Endoscopic lift of the maxillary sinus floor in beagles

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Abstract

The aim of this study was to introduce a modified endoscopic lift of the floor of the maxillary sinus in beagles. Twelve operations (bilateral and randomly chosen) were done in 6 beagles each in the test group (modified endoscopic operation), and the control group, in which the operation was done with an osteotome. All operations were evaluated by two indices of safety (perforation of the sinus membrane and nasal bleeding) and 3 effective indices (the intraoperative height after lifting, volume of bone grafts, and dislocation of the sinus grafts). The sinus membrane was not perforated and there were no nasal bleeds in either group. The intraoperative height after lifting was 13.7 (0.8) mm in the test group and 9.1 (0.5) mm in the control group, so it was significantly higher in the test group than the control group (p=0.0001). Similarly, the volume of bone graft was 0.9 (0.04) ml in the test group and 0.5 (0.02) ml in the control group (p=0.0001). The volume of the anterior and posterior bone grafts in the implant cavity in the test group did not differ significantly (p=0.102), while there were significant differences in the control group (p=0.002). Endoscopic lifting of the floor of the maxillary sinus is a safe and effective approach based on direct observation in beagles.

Keywords: Maxillary sinus floor elevation; Endoscope; Beagle

Introduction

Endoscopy has changed the philosophy and practice of modern surgery. It has enabled the development of minimally invasive operations based on our ability to see the operative field through the endoscope, and to operate through small channels. All types of maxillofacial surgery are now commonly done endoscopically, and the introduction of the endoscope into dental implant procedures, particularly transalveolar sinus lifts, has made advances in implantation techniques possible.

The transalveolar sinus lift used to involve a blind drilling and insertion procedure, but a technique to raise the sinus membrane during the operation under endoscopic control was introduced in the late 1990s. The endoscope was inserted...
into the sinus by a laterobasal approach through a small osteotomy. The membrane was raised and the bone grafts inserted using a transalveolar approach.\textsuperscript{7} The endoscopic sinus lift contributed to a reduction in perioperative morbidity, particularly oroantral fistulas, and control of the position of the bone grafts. The less invasive technique also extended the indications for the transalveolar sinus lift. However, the approach did require an additional laterobasal incision to insert the endoscope into the sinus.\textsuperscript{3,6} The sinus membrane was perforated artificially, and the nose usually bled postoperatively.\textsuperscript{3,7,8}

In 2011, therefore, we acquired a miniature visualisation unit and a modular implant endoscope to use for the transalveolar sinus lift.\textsuperscript{1} The sinus membrane was lifted and the perforations inspected with the endoscopic injection cannula for dental implants. Even though this innovative endoscope could be inserted into the sinus through the implant cavity, it did not enable us to see the actual sinus lift. We therefore wanted to find out how we could raise the sinus membrane under direct vision to get more height, but also to avoid an additional laterobasal osteotomy for insertion of the endoscope.

**Material and Methods**

**Animals**

We used 6 healthy beagles 18 months old, mean weight 14.5 kg. The study was done with the approval of the Ethics Committee of the University School of Medicine.

**Equipment**

A 2.3 mm, 0° angle-view endoscope, including a video monitoring system, an image printer, a Stryker light source, and a Sony video recorder and colour monitor (Stryker, San Jose, CA) were used for direct vision. A 5.0 mm outer protective cannula with a 1.0 mm irrigation channel in the lateral wall was introduced into the implant cavity (Puwei, Shanghai, China) (Fig. 1A). The membrane elevator with a hemispherical head 3.0 mm in diameter and a flexible neck of 0.6 mm in diameter and 25 mm long was used to lift the sinus membrane (Puwei, Shanghai, China) (Fig. 1).

**Operative technique**

General anaesthesia was induced in 6 beagles by intramuscular injection of ketamine 10 mg/kg. Twelve bilateral maxillary sinus lifts were made and randomly repaired with 6 in each of 2 groups. The test group had endoscopic maxillary sinus floor lifts\textsuperscript{3,4,8} and the control group had maxillary sinus floor lifts with an osteotome.\textsuperscript{9,10} Each sinus was treated through a palatal incision at the gingival margin from the distal surface of the third premolar to the palatal surface of the second molar. A full-thickness mucoperiosteal flap was reflected on to the palatal gingival margin to the middle part between the floor of the sinus and the greater palatine foramen. According to the height of residual bone from the preoperative computed tomogram (CT), an implant cavity of 5.0 mm in diameter was prepared, under the site located palatal to the distal dental cusp of the first molar, or buccal to the greater palatine foramen, using a special bone bur together with a stopper in the crestal approach sinus kit (Osstem, Seoul, South Korea).\textsuperscript{11}

In the endoscopic group, the outer protective cannula was first introduced into the implant cavity, and then the membrane elevator was inserted into the sinus through the outer cannula to lift the sinus membrane upwards. Next, the endoscope was also inserted into the sinus. Under direct vision, the elevator was used to peel and push the membrane anteriorly and posteriorly. To maintain good visibility the area had to be washed out, preferably with isotonic saline through a cannula with a small diameter (Fig. 2A, 2B). In the control group, the membrane was pushed upwards with the osteotome. A depth gauge in the crestal approach sinus kit was used to measure the increased height in both groups. The raised spaces were then filled with Bio-Oss (Geistlich Biomaterials, Wolhusen, Switzerland). Finally, the full-thickness mucoperiosteal flap was repositioned and sutured. All beagles were given penicillin (30,000 u/kg) for one day and were kept on a soft diet during the first postoperative week to prevent postoperative infections.

**Evaluation indices**

The indices of safety, including perforation of the sinus membrane and nasal bleeding, were evaluated.\textsuperscript{12,13} During the
operation the endoscope was also inserted into the sinus through the implant cavity in the control group to see the condition of the sinus membrane. Any postoperative nasal bleeding was recorded.

The effective indices, including the intraoperative height after lifting, volume of bone grafts, and dislocation of sinus grafts, were evaluated. The intraoperative height after lifting for both groups was measured directly using the depth gauge in the crestal approach sinus kit. The volume of bone grafts was obtained from postoperative CT scans, which were entered into an interactive ProPlan1.4 (Materialise Medical, Leuven, Belgium) to reconstruct all animals’ 3-dimensional models of bone grafts. The volumes of the anterior and posterior bone grafts in the cavity of the implant were also obtained to assess the degree of dislocation of the sinus grafts.

**Statistical analysis**

We used the Wilcoxon signed rank test in the SAS 9.0 software (Version 11.04, Materialise Medical, Leuven, Belgium) to compare the intraoperative height after lifting, the volume of the bone grafts, and the dislocation of the sinus grafts in both groups. Probabilities of less than 0.05 were accepted as significant, and data are expressed as mean (SD).

**Results**

All beagles survived the operations were healthy during the entire period of observation. The wound healing was also uneventful.

**Safety indices**

Intraoperative views noted the intact, white, and opaque sinus membrane, and no perforations of the sinus membrane in either group (Fig. 3). No beagle developed nasal bleeding postoperatively in either group.
Effective indices

As shown in Figs. 4 and 5, the intraoperative height after lifting was 13.7 (0.8) mm in the test group and 9.1 (0.5) mm in the control group. The height obtained was significantly higher in the test group than in the control group (Z=-4.161, p<0.0001). Similarly, the volume of bone grafts postoperatively was 0.9 (0.04) ml in the test group and 0.5 (0.02) ml in the control group. The volume obtained was significantly higher from the test group than from the control group (Z=-4.157, p<0.0001).

Discussion

The number of sinus lifts done world-wide is on the increase, so there is a need for less invasive techniques to optimise the late results of implants in the posterior maxillary area. The use of an endoscope helps the sinus lift to overcome the shortcomings of the blind technique and achieve a safe and effective procedure.

In the present study we introduced a minimally invasive technique for sinus lift with the assistance of an endoscope. Compared with the previously stated endoscopically controlled sinus lift reported by Engelke and Deckwer in 1997 and Nahlieli et al. in 2011, the endoscopic technique avoids an additional laterobasal osteotomy and artificial perforation of the sinus membrane, and we had no severe postoperative complications. The operator could see the whole process of the sinus lift, so more care was taken to peel back the membrane. With the help of the outer protective cannula, the advantages of the endoscopic technique (as well as facilitating the entire operation) included direct injection of saline through the lateral channel, and lifting the sinus membrane with the sinus elevator. This meant that the sinus lift was completed successfully under good visibility.

Through the endoscope the surgeon can see the microstructure of the sinus membrane with a magnification of $\times$ 20 high-resolution optics. More care can therefore be
given at the weak point of the sinus membrane to prevent perforation of the sinus.\textsuperscript{4,7} Perforation of the membrane was the most common intraoperative complication,\textsuperscript{15} and it has been reported in 7\%–35\% of sinus lifts.\textsuperscript{16} This has been associated with postoperative complications such as infection, nasal bleeding, and even failure of implants. We had no perforations of the sinus membrane or nasal bleeding with the endoscopic technique.\textsuperscript{17} However, there were also no perforations or nasal bleeds in the control group, which may be because the sinus membrane in beagles is thicker than that in humans. The differences in morbidity in both groups must therefore be studied clinically.

With the help of direct vision, the sinus membrane can be peeled and pushed upwards further, both anteriorly and posteriorly. The height of the lift was more in the endoscopic group than in the control group, and the raised spaces were also more.\textsuperscript{4,5,17} In addition, gaps in bone and dislocations, which often occurred in the sinus grafts when conventional approaches were used, led to insufficient volume of bone around the implant.\textsuperscript{17,18} However, the sufficiently lifted spaces obtained under endoscopic control helped us to graft more bone and avoid dislocation of the sinus grafts. The endoscopic approach was therefore more effective.

In conclusion, the endoscopic approach is safer and more effective because it allows the operation to be done under direct vision. However, the procedure is in its early stage of development, having to our knowledge so far been used only in animals. Next we will try to use the technique in patients.

Conflict of Interest

We have no conflict of interest.

Ethics Statement

The study was approved by the Ethics Committee of the University’s School of Medicine.

References


