Factors of Successful Treatment Using the Bone Lid Technique in Maxillofacial Surgery: A Pilot Study

Shintaro Sukegawa, Norio Yamamoto, Tamamo Matsuyama, Kiyofumi Takabatake, Hotaka Kawai, Hitoshi Nagatsuka and Yoshihiko Furuki

Department of Oral and Maxillofacial Surgery, Kagawa Prefectural Central Hospital, Kagawa, Japan
Department of Oral Pathology and Medicine, Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences, Okayama, Japan
Department of Orthopedic Surgery, Kagawa Prefectural Central Hospital, Kagawa, Japan

Correspondence to: Dr. Shintaro Sukegawa, Department of Oral and Maxillofacial Surgery, Kagawa Prefectural Central Hospital, 1-2-1 Asahi-machi, Takamatsu, Kagawa 760-8557, Japan; Tel: +81 87 811 3333; Fax: +81 87 835 8363; E-mail: gouwan19@gmail.com

Abstract: This study aimed to investigate the success factors of the bone lid surgery technique in the maxillofacial region. A retrospective cohort study was performed on 30 maxillofacial patients who underwent bone lid surgery between January 2014 and December 2019 at our hospital. The predictor variables consisted of clinical factors that were classified as attribute (age and sex), health status (smoking and alcohol intake), anatomical (maxillary/mandibular site, left/right side, and cortical bone thickness), lesion (lesion size, location, and pathological diagnosis), and treatment variables (differences in absorbable osteosynthesis materials). The outcome variable was the incidence of bone lid necrosis after surgery. Various risk factors for postoperative bone lid necrosis were investigated statistically. A p value <0.05 was considered statistically significant. Postoperative bone lid necrosis was observed in three patients (10.0%). No significant differences in the attribute, anatomical, and treatment status variables were noted. Significant differences were observed between smoking (p=0.005) and alcohol intake (p=0.003) in the health status variables. There was a significant difference in the distance of the lesion from the alveolar bone crest in the lesion variables (p=0.037). Smoking and alcohol consumption were the health status variables found to be risk factors for bone lid necrosis. In addition, proximity to the alveolar crest was also a risk factor for lesion development.

Key words: Bone lid, Maxillofacial surgery, Retrospective study, Cohort study, Risk factor, Smoking

Introduction

The bone lid surgery techniques in the maxillofacial area include cutting the bony window and removing a portion of the cortical bone. This temporarily removed section of the cortical bone is then repositioned to its original position at the end of the surgery. This surgical technique has the great advantage of preventing the formation of large bone defects following access to the osteotomy. It is also used in some surgical treatments of the maxillofacial area, including maxillary sinus-surgery and deeply impacted teeth, to gain good access to the surgical field.

Sivolella et al. suggested the following factors in choosing the bone lid surgery technique: anatomical limitations, lesion size, feasibility of creating a bony lid of sufficient size and thickness, and patient characteristics. However, the success factors of the bone lid surgery technique in the maxillofacial region are unknown. Surprisingly, there are no previous studies or literature that clinically investigate the risk factors associated with bone lid surgery, so pointing to these factors is very important and novel. Therefore, this retrospective study aimed to investigate the success factors of the bone lid surgery technique in the maxillofacial region as a previous study.

Study design and patients

A retrospective cohort study was conducted using clinical records and radiographic image data, including computed tomography (CT) and panoramic radiographs obtained from maxillofacial patients who underwent bone lid surgery between January 2014 and December 2019 at our hospital, Takamatsu, Japan.

The inclusion criteria for this study were as follows: patients requiring removal of lesions that were completely covered by the maxilla or mandible, consent for bone lid removal in the jaw using the bone lid technique, and the ability to attend scheduled clinical and radiological follow-ups (maxilla; >1 year, mandible; >6 months). The exclusion criteria were as follows: loss to follow-up, absence of radiographic images, and incomplete medical records. Individuals who were pregnant, those taking antiangiogenic medications or anti-resorptive agents such as bisphosphonates or anti-receptor activator of NF-κB ligand monoclonal antibody, and those who had received radiotherapy to the head and neck were excluded from the study.

Of the 33 patients who underwent bone lid surgery, 30 eligible patients who met the inclusion criteria were enrolled in the study. This study was approved by the Ethics Committee of Kagawa Prefectural Central Hospital (Approval No. 967). Ethical considerations were applied throughout the study, and patients’ personal information was anonymized, making the data impossible to identify through medical research.
Surgical procedure and follow-up

All procedures were performed with conscious sedation or general anesthesia. Local anesthesia was used in combination in the treatment of all patients. Depending on the location of the lesion in the jawbone, a full-thickness flap of appropriate size and shape was raised to access the cortical bone above the lesion. In order to achieve an appropriate osteotomy design, a diagnostic model was created preoperatively using CT images to create a detailed treatment plan. A bone lid was created using a piezoelectric device with an appropriate osteotomy tip (Piezosurgery Touch, Mectron, Italy) for all patients. The osteotomy was performed with an internal bevel angle to facilitate repositioning. The removed bone lid was soaked in a physiological solution. After excision of the lesion, the bony lid was returned to its original position and fixed to the bone with an absorbable plate. Absorbent plates were arbitrarily selected by the operator from among the following types: (1) poly-L-lactide (PLLA); (2) GRAND FIX® (Gunze, Kyoto, Japan), uncalcined and unsintered hydroxyapatite (u-HA) particles, and PLLA; (3) Super FIXSORB MX® (Teijin Medical Technologies Co., Ltd., Osaka, Japan), PLLA, and polyglycolic acid (PGA) (LactoSorb®, Lorenz Surgical, Jacksonville, FL, USA).

Primary wound closure was performed using 4-0 sterile absorbable braided PGA sutures (Surgisorb 4-0; Nitcho Corporation, Tokyo, Japan). The same protocol for postoperative clinical management was utilized for all patients. After the surgery, the patients were administered antibiotics (amoxicillin hydrate, 250 mg) thrice daily for 2 days and nonsteroidal anti-inflammatory analgesics (celecoxib 400 mg (for initial pain) or 200 mg every 6 h (for second or succeeding episodes) or acetaminophen 400 mg). Representative cases of the maxilla and mandible were shown in Figs 1 and 2.

All medical records were examined by the two investigators who also took the measurements.

Outcome variables

The outcome variable was the incidence of bone lid necrosis after surgery. The diagnosis of bone lid necrosis was confirmed using CT and panoramic radiographs. Radiographic images were taken at follow-up and when a postoperative infection was clinically suspected.

Predictor variables

The predictor variables for this study consisted of clinical factors that were considered to be convincingly related to postoperative bone lid necrosis and were classified as attribute, health status, anatomical, lesion, operative, and treatment variables.

The attribute variables included age and sex. Health status variables...
included smoking and alcohol intake. Anatomical variables consisted of maxillary/mandibular site, left/right side, and cortical bone thickness. The thickness of the cortical bone was measured by CT using the thinnest part of the cortical bone on the buccal side of the jawbone, which creates the bone lid. Lesion variables included lesion size, location, and pathological diagnosis. The lesion size was measured by CT using the maximum diameter of the mesiodistal and buccolingual diameters. The lesion position was evaluated by setting a perpendicular line passing through the alveolar crest on the occlusal plane and measuring the distance from the alveolar crest to the lesion (Fig. 3).

Using CT, distance measurement was performed thrice by two oral and maxillofacial surgeons, and the average value was used. The treatment variables were the materials that fixed the bone lid to the existing jawbone. The absorbable osteosynthesis materials were composed of three types: PLLA, PLLA/PGA, and u-HA/PLLA.

**Statistical analysis**

Data were recorded and entered into an electronic database using Microsoft Excel (Microsoft Inc., Redmond, WA, USA) over the course of this study. Means and standard deviations (SDs) were used to express data. The database was constructed and analyzed using JMP version
14.2.0 for Mackintosh (SAS Institute Inc., Cary, NC, USA). Predictor variables were treated as follows: For quantitative data, a t-test was used when the data were normally distributed; otherwise, a t-test was used. A Mann-Whitney U test was performed. Pearson’s squared t-test was performed on the qualitative data. P values <0.05 were considered statistically significant.

Results
A total of 30 patients (mean age ± SDs, 36.7 ± 19.6; range, 12-77 years; male/female ratio, 19:11) who underwent bone lid surgery in the maxillofacial region were included in this study. Postoperative bone lid necrosis was observed in three patients (10.0%). No significant differences in the attribute, anatomical, and treatment status variables were noted. Significant differences were observed between smoking (p=0.005) and alcohol intake (p=0.003) in the health status variables. There was a significant difference in the distance of the lesion from the alveolar bone crest in the lesion variables (p=0.037). Bone lid necrosis was more likely to develop near the alveolar crest (Table 1).

Discussion
This study investigated the risk factors for postoperative osteonecrosis following surgery using the bone lid technique. The success rate of middle lesions in the jaw bony lesion was 90%. Smoking and alcohol consumption were the health status variables found to be risk factors for bone lid necrosis. In addition, proximity to the alveolar crest was also a risk factor for lesion development.

The bone lid method is used to gain access to lesions located deep inside the jawbone. The approach used for deep jaw bony lesions is usually very invasive because it involves the removal of large bones. At the same time, the jawbone is lost. Thus, this surgical procedure, which combines a reliable surgical field of view and jawbone preservation, is of great importance for oral and maxillofacial surgeons. This method has enabled the complete removal of jaw bony lesions and accurate examination of recurrent surgical fields. A reduced risk of recurrent cysts has also been reported by other maxillofacial surgeons.

Despite the bone lid procedure being a useful technique, a study on the risk factors for bone lid necrosis, which is a serious postoperative complication, has not yet been conducted so far. Sivolella et al. reported one case of lid necrosis, which was caused by sports trauma, in a case series study. Unfortunately, only case reports were made, and risk factors were not examined. In our study, risk factors for bone lid necrosis were identified. Postoperative necrosis of the repositioned cortical bone is considered severe with uncontrolled infection. In our study, infection

|              | Bone healing N=27 | Infection N=3 | p value |
|--------------|-------------------|---------------|---------|
| Attribute variables |                   |               |         |
| Age          | 35.4 ± 20.2       | 48.7 ± 3.5    | 0.273   |
| Sex          |                   |               | 0.165   |
| Male         | 16                | 3             |         |
| Female       | 11                | 0             |         |
| Health status variables |           |               |         |
| Smoking      |                   |               | 0.005   |
| Yes          | 6                 | 3             |         |
| No           | 21                | 0             |         |
| Alcohol      |                   |               | 0.003   |
| Yes          | 5                 | 3             |         |
| No           | 22                | 0             |         |
| Anatomical variables |           |               | 0.105   |
| Maxilla/ Mandible |             |               |         |
| Maxilla      | 11                | 0             |         |
| Mandible     | 13                | 3             |         |
| Left / Right |                   |               | 0.900   |
| Left         | 10                | 1             |         |
| Right        | 17                | 2             |         |
| Cortical bone thickness (mm) | 1.67 ± 0.66 | 1.83 ± 1.04  | 0.716   |
| Lesion variables |             |               |         |
| Mesiodistal diameter (mm) | 15.65 ± 6.25 | 13.57 ± 1.03 | 0.574   |
| Buccolingual diameter (mm) | 9.49 ± 2.97 | 11.96 ± 2.15 | 0.176   |
| Distance from alveolar crest (mm) | 9.65 ± 3.06 | 5.68 ± 1.44 | 0.037   |
| Pathological diagnosis |           |               |         |
| Radicular cyst | 8                | 0             | 0.329   |
| Follicular cyst | 15               | 3             |         |
| Benign tumor  | 4                 | 0             |         |
| Treatment variables |           |               |         |
| PLLA         | 2                 | 1             |         |
| PLLA/PGA     | 11                | 0             |         |
| u-HA/PLLA    | 14                | 2             |         |
was also associated with all cases of bony necrosis. The risk factors identified in this study were smoking and drinking, both related to patient health status. It has already been reported that smoking and drinking are risk factors for the exacerbation of infection. Smoking is known to be significantly associated with an almost fivefold increase in the risk of infectious complications after the removal of osseous lesions. With regard to alcohol, it has been reported that patients with high alcohol intake tended to have more tartar deposits and poor oral condition compared to patients with low alcohol intake. In addition, patients who drank excessively visited dentists irregularly. In our clinical study, all patients with bone lid necrosis had an unhealthy lifestyle involving smoking and drinking. These factors led to the deterioration of the oral environment, causing infection at the surgical site. Furthermore, it was thought that the exacerbation of the infection caused osteonecrosis. Smoking and alcohol intake are patient factors that oral surgeons can identify preoperatively. Therefore, preoperative smoking cessation and abstinence from alcohol would be clinically significant if it changes the prognosis of the postoperative course. We look forward to future research.

Another risk factor was the lesion’s distance to the alveolar crest. The closer the distance to the alveolar crest, the higher the risk for necrosis. Nevertheless, the bone lid approach for deep intraosseous lesions had a lower risk of postoperative bone lid necrosis.

In oral and maxillofacial surgery, intraosseous lesions are commonly accessed via an oral vestibular incision. Therefore, postoperative wound dehiscence may cause infection due to oral bacteria and food residues. It has been reported that the risk of dehiscence of the oral mucosa after oral and maxillofacial surgery is higher as the surgical site is proximal to the oral side. In addition, the periosteum is lost when it is close to the oral mucosa due to the enlargement of the lesion. Therefore, it is considered that the risk of dehiscence due to periosteal defect is also associated with incomplete closure of the wound in the oral mucosa after surgery. Currently, there is no evidence proving that the distance of the lesion from the alveolar crest is a success factor of bone lid surgery; thereby, this study is considered novel and generates interest on this subject matter.

In this study, the fixation plates used for the bone lids were all absorbable plates. There were no significant differences in the incidence of postoperative bone lid necrosis with the use of different absorbable plates. The plates should not be removed as long as they are comfortable and do not interfere with subsequent implant placement. On the other hand, it was reported that the plate was removed in 38.1% of postoperative bone lid surgery patients. In Japanese patients, the postoperative plate removal rate was 32.9% for orthognathic surgery patients and 64.1% for maxillofacial trauma patients. For all surgical patients, the reason for the plate removal was the patient’s utmost request. In addition, mini plates may be removed due to complications after 5 years, despite having no problems initially. Therefore, the present study, which uses the absorbability to fix the bone lid, shows an important future prospect.

It has been previously reported that a bone lid of sufficient size and thickness should be considered a factor in selecting the technique for bone lid surgery. However, it was demonstrated in this study that the lesion size and cortical bone thickness were not related to surgical success. We believe that this is a significant finding. Although Sivolella et al. required a bone thickness of 1 mm or greater, the thinnest cortical bone thickness in our study was 0.86 mm. This suggests that the bone quality and sufficient bone strength, and not necessarily bone thickness, are important when creating the lid of the bone.

There is no doubt that the bone lid surgery is an excellent procedure. However, this procedure is very difficult to perform because it requires great effort and a high level of experience and skill to properly position the lesion and create a bone window for a lesion that is completely covered by the jawbone. The use of navigation systems and 3D models as supplementary surgical tools for experience enhancement is considered an adjunct diagnostic application. We hope that the bone lid surgery will be applied more extensively as more advanced technology is introduced in the future.

There are some limitations to this study. First is the limited number of targeted cases. However, despite being a pilot study, it is the first study that investigated the risk factors for bone lid necrosis, rendering the findings highly useful. In the future, further studies with an increased number of cases are required. Second is that no surgical procedure was selected for immunocompromised patients, such as those with diabetes and those receiving steroids. Therefore, there is a selection bias, and further case studies are needed to expand the target patients. Lastly, the follow-up period is short and the procedure used an absorbent plate. Despite the use of clinically safe plates from previous reports further investigation of long-term changes may be needed.

In conclusion, this study revealed the risk factors for postoperative osteonecrosis following surgery using the bone lid technique. The success rate of middle lesions in the jaw bone lesion was 90%. Smoking and alcohol consumption were the health status variables found to be risk factors for bone lid necrosis. In addition, proximity to the alveolar crest was also a risk factor for lesion development. Appropriate assessment of the patient’s status and the location of the lesion can facilitate successful treatment.

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**Conflict of Interest**

The authors report no conflict of interest.

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