Endoscopically monitored maxillary sinus augmentation - The chairside approach (Rationale and protocol)

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ABSTRACT

Sinus augmentation procedures have been reported since the time of Boyne, with variable techniques and outcomes.

Sinus membrane perforations may or may not be detected at the intra-operative stage, thereby compromising the outcome.

The aim of this study is to evaluate the usefulness and feasibility of an endoscope used intraorally during manipulation of the schneiderian membrane. This would help confirm sinus health and integrity of the membrane during and after the augmentation.

1. Introduction

Dental implants are a proven modality to rehabilitate part or all of the dentition.

Maxillary sinus pneumatization after extraction of the posterior teeth reduces the vertical component of bone available for implant placement.

Different procedures have been described in literature to overcome this deficiency ever since the time of Boyne.¹

Maxillary sinus lift is an extremely common and predictable procedure nowadays to restore the hard tissue necessary to place implants.

Although sinus augmentation may be included under the invasive category of dental implant procedures, the incidence of reported surgical complications intra and post-operative, is relatively low.

Maxillary sinus elevation may utilise either one methods (A) Surgical access through the lateral wall of maxilla, followed by elevation of the sinus membrane and insertion of bone graft under direct vision, also named 'Direct sinus lift' and (B) An approach via the crestal region where the membrane is not in direct vision, also named 'Indirect sinus lift'.²

The most common complication reported is perforation of the sinus membrane during manipulation. Reported perforation rates vary from a low 7% to as high as 58%.³

Osteotome use has been associated with the development of benign paroxysmal positional vertigo (BPPV).⁴

An alternative method for ostectomy (Huwais et al., 2016) was introduced where the bone instead of being extracted from the osteotomy, is compacted.⁵

This is facilitated via specially designed burs with increased number of lands and negative rake angles. These densify the bone when rotated counter-clockwise at an RPM of 800–1200 in a regular surgical hand-piece with controlled torque.

These burs when moved in a bounce-in bounce-out motion under controlled pressure exert a viscoelastic deformation of the bone along with copious irrigation.

When this protocol of osseodensification is utilised close to the sinus floor the resultant pressure wave created with the slurry produces pressure upon the schneiderian membrane which in turn is elevated along with some autograft being introduced between the membrane and the sinus floor. Given the fact that these burs create a pressure wave apically there does exist a chance of sinus membrane perforation in inexperienced hands where-in autogenous bone particles may be introduced into the antrum.

Thickness and elasticity of the sinus membrane is varies from person to person and there is a strong sex predilection that has been reported.

This lends a high level of variability to the outcome of the procedure (Pommer, Janner).^{6,7}

Endoscopy has various technical applications in minimally invasive oral surgery (A) Direct endoscopy (B) Immersion endoscopy (C) Supported endoscopy (D) Trocar-guided endoscopy.

The traditional approach to endoscopic evaluation of the maxillary sinus is via the middle meatus of the nose to approach the ostium and is best carried out under sedation along with local anesthesia infiltration into the medial infundibular wall or in some cases under general anesthesia.⁸

If the ostium is blocked by an enlarged or curved infundibulum this

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may need to be enlarged using backward cutting punches.

Wiltfang et al. assessed two techniques of sinus augmentation with radiographic, endoscopic, and ultrasound follow-up. They conclude that endoscope-controlled sinus floor augmentation may lower the overall complication rate.⁹

Transcrestal minimally invasive intraoral approach has been described in literature but perforation of the membrane may not be detected unless intra-operative antroscopy is carried out.¹⁰ Most of the perforations during crestal approach sinus augmentation go undetected due to lack of direct vision. These cases may be predisposed to future sinus disease given the possibility of particulate graft being extruded into the antrum.

Andreasi et al. have described a similar technique of intraoral use of the endoscope for subcrestal sinus elevation.¹¹

2. Recommended presurgical evaluation

2.1. Radiological evaluation

Radiological investigations in earlier days involved analog X-rays which evolved to digital X-rays and thereafter to medical grade CT and cone beam CT scans.

Today a cone beam CT (CBCT) is considered the standard of care when planning a sinus augmentation procedure. All sections of the scans should be assessed, coronal, cross-sectional and axial to get a clear picture of the sinus anatomy including the presence of septa and any undulations of the sinus floor which may decrease the predictability of a crestal lift.

These scans need to be of a large FOV (field of view) to include the ostia and infundibulum so the clinician get a clear picture of the health and ventilation status of the sinus.

Patency of the ostia and hypertrophy of the uncinate process should be assessed as any blockage could hamper spontaneous drainage of a grafted sinus.

2.2. Clinical evaluation

Clinicians should use components of the Sino-Nasal outcome test (SNOT-22) to predict likelihood of symptom improvement after surgical intervention in subjects with Chronic rhinosinusitis (CRS) on a scale of 0–5.

Nasal obstruction symptom evaluation (NOSE) test helps assess possible areas of concern that may pose a threat to postoperative development of acute or chronic maxillary sinusitis.^{12,13}

2.3. Clinical conditions that should be ruled out

1. Permanent structural impairment of the nasal walls and/or naso-sinus mucosa that may seriously interfere with normal homeostatic physiology.
2. Inflammatory or infective processes, including recurrent or chronic sinusitis, multiple polyps, impaired muco-ciliary clearance.
3. Benign or malignant neoplasms (e.g., inverted papilloma, myxoma, metastases and primary neoplasms originating from the epithelium)

This study brings to light the well documented facts of endoscopic control during maxillary sinus augmentation at the same time using it to an advantage for sinus lavage and retention cyst drainage.

3. Materials and methods

A total of 20 patients requiring sinus augmentation and a total of 30 implants in all were selected for inclusion into this case study.

A detailed informed consent was taken from all patients for the surgical protocol and requisite data records for storage and research.

Ethical clearance was not applied for in this case study as it was

based on a review of published literature involving similar clinical procedures and protocols that have been utilised and documented as clinically viable and safe. None of the protocols utilised in this study were beyond the scope of scientific evidence.

The cases included had a residual bone height (RBH) between 2 mm and 5 mm.

These cases were taken up for lateral window protocol (Group A) if RBH residual bone height was < 4 mm while those with RBH > 4 mm were taken up utilising the internal lift protocol (Group B).

They were investigated by way of cone beam CT scans and ruled out for any prior or present sinus disease by way of questionnaire and clinical examination as mentioned above.

Nasal symptoms if any were evaluated thoroughly as every sinus lift procedure deals with a part of the sino-nasal complex.

An ENT clearance was requested in patients with a history of chronic recurrent sinusitis.

Subjects were put onto a preoperative dose of amoxycillin + clavulanate potassium 625 mg twice a day along with povidone-iodine 2% mouthrinse 24 h prior to the procedure.

The operative procedure was carried out under local anesthesia (a mix of Lignocaine 2% with adrenaline 1:200,000 and Bupivacaine 0.5%) administered by way of a posterior superior alveolar and infra-orbital nerve block on the buccal and greater palatine nerve block for palatal anesthesia.

The canine fossa was accessed either via a remote small semilunar incision (cases where the augmentation/implant placement was required posterior to maxillary second premolars) or via the same crestal incision extended anteriorly with a vertical release limb (cases where the augmentation/implant placement is as far anteriorly as the first premolar).

The crestal incisions were placed with a slight palatal bias. This helps in keeping suture line remote from the region of intervention.

A 3 mm antrostomy was made with a tungsten carbide rose head bur. A portable endoscope (Xuzhou Ikeda, China) was used with a scope angle of either 45 or 70° depending on the angle of visualization required. More anterior the region of augmentation higher the angle required (Figs. 1 and 2).

White balance in the scope was adjusted prior to insertion. The sinus was examined for health and the presence of any fluid collection or polyps (Fig. 3).

Once a clear view of the sinus anatomy was established the location for crestal or lateral access for augmentation was ascertained.

In such cases where small mucous retention cysts or polyps were

Fig. 1. Portable endoscopy unit.

Fig. 2. Chairside endoscopy armamentarium.

Fig. 3. A clear sinus showing a patent ostium on the right.

Fig. 4. Large polyp in the sinus.

Fig. 5. Trans-crestal lift showing bruising of the membrane.

seen it was to ruled out whether these were in the direct line of augmentation thus exerting turgor pressure on the particulate graft material inserted or not. In one case in Group A where a large polyp was overlying the zone of augmentation it was drained using a 24 gauge needle inserted through the same opening as the scope (Figs. 4 and 7).

In two cases with fluid collection, a sinus lavage was done using a scalp vein tubing inserted from the endoscope entry point, using physiologic saline solution. Aspirated fluids were sent for culture. A sinus clear of any collection as confirmed thereafter on the endoscopic monitor.

The endoscope was stabilised in position while the lateral or crestal access (with the osseodensification protocol) was undertaken thereby allowing direct vision of manipulation of the schneiderian membrane.

In cases where the crestal approach was used (Group B), tenting effect of the sinus membrane was observed on the monitor as the Densah burs worked their way past the osseous floor of the sinus, (standard osseodensification protocol and recommendation limits the increase in height to 3 mm beyond the residual alveolar height). (Fig. 5).

In cases with lateral approach protocol (Group A), the sinus curettes were used sequentially to detach and lift the membrane. The endoscopic view was used to ascertain detachment till the medial aspect of the sinus. In two cases where a tear in the membrane was noticed during manipulation it was sealed using collagen fleece (Collatape, Zimmer), following which a resorbable collagen membrane was used to further protect the perforation (Memlok, Biohorizons). (Fig. 6).

During this procedure the scope was stabilised and at the end an effective seal was assessed both by the endoscopic view and membrane movement upon gentle inspiration.

Upon completion of implant osteotomy to the requisite diameter the implants were inserted (via a prosthetically planned essix stent), except in Group A cases where a perforation was detected and sealed.

Once the implant reached its final position the membrane was once again visualized after about 5–10 min for integrity. The time delay allows for any hemorrhage within the membrane to show up on the monitor and the same may be assessed for any intervention if required (Fig. 5).

Stability of all implants placed was assessed using the RFA (Radio Frequency Analysis, Penguin).

The antrostomy at the canine fossa and the lateral window was

Fig. 6. Lateral window with remote antrostomy over the canine fossa.

covered by a resorbable collagen membrane (Memlok, Biohorizons).

If the operator does not use a collagen membrane to cover the endoscope entry point or the lateral window there may be chances of adhesions forming between the periosteum and the sinus membrane at the site.

Wound closure was done using 4/0 or 5/0 Prolene sutures.

In case a separate semilunar incision was given in the canine fossa region this was closed using 4/0 or 5/0 vicryl sutures.

Patients were examined at follow-up on the 2nd postoperative day for any signs of nasal congestion, bleeding or discharge.

Nasal decongestants were advised in cases of membrane tear. Extended use of nasal decongestants was not advised because they are known to reduce the already low oxygen tension in the sinus by way of vasoconstriction.

All cases were followed up till 2 years after prosthetic loading. There was no evidence of any recurrence of sinus polyps as ascertained on cone beam CT scans. Augmented bone around the implants showed good volume maintenance (Fig. 8).

4. Results

In the lateral window group two cases had an intraoperative perforation which was sealed. In both these cases simultaneous implant placement was not carried out.

In the crestal access group one case showed a small perforation < 2 mm which was sealed off with autograft compaction the moment larger diameter Densah drills were used (Table 1).

The gain in vertical bone height was between 3 and 5 mm in Group

B and between 8 and 13 mm in Group A as measured on cone beam CT scans.

A total of 26 implants were placed at the same stage as the augmentation and 4 implants in two cases of Group A after a period of 4 months as there was a perforation > 4 mm which was sealed.

All cases showed satisfactory progress, no implants were lost during the integration phase.

5. Discussion

The most common complication of lateral sinus augmentation is perforation of the Schneiderian membrane with a reported incidence of 7%–58%. There is a significant correlation between the sinus membrane perforation rate and the thickness of Schneiderian membrane. In a recent CBCT analysis by Wen et al.²⁸ on 122 subjects, the perforation rate was significantly higher in thicker (≥ 3 mm) membrane compared to membrane thickness of 1–2 mm.³

Membrane perforations, are associated with the development of postoperative complications such as acute or chronic sinus infection, bleeding, edema, posterior nasal discharge, wound dehiscence, loss of the bone graft material and disruption of normal ciliary function.

An intact membrane is imperative to contain the biomaterial and allow for unhindered remodelling into de novo bone. Larger tears are easy to detect to the naked eye but small ones may be missed during elevation which then may or may not lead to a compromised outcome.

The aim of the proposed protocol is to provide accurate detection of any tears in the sinus membrane during manipulation and adequate management of the same. The small opening into the antrum made by burs requires very little force compared to a trocar and thus more comfortable for the patient. This also reduces the number of radiographs required intra-operatively to assess the proximity to the sinus floor during crestal sinus lift.

The use of the osteotome technique has its own limitations with reports of benign paroxysmal positional vertigo (BPPV) finding mention in literature.⁴

The dimensions and characteristics of the Schneiderian membrane varies in population and it has been reported that the thickness exhibited a range of 0.16 mm–34.61 mm. The mucosal thickness was maximum in the mid-sagittal regions of the maxillary sinus.^{6,7}

Schleier described simultaneous dental implant placement and particulate graft material insertion under endoscopic control with a two year follow-up showing benefits of the protocol.⁸

Andreasi et al. have described a similar technique where the endoscope is inserted intraorally by means of a small antrostomy for subcrestal sinus elevation.¹⁰ They postulated that this makes the procedure easily amenable under local anesthesia.

Pignataro reported that in such cases where additional instrumentation or cannula insertion is to be catered to via the same antrostomy, the use of an endoscopic trocar especially made for the trans-canine approach helps guide the scope and also allow for instrumentation.¹²

Wiltfang et al. reported a lower postoperative complication rate

Fig. 7. Large polyp obliterating a significant portion of the sinus.

Fig. 8. Scans at 2 years post loading with no evidence of polyp.

Table 1
Patient pool division based on residual bone height (RBH).

RBH (mm)	Protocol	Perforations detected	Implants placed simultaneously	Total number of patients
2-4	Lateral window	2	8 patients	10
4-6	Crestal approach	1	10 patients	10

with transcrestal procedure when endoscope control was utilised.¹⁴
In reality, the incidence of potential postoperative complications in the indirect lift technique may be greater than in the lateral approach technique, which possibly goes undiagnosed in the immediate intraoperative period due to limited visualization of the membrane.¹⁵

Small intra-operative perforations of the sinus membrane may not cause maxillary sinusitis in healthy subjects, but larger perforations may expose more particulate bone material in the antrum, leading to a greater risk of development of post-operative rhino-sinusitis.

At times the distended sinus membrane may show hemorrhage even though the integrity is not disturbed. Thus it is important to review the site on the endoscopic monitor before wound closure.¹⁶

The intraoperative use of sinuscopy as described by Grunenberg and Gerlach in 1990 for maxillary sinus elevation procedures also allows for visualization of sinus pathology intraoperatively, control of the bone graft position, a reduced risk of sinus membrane perforations and fewer postoperative complications.¹⁷

Sub-antrosopic laterobasal sinus floor augmentation has been described by Engelke as an effective alternative for nasal endoscopy. Here the endoscope inserted intra-orally, visualises the space created between the elevated membrane and the residual alveolus. This however does not give adequate control to assess membrane integrity from the superior aspect.

Prior to entry into the antrum it is important to assess the position of the infra-orbital foramen and the lateral nasal wall (at times the wall may extend far laterally). The operator should also factor in the length of teeth in the location of the antral access to avoid inadvertent injury to roots.

During the procedure the operator should be aware of the extent of scope inserted in the sinus thus avoiding complications by way of inadvertent injury to the lateral nasal wall or the orbital floor.

One of the common complications of lateral window sinus elevation is inadequate graft insertion due to incomplete elevation of the membrane all the way to the medial aspect, this can potentially be avoided if the endoscopic control is utilised.

In our study we used the canine fossa approach as described by authors, not only for visual control but also for sinus lavage and cyst fluid aspiration.

Having said that, imperative the dental surgeons embracing this procedure have the requisite training in the technical aspects involving endoscopy.

6. Conclusion

While we maintain that conventional nasal endoscopy is the most commonly used technique for diagnostic and therapeutic measures involving the maxillary sinus, the canine fossa approach does present an alternate technique where the operator can monitor and control the outcome with accurate vision control maintained throughout the procedure.

There is sufficient literature to help guide the clinician on optimal protocols but at the end the comfort level of one clinician may differ from an. Endoscopic control does decrease the chances of particulate graft migration into the antrum going undetected and in turn reduces the chances of attending inflammatory process that may follow.

Conventional per nasal endoscopic evaluation is not the forte of dental surgeons performing sinus lift procedures for insertion of dental implants and would mandate requisite ENT training or referral. Introduction of the endoscope per oral route can be carried put chair-side under local anesthesia and does not require the intervention of an ENT specialist.

Although this study showcases a minimally invasive technique that could prove beneficial in direct as well as indirect sinus augmentation, the author does not recommend it as a routine approach until a much larger sample size is analysed.

Declaration of competing interest

The author declares that there is no conflict of interest.

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