proper bone graft materials for bone regeneration purpose [19]. The BFP is a rounded and biconvex structure, surrounded by a slight capsule and located inside both masticatory spaces [20]. Martin-Granizo R et al., reported its successful use in small or medium sized intraoral defects like due to tumoural resection, maxillary cysts, communications or secondary to posttraumatic defects [20]. Rapidis AD et al., also described the extended use of BFP in closure of defects due to excision of malignancy [16]. Weinstock RJ et al., proposed a three layer composite closure technique for an OAC while avoiding secondary donor site morbidity [5].

Tongue flap: The tongue is another good choice as donor site for defects of the oral cavity especially soft-tissue defects. This flap was first described by Eisenberg for intraoral defects [21]. Later on, Lexer used a lateral based tongue flap in 1909 for reconstruction of defects of retromolar trigone and tonsillar area. Guerrero-Santos and Altamirano 1966, first described suitability of an anteriorly based Dorsal Tongue Flap (DTF) for reconstruction of palatal fistulae [22]. Siegel et al., used a pedicled flap from the lateral margin of the tongue to close a large OAC after partial maxillectomy [23]. Kim YK

et al., also used a posteriorly based full-thickness lateral tongue flap to close an OAC with success [24].

Tongue flaps may include the dorsal, ventral, or lateral portion for reconstruction of a variety of oral defects [24]. Based on this several designs of tongue flap have been described. The anteriorly and posteriorly based DTF, the lateral tongue flap, the central tongue flap, and the ventral tongue flap have been used [24]. Generally the location of the defect, guide the preference of tongue flap. The lateral tongue flap is usually indicated for closure of OACs [3,10]. Other indications especially anterior or posterior based flap include palatal fistula, cleft palate etc., however some complications are associated with the use of tongue flap like difficulty in speech, need of second surgery to debulk the pedicle, haematoma [3,10,24].

Success Rate of Different Soft-tissue Flaps [Table/Fig-1]

Buccal advancement flap is one of the most popular techniques used for closure of OAC/OAF with reported success rates of 60-97%; however technique entails a substantial buccal sulcus reduction, which may cause patient discomfort and compromise future dental rehabilitation options. This problem is overcome by palatal flap for closure of OAC/OAF with a reported success rate of 76%-93%. In addition, the palatal mucosa is thicker and keratinised, eliminating the shrinkage of the closing flap [25].

Various literature highlights that tongue flaps, particularly DTF and Posterior Tongue Flaps (PTF), are effective options for palatal fistula closure, demonstrating high success rates (85-95.5%) and a favourable complication profile [26]. Also, tongue flap has an excellent outcome in cleft palate patient due to their rich vascularity and large amount of tissue available [27].

Apart from these, BFP in combination with soft-tissue flap showed the high success rate (96.7%) in closure of OAC/OAF. This is particularly useful in previously attempted failed closure cases [28]. Tongue flap provide an excellent closure for OAC/OAF or complex palatal fistula with shortage of surrounding tissues with a success rate of 85% to 95.5%

Autogenous Bone/Cartilage Grafts

Iliac crest graft/Chin graft/Zygomatic process/Coronoid process:

Due to rising interest for implant rehabilitation and the necessity of pre-implant surgery in terms of sinus floor elevation, usual soft-tissue closure of OAFs has become a major concern as it leads to matting of the mucosa and the Schneiderian membrane. This causes difficulty in elevation of the intact sinus membrane and this also become intensified due to alveolar bone recession so the use of bone grafts for closing OAFs provides a sound basis for subsequent conventional sinus lifting, and preserves the teeth adjacent to OAFs [2].

Proctor B first suggested the closure of large OACs by using bone grafts taken from the iliac crest [29]. However this entails considerable donor-site morbidity, e.g., probable sensory disturbance and prolonged postoperative pain. Therefore, alternative donor areas have been explored including bone grafts from the intraoral sites like retromolar area, zygomatic process, and the chin. Moreover, harvesting bone from intraoral donor areas significantly reduces patients' postoperative sequelae and can be performed under local anaesthesia.

Haas R et al., used the chin graft as autogenous graft material for closure of OAF [30]. Watzak G et al., treated OAFs by using monocortical bone blocks harvested from the retromolar or interforaminal regions of the mandible [2].

Kainulainen VT et al., described an additional donor area for bone regeneration in extraction sockets involving grafts harvested from the zygomatic process [31]. Advantage is that the proximity of the donor site and receptor bed contributed to reduction of surgical time and patient discomfort. Peñarrocha-Diago M et al., used zygomatic

bone as a bone graft for closure of an OAC in one patient followed by implant supported rehabilitation [32]. Pourdanesh F et al., performed closure of large OAC in a patient using coronoid process pedicled on temporalis muscle flap which is a new alternative technique [33].

Success Rate of Autogenous Grafts Material [Table/Fig-1]

Autogenous bone grafts are highly successful for the closure of OAC and have a reported success rate of over 90%, with some studies showing success in nearly 100% of cases when used as part of a multi-layered closure technique [3]. Particulate Ramus bone graft in combination with a buccal flap reported successful healing in 100% of cases while Iliac Crest Bone Graft for bone augmentation procedures (not specifically OAC but general bone grafting) has a high healing success rate, sometimes reported around 95.6%. Mandibular symphysis bone graft showed approximately a 90.9% success rate [2,30,31].

The major disadvantage of iliac crest bone graft is requiring a second surgical procedure for bone harvesting, also it increases patient morbidity. So in order to overcome this, bone harvesting from intraoral site is very crucial. Retromolar bone and graft taken from chin region closure of an OAC is indicated for patients having maxillary atrophy undergoing sinus augmentation before implant placement [3,30].

Septal cartilage: Use of septal cartilage was also described for the closure of OAFs in literature [34,35]. Kansu L et al., used nasoseptal cartilage graft in a female case with OAF and nasal septal deviation [34]. This graft is easily obtained with least morbidity. Saleh EA and Issa IA also successfully used nasal septal cartilage for closure of OAF and reported 90.9% success rate [35]. For harvesting the nasal septal cartilage, a standard hemitransfixion incision is usually given at the caudal end of the septal cartilage and a mucoperichondrial flap is elevated. A cartilage island is outlined and dissected free. In cases with extensive sinus disease, endoscopic sinus surgery is performed [35].

Auricular cartilage: Auricular cartilage graft is another good option for the closure of OAFs as the graft is biocompatible, resistant to infection, non resorbable, and easily manipulated. Also, it doesn't require vascularisation for the integration of the graft to the recipient site and this distinctive feature decreases the possibility of graft failure [1,3].

Mohanna PZ et al., used auricular conchal cartilage graft for closure of palatal fistula [36]. Isler SC et al., used auricular cartilage graft in closure of OAF and supported by palatal island flap for the closure of an OAF [37]. Ram H et al., in their study, closure of OAF were performed by using auricular cartilage [1].

Aladag I et al., described a novel endoscopic technique Caldwell-Luc approach to close the OAFs by harvesting bone from anterior wall of the maxillary sinus to obliterate the OAF [38].

Success Rate of Autogenous Cartilages [Table/Fig-1]

Studies on the use of autogenous cartilage (tragal, conchal, or septal) for closure of OACs suggest high success rates, generally over 90%. Cartilage is often preferred over other autologous materials like temporalis fascia, particularly in complex or revision cases, due to its rigidity, resistance to resorption and excellent long-term stability [1,3,34-36].

Allogeneous Materials

Lyophilised fibrin glue: Closure of OACs by using lyophilised fibrin glue of human origin was also described by some authors. Stajic Z et al., used Tissucol which is a lyophilised fibrin seal (human) and achieved complete closure of OAC in 16 patients out of 17 using a single application [39].

Kniha H et al., and Gattinger B used the fibrin glue in combination with a collagen sheet [40,41]. Advantage of this technique is that no need to raise the flap but according to the manufacturer this method carries a small risk of transmission of viral hepatitis and the preparation time needed for the fibrin glue. Kinner U and Frenkel G used lyophilised dura to treat OACs [1,42].

Acellular dermal graft tissue matrix: Blythe JN et al., reported a novel approach for the closure of a persistent OAF by using an acellular dermal graft tissue matrix (AlloDerm®) of cadaveric origin [43]. Beech AN and Farrier JN also reported acellular dermal graft as a novel approach in the treatment of persistent OAF [44]. They used the Integra® which is a two-layered system prepared of a bovine type I collagen and shark chondroitin-6-sulphate glycosaminoglycan. They used it successfully to close intraoral and extraoral defects of various aetiology.

Xenografts

The use of lyophilised porcine for closure of OAC/fistula has also been described in the literature. Shaker MA et al., in their study closure of chronic oroantral fistula was done by Zenoderm (lyophilised porcine dermis) covering the bony defects [45]. The Zenoderm was covered by buccal sliding and rotating pedicle palatal flaps.

Ogunsalu C described a new surgical technique to close the OACs by using Bio-Guide (porcine collagen membrane) and Bio-Oss (bovine bone grafting material) (Geistlich Pharma AG, Wolhusen, Switzerland) [46]. In this technique granules of Bio-Oss® were sandwiched between sheaths of suitably trimmed Bio-Guide® membrane.

Synthetic Closure

Gold/Aluminium/Tantalum/Titanium/Polymethyl methacrylate:

Synthetic materials have been also illustrated in the literature for closure of OACs. Studies have reported gold foil or gold plate for closure of OACs. Crollius used 24 carat 36 gauge gold plate for the closure of OAF [47]. Goldman EH et al., also use the gold foil and gold plate for the same purpose [48]. In this technique, the gold is annealed by heating to a cherry red colour and quenched in water. Then, it is laid over the defect site/opening and burnished down snugly against the bone. Both the tissue flaps buccal as well as palatal flap returned back to place over the gold and held in place without tension by sutures [49]. Shapiro DN and Moss M also successfully used this gold plate technique for closure of OAF in 16 out of 17 patients [49].

Steiner M et al., proposed 36-gauge pure aluminium plates for closure. Advantages of the aluminum are its malleability and softness, and also its low cost as compared to gold [50]. McClung EJ, Chipps JE reported use of tantalum foil (0.00025-inch thick and 1 inch in diameter) for closure of an OAF [51]. Tantalum is a highly biocompatible metal.

de Souza Lopes PH et al., described an alternative surgical technique for closure of OAF due to trauma caused by firearms using a titanium mesh combined with a palatal rotation flap for OAF closure [52]. Advantages of Titanium mesh are non resorbable, easily manipulated and biocompatible. Polymethyl methacrylate has been described as an alternative technique for closing OAFs by Al Sibahi A and Shanoon A [53]. This technique involves the immersion of polymethyl methacrylate plate in a sterilising solution for 24 hours and then this plate is placed over the defect.

Hydroxylapatite: Zide MF and Karas ND used hydroxylapatite blocks for closure of OAFs [54]. In this technique, a non porous HA block was carved to shape and fitted to the defect. A 26-gauge wire was passed after drilling holes in both the bony margins. The HA block was held by tightening of the wire. Primary closure was achieved without compromise of the vestibular tissue height.

Bioabsorbable root analog β -tricalcium phosphate: Bioabsorbable root analog β -tricalciumphosphate was used by Thoma K et al., for the closure of OACs [55]. They described this technique as a valuable alternative for close OACs but cannot be performed in all patients because of technical limitations.

Success Rate of Synthetic Materials for Closure of OAC/OAF [Table/Fig-1]

Synthetic materials for closure of OAC/OAF, often in combination with soft-tissue flaps showed high efficacy in clinical studies and success rate range from 90-95%, this generally depend on factors like size of the defect, chronicity, and the presence of sinusitis [54,55].

Other Techniques

Third molar transplantation: Kitagawa Y et al., described third molar transplantation as a promising and unique option for immediate closure of OAC after extraction [56]. The recipient site is prepared; the donor third molar is carefully extracted with least injury to the root surface and is transplanted to the prepared bone socket. It is very critical that there must be minimal delay/time lapse between extraction and transplantation to ensure preservation of periodontal membrane vitality [57].

Assad M et al., evaluated the auto-transplantation of upper third molar for closure of OAF in their study and achieved success in 95% cases [58]. Nagori SA et al., also reported a case of OAC treated by autogenous third molar transplantation [57]. On 18 months of follow-up, the autotransplanted tooth was functioning well with radiographic evidence of lamina dura and periodontal ligament space.

Advantage of this technique is that no need to harvest any bone graft from regional or distant site and also no dependency on any synthetic material to close the defect. Most of the times third molar is not functional and with time it may require extraction, so its use as a means of closure the defect is very crucial, however in certain situation where the third molar can acts as an abutment in fabrication of fixed prosthesis in replacing adjacent teeth, in this particular clinical scenario loss of third molar would affect future fixed prosthetic rehabilitation [56-58].

Interseptal alveolotomy: Use of interseptal alveolotomy was also described for closure of small OACs by Hori M et al., [59]. This procedure is based on the Dean's preprosthetic technique which is originally designed for smoothing the alveolar ridge. In this extended Dean's technique, the interseptal (interradicular) medullary bone is removed anteriorly and posteriorly to the fistula using a bur, then following the vertical osteotomies, finger pressure is used to fracture the buccal cortex in the direction of the palate. This produces a horizontal "greenstick" fracture across the floor of the sinus. In this technique the bony base is created for closure which results in less postoperative swelling compared with a flap procedure.

Major advantage of this technique is that the autogenous graft is available locally close to the defect region; however it may also affect the future prosthetic rehabilitation [59].

Guided tissue regeneration: The application of guided tissue regeneration technique for the closure of OACs was described by Waldrop TC and Semba SE [60]. This technique entails an absorbable gelatine membrane, allogenic bone graft material, and a non resorbable poly-Tetra-Fluoro-Ethylene (ePTFE) membrane. Disadvantages of the method are the need for a full-thickness flap and a second procedure to remove the non resorbable ePTFE membrane [60].

Logan RM and Coates EA explained a procedure to ease the closure of OAF in immuno-compromised patients [61]. The OAF was de-epithelialised under local anaesthesia, and the patient was put on an acrylic surgical splint constantly for an eight weeks period. The

splint should cover the fistula and edentulous area including the hard palate. The authors reported the complete healing of the OAF.

Human Amniotic Membrane (HAM): Laxmi S et al., used human amniotic membrane for the closure of OAC [62]. In this technique, a donor mother was recognised who was to undergo caesarean section. The donor was screened for any infections like HIV and hepatitis B surface antigens, and other routine investigations were carried out. During the caesarean, the placenta was collected by the obstetrician and handed over to the oral and maxillofacial surgeon who then carefully separated the amniotic membrane from the chorion of the placenta under sterile aseptic conditions. This amniotic membrane was cleared of all blood clots and gross tissue attachment, then it is stored overnight in a large bottle containing 85% of glycerol and 5 mL of gentamycin 80 mg/mL and stored in refrigerator at a temperature of 4°C. On the next day, just prior to its application over the recipient site, the membrane was soaked in normal saline for a period of 10 minutes. Amniotic membrane was then folded in layers, applied over the extraction socket and secured with sutures.

Human Amniotic Membrane (HAM) and healing was clinically evaluated at various intervals. The study showed that the human amniotic membrane is an efficient graft material for repairing the defect created by an iatrogenic OAC following tooth extraction.

The HAM as biological substitutes can be efficient scaffolds for promoting the repair of OAC/OAF. Its ease of availability, cost-effectiveness, simple preparation, and simple storage requirements facilitates its application in most conventional dental and maxillofacial units [62].

Platelet-Rich Fibrin (PRF): Recently the use of Platelet-Rich Fibrin (PRF) for closure of OAC has gained interest. PRF is a new generation platelet concentrate which was first described by Dohan DM et al., [63,64]. A PRF clot is formed by platelets, white cells, cytokines, and circulating stem cells enmeshed in a fibrin matrix. Also, it is a natural biomaterial to facilitate optimal healing. PRF can be sutured to tissue due to its three dimensional fibrinous architecture [40]. Agarwal B et al., described the use of PRF as a new technique for closure of OAF [65]. They prepared four PRF clots which are then squeezed to form a membrane. Three of them rolled together to create a cylinder-shaped fibrin plug to seal the fistula while the last one was sutured below the buccal and palatal flap to close the oral cavity from the underlying fistula and the fibrin plug. Gülsen U et al., performed flap-free treatment of an OAC with PRF [64]. Assad M et al., reported two cases of OAC which were successfully managed by platelet rich fibrin [66]. Kapustecki M et al., described PRF along with autogenous bone grafts as an alternative treatment strategy for the closure of OAF [67]. Bilginaylar K compared the clinical outcomes of buccal advancement flap versus PRF application for the immediate closure of acute OAC in his study [68]. He highlights the advantages, particularly it is associated with reduce pain and swelling as compared to buccal advancement flap surgery. Furthermore, PRF procedure was less traumatic, more appropriate and less stressful. Pandikanda R et al., described flapless closure of Oro-antral communication with PRF membrane and composite of PRF and collagen in three patients and achieved good result [69].

The PRF as a new technique for closure of OAC/OAF is crucial in terms of autogenous, atraumatic, less postoperative pain and swelling in comparison to other soft-tissue flap or bone graft procedures with an excellent postoperative outcome [69].

DISCUSSION

The association among the maxillary sinus floor and maxillary posterior teeth always have a challenge in treatment procedures like extraction, or surgical removal of maxillary posterior teeth which are close to maxillary sinus, can lead to development of Oro-antral communication [70]. If unable to close spontaneously and left untreated can lead to development of OAF and further sequelae.

With the presence of a fistula the sinus is permanently open, which enables the passage of microbial flora of the oral cavity into the maxillary sinus and the occurrence of inflammation with all possible consequences [1].

Many approaches to the management of OACs have been described. Starting from simple tissue flaps to autogenous grafts to alloplastic materials, an array of procedures have been evaluated in literature [1,3]. Although any technique can be used for closure

of OAF and good results can be obtained but every technique has some shortcomings and pitfalls. So the choice of surgical technique used for closure of OAF varies under different clinical conditions and also depends on the outcome desired like choice for bone or bone substitute grafting technique if dental implant has to be placed in near future [1-5]. Studies/case reports described various surgical techniques and related details is shown in [Table/Fig-2] [1,2,12-15,17,20,22,24-30,32,39,45-47,49-52,54-56,58-60,62,66,68-77].

S. No.	Author, year	No. of patients	Age range/ Gender	Site	Aetiology	Treatment method	Complications
Autogenous soft-tissue flaps							
Buccal/Palatal flap							
1.	Ehrl PA (1980) [12]	175	-	-	-	Palatal flap	-
2.	Lin PT et al., (1991) [71]	16	-	-	-	Buccal and/or palatal	-
3.	Salins PC and Kishore SK (1996) [13]	12	-	Large tuberosity defect	-	Anteriorly based palatal flap	-
4.	Lee JJ et al., (2002) [14]	21	36-72 y 15: Male 6: Female	Defect located in third molar region	Extraction	Random palatal rotation flap	Failure occurred in 5 patients due to flap necrosis
5.	Yalçın S et al., (2011) [15]	23	17: Male 6: Females	10 cases: Left-side of the maxilla 13 cases: Right-side of the maxilla	20 cases: Due to extraction 1 Case: Cyst enucleation 2 cases: Arsenic leakage	The buccal advancement flap was used in 10 patients, and the palatal island flap in 13	Postoperative infection and fistula recurrence in 1 patient
Buccal Fat Pad (BFP)							
6.	Hanazawa Y et al., (1995) [72]	14	21-56 y 12: Male 2: Female	10 cases: First molar region	10 cases: Extraction 4 cases: Cyst	Pedicled buccal fat pad	1 case: Fistula
7.	Martin-Granizo R, (1997) [20]	30	-	10 cases in the superior maxillary area, 3 cases in the cheek mucosa, 2 cases in the oropharynx (1 soft palate and 1 tonsillar fossa)	15 cases: Due to tumoral resection 8: Maxillary cyst 6: Communication 1: Post traumatic defect	Pedicled buccal fat pad	Partial necrosis of the flap in 2 with no clinical repercussions, achieved a complete epithelisation later
8.	Adams T (2015) [73]	40	-	-	-	Combined approach, functional endoscopic surgery and BFP/ buccal advancement flap with BFP	No reported complications except tightness in the graft area to paresthesia of nerve V2
9.	Yang S et al., (2018) [17]	3	Case 1: F-21 y Case 2: F- 80 y Case 3: M-80 y	Case 1: Right maxillary posterior area Case 2: Right maxillary posterior area Case 3: Left maxillary posterior area	Case 1: Impacted third molar right-side and large cystic lesion Case 2: Osteomyelitis Case 3: Recurrent ameloblastoma	Pedicled buccal fat pad in all the three patients	No reported complications
Tongue flap							
10.	Coghlan K et al., (1969) [22]	20	18-37 y 11: Male 9: Female	Oro-nasal fistulae	Cleft lip and palate deformity	Anteriorly based dorsal tongue flap	Failure in 3 cases due to flap necrosis, detachment and mechanical flap destruction
11.	Kim YK et al., (1998) [24]	16	16 to 65 years	3 case: Oro-nasal fistulae 1 case: OAF	Traumatic defects	Tongue flap	1 case: Partial necrosis 1 case: Infection
Autogenous bone grafts							
12.	Proctor B (1969) [29]	18	-	-	-	Iliac crest	-
13.	Haas R et al., (2003) [30]	5	32-50 years	4 cases: Left-side of maxilla 1 case: Right-side of maxilla	4 cases: Due to explantation 1 case: Extraction	Chin region	In 1 patient, mucosal dehiscence
14.	Watzak G et al., (2005) [2]	21	Age range, 32-73 years	14 cases: Left-side of Maxilla 9 cases: Right-side of Maxilla	Mostly extraction of tooth followed by implant removal	In 17 cases: Graft from retromolar region 4 cases: Graft from interforaminal regions of the mandible	In 3 cases, mucosal dehiscence
15.	Peñarrocha-Diago M et al., (2007) [32]	1	52 y Female	Maxillary right second molar	Extraction	Zygomatic bone	No reported complications
Autogenous cartilage grafts							
16.	Ram H et al., (2016) [1]	20	18 to 65 y	9 cases: Maxillary 1 st molars region, 6 cases: Maxillary 2 nd molar, 3 cases: Maxillary 2 nd premolar, 2 cases: maxillary 1 st premolar	Extraction in 80% cases, Cyst in 15% cases	Auricular cartilage graft	2 patients: Graft extrusion

Allogeneous material							
17.	Stajic Z et al., (1985) [39]	17	19 to 55 y	-	13 patients: Extraction, 3 patients: Persistent OAF, failure of surgical technique 1 case: Persistent fistula formed upon removal of the gold plate	Lyophilised fibrin seal (Tissucol)	1 patient: Persistent fistula
Xenografts							
18.	Shaker MA et al., (1995) [45]	10	-	-	-	Zenoderm (lyophilized porcine dermis)	1 patient: Infection
19.	Ogunsalu C (2005) [46]	1	40 y Male	Right maxillary second molar	Extraction	Bio-Oss-Bio-Gide (pure collagen membrane) Sandwich technique	-
20.	Sandhya G et al., (2013) [74]	10	19-42 y 5: Males 5: Females	Mostly maxillary right 2 nd molar region	Extraction	Resorbable guided tissue regeneration membrane (PERIOCOL-GTR) and freeze dried mineralised bone allograft material-Sandwich technique	No reported complications
Synthetic/Metal closure							
21.	McClung E and Chipps J (1951) [51]	4	-	-	-	Tantalum foil	No reported complications
22.	Crolius WE (1956) [47]	4	-	-	-	24 carat. 36 gauge Gold plate	-
23.	Shapiro DN and Moss M (1972) [49]	17	-	-	Mostly extraction	Gold plate	1 case
24.	Steiner M et al., (2008) [50]	8	39-64 yrs 4: Male 4: Female	6 cases: Maxillary left-side 2 cases: Maxillary right-side	Extraction	Aluminum plates	No reported complications
25.	Ahmed WMS (2015) [75]	10	Age range 29 to 52 years 8: Male 2: Female	8 cases: Right-side of maxilla 2 cases: Left-side of maxilla	Extraction	Titanium plates with transalveolar wiring fixation	No reported complications
26.	de S Lopes PH, (2015) [52]	1	41 y male	Perforation entrance on the palate	Firearm projectile wound	Palatal flap rotation combined with the use of titanium mesh	-
27.	Thoma K et al., (2006) [55]	20	Mean age 38±11 y 11: Male 9: females	-	Extraction	β- tricalcium phosphate root analogs	No reported complications
28.	Zide MF and Karas ND (1992) [54]	6	Case 1: 38 y male Case 2: 32 y female	Case 1: Right maxillary second molar region Case 2: Upper first molar region	Extraction	Hydroxylapatite (HA) blocks	No reported complications
Other technique							
29.	Kitagawa Y et al., (2003) [56]	2	Case 1: 31 y female Case 2: 30 y female	Case 1: Left upper first molar Case 2: Left upper second molar	Extraction	Third molar transplantation	No reported complications
30.	Assad M et al., (2018) [58]	20	20-40 y Males > Females	75% Cases: Maxillary first molar region 25%: Maxillary second molar region	Extraction	Third molar transplantation	Failure in 2 cases
31.	Hori M et al., (1995) [59]	8	-	-	6 cases: Extraction 2 cases: Extraction and cyst removal	Interseptal alveotomy	-
32.	Grzesiak-Janak G and Janak A (2001) [76]	61	Age range: 14-58 y 38: Male 23: Female	54 cases: Maxillary first molar region 7 cases: Maxillary third molar region	Extraction	Laser light	No reported complications
33.	Waldrop TC and Semba SE (1993) [60]	2	Case 1: 63 y Male Case 2: 74 y Male	Case 1: Mid-lingual surface of the palatal root of the maxillary left first molar. Case 2: Facial furcation and mesial buccal root of the maxillary left first molar	Advanced periodontitis	Absorbable gelatin film (membrane), allogenic bone graft material (DFDBA), and non resorbable expanded Polytetrafluoroethylene (ePTFE) membrane	No reported complications
34.	Lakshmi S et al., (2015) [62]	1	29 years female	Upper right second molar tooth region	Extraction	Human amniotic membrane	No reported complications
35.	Assad M (2017) [66]	2	Case 1: 29 y Male Case 2: 44 y female	Maxillary first molar region in both cases	Extraction	Platelet-rich Fibrin (PRF)	No reported complications

36.	Bilginaylar K (2019) [68]	36	Two groups	Group-A (PRF Group): 21 patients Group-B (Buccal advancement flap): 15 patients	Extraction	Group A: PRF Clot used Group B: Buccal advancement flap	No reported complications in both groups
37.	Demetoglu U et al., (2018) [77]	21	12 cases: Male 9 cases: Female	14 cases: First molar tooth region 4 cases: Second molar tooth region 2 cases: Third molar tooth region and 1 cases: Second primary molar tooth	Extraction	Platelet-rich Fibrin (PRF)	-

[Table/Fig-2]: Studies/Case reports describing various surgical techniques for closure of Oroantral Communication (OAC)/fistula and their related details [1,2,12-15,17,20,22,24-30,32,39,45-47,49-52,54-56,58-60,62,66,68-77].

The condition of sinus mucosa is very important aspect while formulating the treatment plan. Complete elimination of any sinus pathology must be done in order to achieve the successful closure of the OACs/OAFs [6,10]. Soft-tissue closure by using buccal or palatal flap is most commonly performed flap procedure for closure of OAC [3].

The use of a pedicled BFP in closure of large Oro-antral openings has become popular. Many surgeons preferred to combine the BFP flap with a buccal advancement flap producing a double-layer closure which amplified the success rate of OAC closure as compared with single-layer closure [5]. Other distant flaps from the extremities or forehead or tongue flaps have also been described. However, soft-tissue closure alone may not succeed in case of large or chronic OAFs, need of implant rehabilitation or pre-implant surgical procedures, like sinus lift. Coverage of the soft-tissue alone above a bony defect might result in a dead space, accumulated excess fluid/haemorrhage can produce pressure on the wound edges leading to the failure of surgical closure [2]. Incorporation of a biologic "barrier" like bone in defect region close to the sinus floor act as a scaffold and avoid oral soft-tissue collapse into the defect, also it prevent pneumatisation of maxillary sinus and matting of the sinus membrane to the oral soft-tissue [2].

When placement of an endosseous implant is desired, bone grafting for closure of the OACs might be the best option. Bone harvesting from the intraoral site is more favoured and suitable in terms of reducing patient morbidity as compared to extra oral site but due to concern of donor site morbidity and second surgical procedure, other grafting options/material gained attention like allograft, xenografts, alloplastic or synthetic materials. All these are having their own advantages and limitations. Recently, the application of PRF an autologous biomaterial gained attention as an effective technique for closure of OACs/OAFs.

CONCLUSION(S)

Based on this review it may be concluded that a broad array of techniques have been proposed in the literature for the closure of OACs/OAFs. Some aspects must be taken into consideration to decide the suitable approach for treating the OACs/OAFs like the size of the defect, its time of diagnosis whether it is acute or chronic, the presence of any local or sinus infection, availability of soft/hard-tissue options for repair and the future aspects for dental implant rehabilitation need. All these factors possibly influence the treatment strategy and one should manage the same in an appropriate manner.

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