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A comparative study of dog models for osteotome sinus floor elevation and dental implants in posterior maxilla subjacent to the maxillary sinus

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Objective. The objective of this study was to investigate the suitability of beagles and Labrador retrievers as animal models for osteotome sinus floor elevation (OSFE) and dental implants in posterior maxilla subjacent to sinus.

Study Design. Ten beagles and 8 Labrador retrievers were included. Their posterior maxillas subjacent to the sinus were studied by a gross survey, CT scan, and histologic analysis.

Results. In the posterior maxilla subjacent to sinus, the bone height was significantly higher for Labrador retrievers than for beagles ($P < .05$). There was no significant difference in sinus size from the coronal section and its location from the sagittal section ($P > .05$) between Labrador retrievers and beagles.

Conclusions. As an animal model, the Labrador is more suitable for OSFE and dental implants in posterior maxilla subjacent to sinus. The midpoint of the maxillary fourth premolar is an ideal site for implantation. (Oral Surg Oral Med Oral Pathol Oral Radiol 2013;115:e15-e20)

With the improvement of dental implant technology, implants can perform the normal functions of the original teeth without injuring neighboring teeth and are accepted as a conventional procedure for a dentition defect or in edentulous individuals. The consensus conference on sinus lift in 1996 suggested that the surgical procedure should be adapted based on the residual bone height (RBH). If RBH in the posterior maxilla subjacent to sinus was less than 6 mm, the osteotome sinus floor elevation (OSFE) procedure was not recommended.[1] Compared with the lateral approach, OSFE causes less trauma, and is less time-consuming and more cost-effective.[2,3] Therefore, many researchers are still working on novel technologies and methods to explore the application of OSFE with less RBH for greater survival rate of the implants.[4-7] Extensive preclinical basic research for novel technologies and new materials is essential. The data acquired from animal experiments are of great significance; hence, it is crucial to select the proper animal model. Usually pigs, sheep, dogs, or monkeys serve as animal models for implants in the maxillary sinus region.[8-10] Dogs have been found to be ideal as animal models for complicated maxillofacial surgery because they are abundant in quantity, easy to keep, adaptable to their environment, durable, strong against infection, and have bigger oral clefts than pig or sheep models, all of which are suitable qualities for dental animal experiments.[9,11] Research by Martini et al.[12] shows that animal models of an adequate size, with conditions similar to clinical surgery, are frequently used when new techniques and material research are applied to clinical studies. Dogs were the most used animal models for orthopedic surgery research from 1990 to 2001, which accounted for 37% of all models. This further proves the benefits of using dogs as animal models.[12]

There is not enough literature on dog models in OSFE and no adequate data on macro- and microanatomical investigation, however. Our study on the anatomical aspects of beagles and Labrador retrievers fills in this gap and explores their suitability as animal models for OSFE and dental implants in posterior maxilla subjacent to sinus.

MATERIAL AND METHODS

Samples

Ten adult, female beagles and 8 adult, female Labrador retrievers, 12 months old, from the Department of Laboratory Animal Science (Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai, China) were selected. Beagles weighed 18.89 ± 2.57 kg and Labrador retrievers weighed 27.06 ± 1.37 kg. The dogs had complete dentition, with no dental defects, and no pathologic changes caused by

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local or systematic diseases. The dogs were kept for more than a week to ensure they were in good condition. They were fed in cages during the experiment. The 10 beagles formed Group 1, producing 20 lateral maxillary samples. The 8 Labrador retrievers formed Group 2, producing another 15 samples. This study was approved by the ethics committee and the animal care and use committee of Shanghai Jiao Tong University School of Medicine.

Macroscopic analysis

Six samples from Group 1 and 6 samples from Group 2 were randomly chosen for macro-anatomical investigation. The animals were killed by 3% pentobarbital (Nembutal) injection. They were sected sagittally along the nasal septum to investigate the anatomical indicators in the maxillary sinus region, the position and the size of the maxillary sinus, and its relationship with surrounding tissues. The skulls were further sected coronally at the midpoint between maxillary fourth premolar (PM4) and the first molar (M1), thus to divide the maxillae into anterior and posterior portions.[13] Then, the following measurements were taken: (1) The vertical distance from A to the crest, "a"; (2) the vertical distance from B to the crest, "b"; (3) the maxillary sinus cavity height (MSCH); and (4) the maxillary sinus cavity width (MSCW) (Figure 1).

Histologic analysis

Samples from Groups 1 and 2 were investigated histologically 6 hours postmortem. The tissues were obtained using a high-speed dicing saw, with the mesio-occlusion of the maxillary fourth molar and the distal of the first molar as the anterior-posterior border, and with the superior border at the infraorbital plane. They were immersed in a mixture of 4% paraformaldehyde and 0.05% glutaraldehyde. Then, they were decalcified by 10% formic acid for 2 weeks. The tissues were slowly rinsed by phosphate buffer in different containers. Then, they were dehydrated by gradient ethanol, immersed in wax, and then embedded. The embedded blocks were trimmed and sliced into 5-μm sections by tissue cutter. The sections were roasted, stained with hematoxylin-eosin, and then sealed. The sections were investigated by optical microscope (Olympus BX51, Tokyo, Japan) and photographed with a digital camera. As the width of the tissues was too large to be investigated in one section, the tissues were sliced into 9 coronal parts. The images were integrated into whole visions using Photoshop CS5 (Adobe Systems Inc., San Jose, CA).[14]

Computed tomography scan analysis

A helical computed tomography (CT) scan (64-detector row multislice helical CT, Philips, Tokyo, Japan) was taken of each sample for the sagittal and coronal tomograms (tube voltage 80 kV, current 800 mA, 1.0 mm incremental, thickness 0.8 mm). The images were stored in Digital Imaging and Communications in Medicine (DICOM) format. Procera Software CT Converter 2.1.1.2 (Materialise, Leuven, Belgium) was used to read the CT data and to reconstruct each sample's 3-dimensional (3-D) surface model. Procera Software Clinical Design v4.2.1.2 (Materialize) was used to analyze the 3-D surface model, by reconstructing coronal tomograms vertical to the occlusal plane and the nasal septum plane. Two candidate sites, one at the mesial of PM4 and the other at the midpoint between PM4 and M1, were identified with their coronal tomograms as P1 and P2. The lowest point of the superior border of the zygomatic process to the occlusal plane was marked as A. The lowest point of the maxillary sinus floor to the occlusal plane was marked as B. The measuring baseline L1 goes through B and is vertical to the nasal septum. The measuring baseline L2 goes through A and the measuring baseline L3 goes through B. They are parallel to the nasal septum. Then, the following measurements were taken: (1) the vertical distance from A to the crest, "a"; (2) the vertical distance from B to the crest, "b"; (3) the horizontal distance from L2 to L3, "c"; (4) the MSCH; and (5) the MSCW (Figure 2). Further data from the sagittal tomograms of the samples were measured: (6) maxillary sinus cavity length (MSCL); (7) the vertical distance from the lowest point of anteroposterior maxillary sinus to P2 (D1); and (8) the vertical distance from the most posterior point of anteroposterior maxillary sinus to P2 (D2). All measurements were taken 3 times by 2 independent examiners (N.L. and F.S.). Each measurement was taken on a separate day.

Statistical analysis

The data were analyzed using SPSS17.0 software package (SPSS Inc., Chicago, IL).

RESULTS

Macroscopically, the maxillary sinus was located palatal to the root of PM4 and M1. In sagittal section, the sinus floor curve descends from back to front, connected to the cavitas nasi in the front, and ends before the midpoint plane of M1. The lowest point of the maxillary sinus was located near to P1. In the coronal section, the sinus floor was flat at the lowest point with both ends curving upward, no crest or septations were detected in the examined samples. The maxillary sinus was lined with sinus membrane, which was complete and easy to remove. The infraorbital nerve canal passed between the sinus and posterior teeth, above the lowest