Assessment of the Effects of Curacel and Bone Wax on the Acute Oroantral Opening Site by means of Computer Tomography and Histopathology

Mehtap Muglali · Ahmet Ozak · Murat Yarım ·
Mehmet Selim Nural · Nukhet Celebi ·
Tolga Aksoz

Received: 6 April 2011 / Accepted: 22 August 2011 / Published online: 23 September 2011
© Association of Oral and Maxillofacial Surgeons of India 2011

Abstract

Purpose In this study, the effects of Curacel TM oxidized regenerated cellulose and bone wax on the healing bone were compared to each other by means of CT based bone density measurement and histopathological evaluation.

Methods The bone density measurements of the control group were significantly higher than those of both Curacel and bone wax groups.

Results There was no significant difference between Curacel and bone wax. Histopathologically, the bone wax group showed more osteoblastic activation than Curacel group. For all measurement parameters (osteoblastic activation, osteoclastic activation, fibrous connective tissue, osseous trabeculae), Curacel and bone wax groups had worse results than control group. It is concluded that Curacel has no superiority over bone wax in terms of

osseous healing in the oroantral region. There is no need to use oxidized regenerated cellulose or bone wax for small oroantral openings since the healing is better without any intervention. In addition, bone density measurement and histopathological evaluation were consistent in terms of osseous healing of the oroantral opening.

Keywords Oroantral communication · Curacel · Bone wax · Wound healing · Oxidized regenerated cellulose

Introduction

An oroantral communication (OAC) is an open connection between the oral cavity and maxillary sinus. OACs are usually caused by the extraction of the maxillary posterior teeth [1–3]. The incidence rates are 0.31 and 4.7% after the extraction of upper teeth [1, 4]. The presence of an OAC itself is not a major problem; however, severe complications with persistent sinusitis can occur if proper treatment is not provided. Smaller OACs are often closed by a coagulum and heal spontaneously. In the literature, it is reported that the dimensions of small OACs vary from 5 mm [5] to 3 mm [6] and 2 mm [7]. However, it is difficult to determine the size of the OAC clinically, which makes it also difficult to predict whether an OAC will heal uneventfully without intervention. In order to prevent chronic sinusitis and the development of fistulas, it is widely accepted that all such defects should be surgically closed within 24–48 h [5].

The closure of OACs is commonly performed by a surgical procedure using a mucoperiosteal flap. Various forms of buccal flaps, palatal flaps, and tongue flaps are described in literature for this purpose [8–11]. Surgical closure has several disadvantages. The mobilization of soft

M. Muglali (✉)
Department of Oral Maxillofacial Surgery, Faculty of Dentistry,
Ondokuz Mayıs University, Dis Hekimligi Fakultesi,
Samsun, Turkey
e-mail: mehtapm@gmail.com

A. Ozak
Department of Surgery, Faculty of Veterinary, Ondokuz Mayıs
University, Samsun, Turkey

M. Yarım
Department of Pathology, Faculty of Veterinary, Ondokuz Mayıs
University, Samsun, Turkey

M. S. Nural · T. Aksoz
Department of Radiology, Faculty of Medicine, Ondokuz Mayıs
University, Samsun, Turkey

N. Celebi
Department of Oral Maxillofacial Surgery, Faculty of Dentistry,
University of Erciyes, Kayseri, Turkey

tissue flaps requires surgical expertise and equipment that may not be available when the OAC occurs [12]. Furthermore, in the short term, the patient suffers from more postoperative pain and swelling than an uncomplicated extraction. In the long term, the vestibular sulcus depth may remain permanently decreased. If the patient becomes (partly) edentulous, this might interfere with the proper construction of a prosthetic intraoral appliance.

Because of the disadvantages of surgical closure, several alternative treatment modalities have been suggested, including the third molar transplantation, hydroxylapatite blocks, bioabsorbable root analog, the Bio-Oss-Bio-Gide sandwich technique (Osteohealth, Shirley, NY) and bio-degradable polyurethane foam [3, 13–16]. In addition, some metals like gold [17], tantalum [18] and aluminum [19] are used for closures. Each technique has advantages and disadvantages of its own.

Homeostatic agents can be used to initiate and facilitate blood clot in the extraction socket for the treatment of small OACs. One of these, Bone wax (BW) is used in many surgical procedures to control bleeding. It is non-absorbable with no biochemical action. It achieves hemostasis by occluding the blood channels mechanically [20].

Another agent used to provide hemostasis is Curacel TM oxidized regenerated cellulose (ORC). Cellulosin is oxidized cellulose made of calcium. It provides hemostasis by reducing the pH and acting as a mechanical tamponade [21].

In this experimental study, the effects of Curacel (Curacel-i[®], CuraMedical B.V., Regenerated Oxidized Cellulose Gauze) and BW (Ethicon[®], Johnson & Johnson GNTL) on bone healing in the treatment of OACs in rabbits were evaluated by means of CT based bone density measurement and histopathological measurement.

Materials and Methodology

Before commencement of the study, the approval of the local ethics committee was obtained. Fifteen adult male New Zealand white rabbits were used in this study. BW was applied to ten different hemimaxillas and Curacel was applied to ten different hemimaxillas. Also, control group was composed of ten hemimaxillas. The first premolars of the rabbits were extracted under a combination of 2.5 mg/kg xylazine-hydrochloride (2% Alfazyme[®], Egevet) and 22–25 mg/kg ketamine (10% Alfamine[®], Egevet) anesthesia. The OACs were created with a 2 mm bur in the extraction sockets. 2 × 2 × 1 pieces were formed from bone wax in the form of flat slates by means of a tweezer and BW was placed to the apex of the socket in each hemimaxilla. The curacel in the form of braided cloth was

cut in similar dimensions and placed in the same way. OAC was formed in the control group and left as it is without placing any material. Since five hemimaxillas in the control group developed sinusitis, they were excluded from the study.

CT images were taken on the day of the surgery and on the 2nd, 4th, 8th and 12th weeks. The measurement of the bone density was performed by a radiologist who was uninformed of the material used. All CT studies were performed with a 16-MSCT scanner (Aquilion 16 system, Toshiba Medical Systems Corporation, Japan). Examination parameters were as follows: collimation, 16 × 0.5 mm; reconstruction interval, 0.5 mm; tube rotation period, 1 s, 120 kV, 50 mAs. The space between the posterior and anterior walls of the maxillary sinus was scanned in prone position. Coronal sections were obtained. The density was measured as Hounsfield Unit on the region of interest of the sections in which the oroantral communication was scanned. The density value of an individual oroantral communication was defined as a mean of these measurements, and compared in terms of different time periods. Kruskal–Wallis *H* and Mann–Whitney *U* tests were performed.

The rabbits were sacrificed using a high dose of pentobarbital at the end of the 12th week. The tissue samples taken from the floor of the sinus which communicated with the extraction socket were fixed in 10% formalin for 24 h and decalcified in formic acid and sodium citrate solutions. A comparative histopathological analysis of the maxillary sinus floor was carried out with hemimaxillas. Decalcified tissue samples were embedded in paraffin and sections of about 5 µm in thickness were prepared using a microtome. The sections were stained with Masson's trichrome and hematoxylin and eosin (HE), and examined by light microscopy. Histopathological; 0: no changes, 1: mild, 2: moderate and 3: marked changes. The Kruskal–Wallis *H* Test was performed to compare the difference between the set of mean scores of the groups.

Results

Changes in CT Bone Density

The diameters of the OACs were reduced on the 8th and 12th weeks in all groups (Fig. 1). The mean density values of the groups are shown in Table 1. The density values of the groups were not statistically different on the 1st day, 2nd and 4th weeks ($P < 0.05$). The control group was significantly different from the Curacel and BW groups in the 8th week, whereas there was no significant difference between the Curacel and BW groups. However, the BW group was significantly different from the control group in the 12th week ($P < 0.01$).

Fig. 1 Axial CT scans of the OAC. Its diameter was reduced on the 8th and the 12th weeks. **a** 1st day, **b** 2nd week, **c** 4th week, **d** 8th week and **e** 12th week

Table 1 Mean density values of the groups*

Groups	Mean $\pm$ SD				
	1st day	2nd week	4th week	8th week	12th week
Bone wax	76.5 $\pm$ 43.29	109.9 $\pm$ 42.37	157.80 $\pm$ 64.42	197.60 $\pm$ 55.71	282.30 $\pm$ 91.66
Curasel	34.5 $\pm$ 48.2	124.1 $\pm$ 62.66	201.30 $\pm$ 76.08	223.60 $\pm$ 93.91	304.10 $\pm$ 105.88
Control	75.8 $\pm$ 21.07	126.0 $\pm$ 44.10	192.4 $\pm$ 90.13	350.0 $\pm$ 56.56	415.0 $\pm$ 24.74

* $P < 0.05$

Histopathological Findings

The tissue changes at the end of the 12th week of Curacel, BW and control groups are shown in Table 2. Four hemi-maxillas to which BW were placed were excluded because OAC could not be found in their sections. The formation of the osseous trabecule and connective tissue were observed in all groups (Fig. 2a–f). In one case of each Curacel and BW groups, giant-cells were encountered (Fig. 3). Chronic inflammation was observed in both of the groups.

Statistical analyses showed no significant difference between the three different groups in the 12th week ($P > 0.05$). The mean scores of the groups are shown in

Table 3. The bone wax group showed more osteoblastic activation than the Curacel group. For all measurement parameters (osteoblastic activation, osteoclastic activation, fibrous connective tissue, osseous trabeculae), both the Curacel and bone wax groups had worse results than the control group ($P < 0.05$).

Discussion

The treatment modalities of OAC are a concern for maxillofacial surgeons. In the previous literature, there are many studies evaluating the effects of the treatment

Table 2 The tissue changes in the 12th week of Curacel, BW and control groups

Groups	Fibrous connective tissue	The formation of osseous trabeculae	Osseoclastic activation	Osseoblastic activation
Curacel	+++	+++	–	–
Curacel	+++	+++	–	+
Curacel	++	++	++	+
Curacel	++	+	–	–
Curacel	++	++	–	–
Curacel	++	++	–	–
Curacel	++	++	–	–
Curacel	++	+	–	–
Curacel	+	+	–	–
Curacel	++	+	–	–
BW	++	++	–	–
BW	++	++	–	+
BW	++	++	–	+
BW	+++	+++	–	++
BW	++	+++	–	–
BW	++	++	++	+
Control	+++	+++	++	++
Control	+++	+++	++	++
Control	+++	+++	++	+++
Control	+++	+++	++	++
Control	+++	+++	++	+++

– None, + mild, ++ moderate, +++ severe

Fig. 2 Histopathological appearance of the groups at the 12th week. **a** Control group. Presence of thick osseous trabeculae and connective tissue in the oroantral communication. HE, $\times 60$. **b** Control group. Connective tissue and thick osseous trabeculae in the lumen of the oroantral communication. HE, $\times 300$. **c** Curacel group. Thin connective tissue surrounds the oroantral communication. HE, $\times 60$. **d** Curacel group. Thin connective tissue surrounds the oroantral

communication. The oroantral communication presents a thick osseous trabeculae. HE, $\times 60$. **e** BW group. Thick connective tissue surrounds the oroantral communication. The oroantral communication presents an osseous trabeculae. HE, $\times 120$. **f** BW group. Thin connective tissue surrounds the oroantral communication. Osteoid tissue and BW material fills the oroantral communication. HE, $\times 120$

Fig. 3 Curacel group. 12 weeks postoperative. Thin connective tissue surrounds the curacel material. An osseous trabeculae and some giant cells present in this connective tissue. HE, $\times 300$

techniques on the healing process using either osteogenic tissues or biomaterials. These studies often investigate the surgical closure techniques in patients with an OAC larger than 6 mm in diameter [22]. The techniques for smaller acute OACs are limited, and they can be treated by maintaining a blood clot using a homeostatic agent without any further intervention.

As far as known, there is no report in literature evaluating the treatment of sinus communications of small diameter using BW. This may result from the fact that surgeons avoid problems associated with the hydrophobic nature of bone-wax and its minimal resorption in the organism [23, 24].

BW provides hemostasis in osseous surfaces by mechanical tamponade. It allows formation of the clot by blocking the blood flow of the damaged vein. The idea that BW may obstruct the communication between the oral and antral cavities was the basic hypothesis of this experimental study. BW was chosen, for it is cheap and can easily be shaped. This material's plasticity helped us apply it to the extraction socket with ease. Authors claim that bone-wax inhibits new bone formation [25, 26] and provides hemostasis by producing an intense foreign-body and inflammatory reactions [23, 24]. Von Arx et al. [27] reported that BW remnants produced an intense tissue reaction after periradicular surgery.

In contrast to these studies, no significant adverse effect of BW was found on bone regeneration. In the present study, chronic inflammation cells were encountered in all samples and giant-cells in one case of the BW group. Low-grade inflammation was associated with new bone formation. Hence, although better results were obtained for all parameters measured in the control group compared to the BW group, BW was not considered to be an inappropriate material for the treatment of OAC.

It was previously reported that Surgicel[®] with ORC content has positive effects on osseous healing of the jaw bone [28]. Favorable effects of Surgicel[®] on osseous healing in the treatment of cleft palate was first described by Skoog and later by Thilander [29, 30]. Olson et al. [28] confirmed this effect for the healing of the extraction socket. Recently, authors have evaluated the effects of Surgicel[®] in MS elevation surgery. In their study, Gray et al. [31] reported new bone formation after using it as a grafting material for the augmentation of the MS floor. Jensen et al. [32] also reported favorable results using Surgicel[®]. In the present study, Curacel, which is an equivalent of Surgicel[®], was used to provide homeostasis in the treatment of OAC. OT formation was, however, better in the BW group than in the Curacel group. It is, therefore, concluded that Curacel has no superiority over BW for the osseous healing in the oroantral region.

CT was used to evaluate quantitative bone healing [33, 34]. In the present study, bone density was observed to increase in weeks on the CT images. In the 12th week, the control group showed better density than the BW group in CT evaluation. Although it was not significantly different from the Curacel group, the mean density values were observed to be higher than both BW and Curacel groups.

In this study, the gold standard was performed histopathologically. The study findings were consistent with CT. The bone improvement could have been assessed with smooth graphics, which is a limitation of the study.

Conclusion

On the basis of histopathology and CT, the results of this study show that hemostatic agents do not significantly

Table 3 Mean scores of the tissue changes in the 12th week of curacel, bone wax and control groups*

	Curacel group Mean $\pm$ SD	Bone wax group Mean $\pm$ SD	Control group Mean $\pm$ SD
Fibrous connective tissue	2.10 $\pm$ 0.56	2.00 $\pm$ 0.57	3.00 $\pm$ 0.00
The formation of osseous trabecula	1.80 $\pm$ 0.78	2.00 $\pm$ 1.00	3.00 $\pm$ 0.00
Osteoclastic activity	0.20 $\pm$ 0.63	0.57 $\pm$ 0.07	2.00 $\pm$ 0.00
Osteoblastic activity	0.20 $\pm$ 0.42	0.71 $\pm$ 0.75	2.50 $\pm$ 0.57

* $P < 0.05$

contribute to either new bone or fibrous connective tissue formation in the oroantral area. For this reason, further studies should investigate the clinical effects of using the same hemostatic agents for the treatment of acute OACs larger than 5 mm.

References

- Hirata Y, Kino K, Nagaoka S, Miyamoto R, Yoshimasu H, Amagasa T (2001) A clinical investigation of oromaxillary sinus perforation due to tooth extraction. *Kokubyo Gakkai Zasshi* 68:249–253
- Abuabara A, Cortez AL, Passeri LA et al (2006) Evaluation of different treatments for oroantral/oronasal communications: experience of 112 cases. *Int J Oral Maxillofac Surg* 35:155–158
- Thoma K, Pajarola GF, Gratz KW, Schmidlin PR (2006) Bio-absorbable root analogue for closure of oroantral communications after tooth extraction: a prospective case-cohort study. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 101:558–564
- del Rey-Santamaria M, Valmaseda CE, Berini AL et al (2006) Incidence of oral sinus communications in 389 upper third molar extraction. *Med Oral Patol Oral Cir Bucal* 11:E334–E338
- von Wowern N (1973) Correlation between the development of an oranal fistula and the size of the corresponding bony defect. *J Oral Surg* 31:98–102
- Martin-Granizo R, Naval L, Costas A et al (1997) Use of buccal fat pad to repair intraoral defects: review of 30 cases. *Br J Oral Maxillofac Surg* 35:81–84
- Guyen O (1998) A clinical study on oroantral fistulae. *J Cranio-maxillofac Surg* 26:267–271
- Johnson PA, Banks P, Brown AE (1992) Use of the posteriorly based lateral tongue flap in the repair of palatal fistulae. *Int J Oral Maxillofac Surg* 21:6–9
- Salins PC, Kishore SK (1996) Anteriorly based palatal flap for closure of large oroantral fistula. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 82:253–256
- el Hakim IE, el Fakharany AM (1999) The use of the pedicled buccal fat pad (BFP) and palatal rotating flaps in closure of oroantral communication and palatal defects. *J Laryngol Otol* 113:834–838
- Lee J-J, Kok S-H, Chang H-H, Yang P-J, Hahn L-J, Kuo YS (2002) Repair of oroantral communications in the third molar region by random palatal flap. *Int J Oral Maxillofac Surg* 31:677–680
- Grzesiak-Janias G, Janias A (2001) Conservative closure of antro-orantral communication stimulated with laser light. *J Clin Laser Med Surg* 19:181–184
- Zide MF, Karas ND (1992) Hydroxylapatite block closure of oroantral fistulas: report of cases. *J Oral Maxillofac Surg* 50:71–75
- Kitagawa Y, Sano K, Nakamura M et al (2003) Use of third molar transplantation for closure of the oroantral communication after tooth extraction: a report of 2 cases. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 95:409–415
- Ogunsalu C (2005) A new surgical management for oro-antral communication: The resorbable guided tissue regeneration membrane bone substitute sandwich technique. *West Indian Med J* 54:261–263
- Visscher SH, van Minnen B, Bos RR (2010) Closure of oroantral communications using biodegradable polyurethane foam: a feasibility study. *J Oral Maxillofac Surg* 68:281–286
- Goldman EH, Stratigos GT, Arthur AL (1969) Treatment of oroantral fistula by gold foil closure: report of case. *J Oral Surg* 27:875–877
- McClung E, Chipps J (1951) Tantalum foil used in closing antro-orantral fistulas. *US Armed Forces Med J* 2:1183–1186
- Steiner M, Gould AR, Madion DC, Abraham MS, Loeser JG (2008) Metal plates and foils for closure of oroantral fistulae. *J Oral Maxillofac Surg* 66:1551–1555
- Lavigne M, Reddi Boddu Siva KR, Doyon J, Vendittoli P-A (2008) Bone-wax granuloma after femoral neck osteoplasty. *Can J Surg* 51:E58–E60
- Masova L, Rysava J, Krizova P et al (2003) Hemostyptic effect of oxidized cellulose on blood platelets. *Sb Lek* 104:231–236
- Hanazawa Y, Itoh K, Mabashi T et al (1995) Closure of oroantral communications using a pedicled buccal fat pad graft. *J Maxillofac Surg* 53:771–775
- Anfinson OG, Sudmann B, Rait M et al (1993) Complications secondary to the use of standard bone wax in seven patients. *J Foot Ankle Surg* 32:505–508
- Allison RT (1994) Foreign body reactions and an associated histological artefact due to bone wax. *Br J Biomed Sci* 51:14–17
- Ibarrola JL, Bjorenson JE, Austin BP, Gerstein H (1985) Osseous reactions to three hemostatic agents. *J Endod* 11:75–83
- Alberius P, Klinge B, Sjogren S (1987) Effects of bone wax on rabbit cranial bone lesions. *J Craniomaxillofac Surg* 15:63–67
- Von Arx T, Jensen SS, Hanni S et al (2006) Haemostatic agents used in periradicular surgery: an experimental study of their efficacy and tissue reactions. *Int Endod J* 39:800–808
- Olson RA, Roberts DL, Osborn DB (1982) A comparative study of polylactic acid, gelfoam, and surgicel in healing extraction sites. *Oral Surg Oral Med Oral Pathol* 53:441–449
- Skoog T (1967) The uses of periosteum and surgicel for bone restoration in congenital clefts of the maxilla. A clinical and experimental investigation. *Scand J Plast Reconstr Surg* 1:113–130
- Thilander B, Stenstrom S (1974) Maxillary growth after implantation of surgicel in clefts of the maxilla. *Scand J Plast Reconstr Surg* 8:52–57
- Gray CF, Redpath TW, Bainton R et al (2001) Magnetic resonance imaging assessment of a sinus lift operation using reoxidised cellulose (surgicel) as graft material. *Clin Oral Implants Res* 12:526–530
- Jensen OT, Brownd C, Baer D (2006) Maxillary molar sinus floor intrusion at the time of dental extraction. *J Oral Maxillofac Surg* 64:1415–1419
- Choi BH, Yoo JH, Sung KJ (1996) Radiographic comparison of osseous healing after maxillary sinusotomy performed with and without a periosteal pedicle. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 82:375–378
- Lynch JA, Grigoryan M, Fierlinger A et al (2004) Measurement of changes in trabecular bone at fracture sites using X-ray CT and automated image registration and processing. *J Orthop Res* 22:362–367