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Anterior maxillary wall and lacrimal duct relationship in Orientals: CT analysis for prelacrimal access to the maxillary sinus

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Abstract

Background The pre-lacrimal window approach (PLWA) is a promising technique in approaching lesions of the anterior wall and floor of the maxillary sinus. Simmen et al. previously reported that this approach is feasible in only 2/3 of their patients. This percentage appears to be lower than that of our local (mainly Chinese) population based on our clinical experience. Our study aims to measure the distance between the anterior maxillary wall and lacrimal duct in ethnic Chinese. A higher incidence of sphenoid–ethmoidal cells has been reported in Orientals. We postulate that there is also a higher incidence of wider pre-lacrimal recesses in Orientals thus making the PLWA more feasible to perform in Orientals.

Methods 100 consecutive sinus CT scans of adult patients with various rhinologic diseases that did not distort the bony anatomy of the maxilla were reviewed (2 sides each). The distance between the anterior maxillary wall and the anterior border of the lacrimal duct was measured in 200 sides. We have adopted the methodology of measurements previously published by Simmen et al. This is so that we could compare between Oriental and Occidental paranasal sinuses.

Results A distance of more than 7 mm was found in 39.5% of our subjects and a distance of > 3–7 mm was seen in 53.5%. In 6.5% of our subjects we found a prelacrimal recess < 3 mm.

Conclusion The PLWA could have been performed without removal of the bony lacrimal canal in 39.5% of our subjects (> 7 mm). Good access to the anterior maxilla wall could also have been possible for 53.5% with sub-periosteal removal of the bony lacrimal canal and medial maxillary wall. Thus, the PLWA would have been feasible for 93% of our subjects. These percentages are significantly higher than Simmen's study of 68.5% in an Occidental population.

Keywords Endoscopic sinus surgery · Prelacrimal approach · Prelacrimal recess · Medial maxillectomy · Modified medial maxillectomy · Maxillary sinus

Introduction

Lesions along the anterior wall and the floor of the maxillary sinus are difficult to access surgically.

A large medial meatal antrostomy (MMA) provides good access only to the posterior superior aspects of the maxillary sinus and is often inadequate for lesions in the anterior wall and floor of the maxillary sinus [1]. Proposed approaches for lesions at the anterior wall and floor of the maxillary sinus include open approaches such as the Caldwell–Luc, lateral rhinotomy or midfacial degloving approaches. Post-operative morbidity can be significant in these open approaches.

Although a large MMA allows for visualization of the anterior wall of the maxilla with a 70° endoscope, stripping of the sinus mucosa for extirpation of lesions which require this procedure such as an inverted papilloma with angled instruments through the MMA is not possible. Endoscopic medial maxillectomy and canine fossa (Caldwell–Luc) [2] approaches are possible options with a greater likelihood of morbidity.

Zhou et al. [3, 4] first described a prelacrimal window approach (PLWA) (In Chinese medical literature in 2007 and in English in 2013) proposing the sub-periosteal removal of the bony medial maxillary wall including the bony lacrimal

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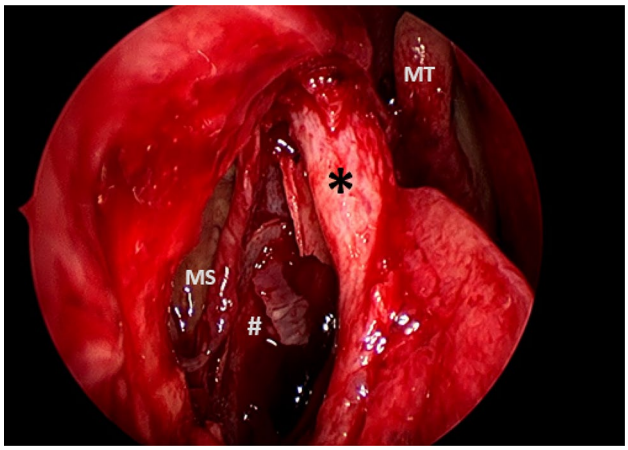

Fig. 1 Intraoperative photo showing the PLWA to the right maxillary sinus (MS). The lacrimal duct (asterisk) is shown clearly with part of its postero-lateral bony canal. The mucosa of the medial wall (ash) of the MS is seen after partial submucosal removal of the medial wall of the MS. The middle turbinate (MT) is clearly seen for orientation

canal whilst at the same time preserving the lacrimal apparatus and inferior turbinate. This approach involves first making a curvilinear incision on the lateral nasal wall anterior to the head of the inferior turbinate. The maxillary sinus is entered by a bony cut anterior to the lacrimal duct by chisel, preserving the lacrimal duct. The mucosa medial to the bony lateral nasal wall is dissected subperiosteally to the head of the inferior turbinate and the anterior edge of the sinus ostium. The bony canal of the lacrimal duct is removed with this dissected bony lateral nasal wall. Remnant bony lateral nasal wall arising off the junction of the anterior and medial maxillary sinus is removed with Kerrison's punch. Medial retraction of the lacrimal duct and the remaining lateral nasal wall containing the inferior turbinate allows direct visualization and surgical access to the anterior wall and floor of the maxillary sinus. In 2015, DK Morissey and PJ Wormald further elaborated on the approach to include an uncinectomy and middle meatal antrostomy [5] (see Fig. 1).

This approach is possible only when a pre-lacrimal recess is present. Removal of the bony lacrimal duct canal facilitates medial retraction of the lateral nasal wall and is necessary in narrow pre-lacrimal recesses. Pre-operative CT scan assessment helps to determine the level of difficulty for the PLWA. Simmen et al. proposed that a distance of > 7 mm (Type 3) allows the PLWA to be done with little difficulty, a distance of > 3–7 mm (Type 2) allows the PLWA to be done with partial dislocation of the lacrimal duct and a distance of 0–3 mm (Type 1) will require significant amount of bone removal, dislocation of the lacrimal sac and a smaller pre-lacrimal window, thus rendering this approach to be less feasible (see Fig. 2).

In a study of 100 patients, Simmen et al. reported that the PLWA would not be feasible in 31.5% of their subjects as

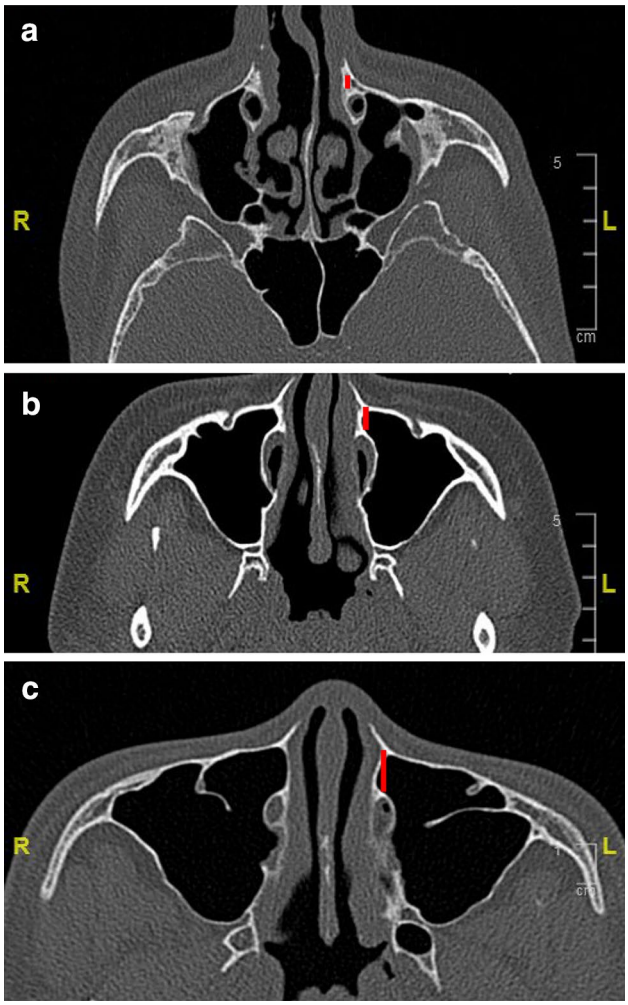

Fig. 2 **a** Axial CT scan showing a type 1 left prelacrimal recess measuring 2.7 mm (Red line). Simmen et al. propose that a prelacrimal recess of this size will be challenging for PLWA. **b** Axial CT scan showing a type 2 left prelacrimal recess measuring 6.4 mm (Red line). Simmen et al. propose that a prelacrimal recess of this size will allow PLWA to be done with medial retraction of the lacrimal duct. **c** Axial CT scan showing a type 3 left prelacrimal recess measuring 11.5 mm (Red line). Simmen et al. propose that a prelacrimal recess of this size will allow PLWA to be done without bony disruption of the lacrimal duct

the pre-lacrimal recess was absent [6]. Our surgical experience with Oriental patients suggested otherwise. Previous reports of a higher incidence of sphenoid–ethmoidal cells in Oriental patients suggest a higher incidence of pneumatization in the paranasal sinuses of Oriental patients [7, 8]. We postulate that there is a correspondingly higher incidence of wide pre-lacrimal recesses in Oriental maxillary sinuses. This study was thus embarked upon.

This study aimed to evaluate the distance between the anterior maxillary wall and the lacrimal duct in a Chinese population based on measurements on an axial CT section. We adopted the protocol of Simmen et al. and a similar

number of 100 patients to make a direct comparison between an Occidental and an Oriental population. We confirmed with Simmen et al. that their study population was based on mainly Caucasian patients presenting at a Swiss clinic.

Materials and methods

Study design

A retrospective review of 100 CT sinuses performed on Chinese patients in our tertiary institution was done. Chinese patients above the age of 18 were included in our study. Patients with whom there was loss of bony landmarks due to extensive sinus disease (such as tumors and mucoceles) were excluded. Hospital Institutional review board approval was obtained prior to the study.

The images were acquired using a 128 multi-detector-CT scanner (Siemens SOMATOM Definition Flash). Images were acquired in the axial plane from the maxillary alveolar process to the roof of the frontal sinus. Intravenous medium contrast administration was not administered unless assessment of a nasal mass was required.

The raw data were reconstructed at 0.6/0.4 mm (slice thickness and increment). Multiplanar 2 mm slices with a 1 mm overlap were performed in the coronal and sagittal planes. The images were reviewed on a Picture Archiving and Communications System (PACS) workstation.

The width of the prelacrimal recess was measured by obtaining the distance between the anterior wall of the maxillary sinus and the anterior border of the lacrimal duct. In concordance with Simmen et al. measurements were taken at the level of the anterior insertion of the inferior turbinate into the frontal process of the maxilla, identified in the coronal plane (Point A) (See Fig. 3), and confirmed in the corresponding axial plane by positioning a tangential line along the posterior surface of the anterior maxillary sinus wall (line A). Parallel lines were then marked/drawn at the anterior (line B) and posterior walls (line C) of the lacrimal duct (Fig. 4). The distances between line 1 and 2 (distance 1) and line 1 and 3 (distance 2) were measured and statistically analyzed. The bony anterior insertion of the inferior turbinate to the frontal process of the maxilla served as a consistent landmark on CT to base our measurements. The size of the nasolacrimal duct (distance 2–distance 1) was also calculated from the results.

All results were analyzed with SPSS V22. The data were assumed to be not normally distributed and thus a Mann–Whitney Wilcoxon test was performed to compare the two sets of variables. A two-sided P value of < 0.05 was considered statistically significant. There was no statistical difference between the results of the right and left side ($P > 0.05$) and thus the left and right sides were pooled together for analysis.

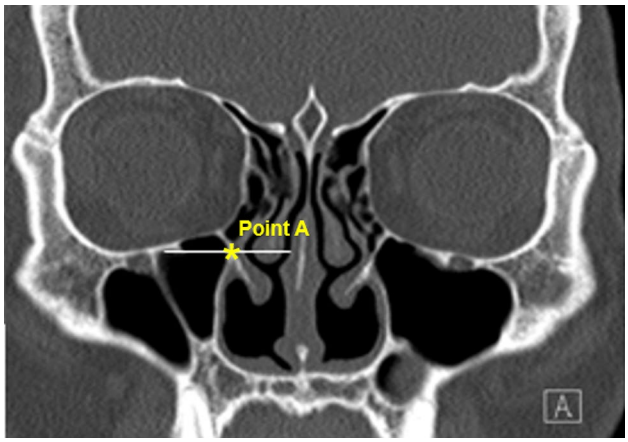

Fig. 3 Star indicating point A: the anterior insertion of the inferior turbinate into the frontal process of the maxilla, identified in the coronal plane. The corresponding axial cut at this plane was used for the measurements subsequently

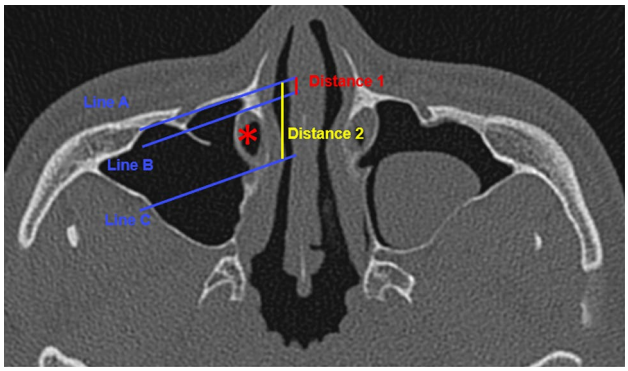

Fig. 4 Measurements of distance 1 and distance 2. Distance 1 is the prelacrimal recess and prognosticates the ease by which the prelacrimal window approach can be done. Asterisk marks the lacrimal duct

Results

A total of 100 patients with 200 sides were measured. The mean distance from the anterior wall to the anterior border of the lacrimal fossa (Distance 1) was 6.64 ± 2.36 mm (Min 1.00 mm, Max 13.30 mm). The mean distance from the anterior wall to the posterior border of the lacrimal duct (Distance 2) was 20.70 ± 4.31 mm (Min 9.00 mm, Max 32.60 mm). The width of the lacrimal duct had a range of 6.10–31.60 mm with a mean of 14.06 ± 3.46 mm.

To assess the feasibility of the PLWA, the patients were divided into three groups as per Simmen et al. Type 1 (0–3 mm) where the PLWA would not be feasible, Type 2 ($>$ 3–7 mm) where PLWA could still be possible but the

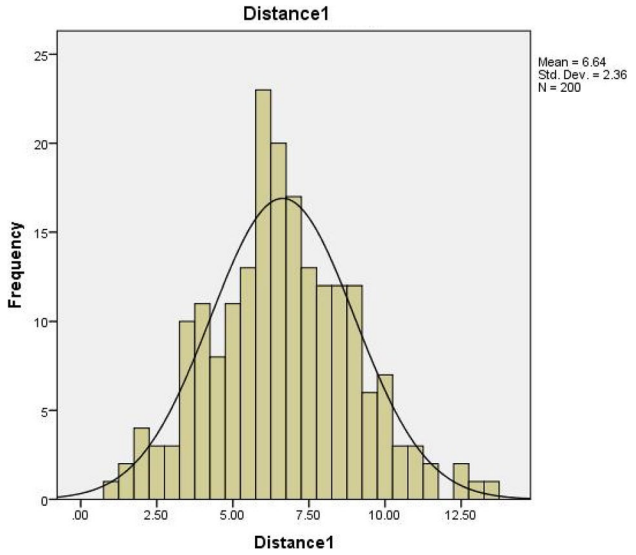

Fig. 5 Distribution of the distances between the anterior maxillary sinus wall and the anterior border of the nasolacrimal fossa (distance 1). Mean is 6.64 mm

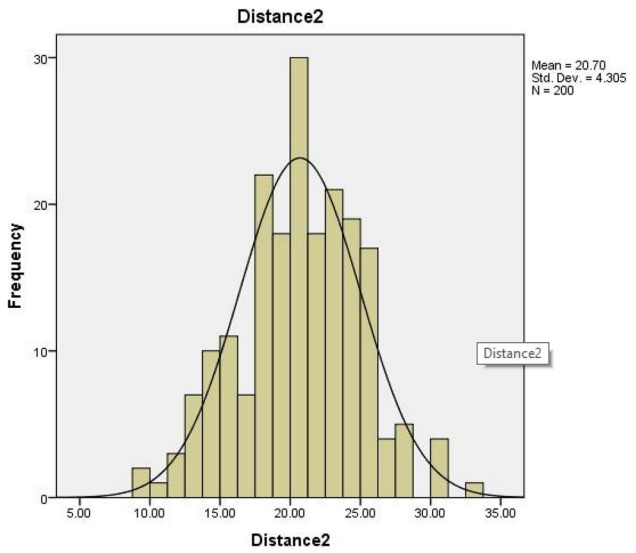

Fig. 6 Distribution of the distances between the anterior maxillary sinus wall and the posterior border of the nasolacrimal fossa (distance 2). Mean is 20.7 mm

duct would need to be displaced and retracted and Type 3 (> 7 mm) where the PLWA could be easily performed with minimal manipulation to the lacrimal duct.

There were a total of 13 sides with type 1 (6.5%), 107 sides with type 2 (53.5%) and 79 sides with type 3 (39.5%) (see Figs. 5, 6).

Discussion

The PLWA allows for good visualization and surgical access of the anterior wall and floor of the maxillary sinus with lower morbidity and recurrence rates compared to open approaches [9, 10]. In addition it could also enable surgical access to the pterygopalatine fossa (PPF), infratemporal fossa (ITF) and the middle cranial fossa (MCF) [11].

The PLWA requires 2–3 mm of bone anterior to the lacrimal duct to be removed with retraction and displacement of the "deboned" medial maxillary wall medially during surgery. This medially displaced mucosa is placed back post-operatively with the function of the lacrimal duct undisturbed, the inferior turbinate somewhat recessed laterally and excellent cosmetic healing of the cut mucosal edges.

The ascending process of the maxilla forming the bony canal of the lacrimal duct can be removed without causing epiphora as the function of the valve of Hasner is not dependent on bony support. Removing the bone surrounding the lacrimal duct and the bone of the medial wall of the maxilla constituting the inferior meatus allows for maximum medial displacement of the remaining mucosa within which is the lacrimal duct.

Unless the anterior aspect of the lacrimal duct is flush with the anterior medial corner of the maxilla, medial retraction of the mucosa of the medial maxilla is always possible and provides an effective endoscopic access route to the anterior maxillary wall.

Based on our results, the feasibility of easily achieving anterior maxillary wall access with the PLWA in Chinese subjects in our study is 93% (combining incidences of Type 3 and 2) as compared to Europeans at 68.5% from the Simmen et al. study.

Also, in comparing lacrimal duct width, our population had a significantly larger width compared to the Swiss study (14.06 ± 3.46 mm vs. 6.81 mm ± 1.30 mm). The clinical implications of having a larger lacrimal duct will have to be further studied to ascertain its clinical significance as there is a paucity of research on this topic [12]. One could postulate that a lacrimal duct of wider girth could be more easily identified and be less likely damaged. Post-operative epiphora from lacrimal duct damage would also be less likely.

The limitation of this study is that it is an observational study, and as such there is no control group. We also acknowledge that our study size of 200 sides may confer selection bias when extrapolated into the population.

Despite the above limitations, our results are greatly different from those obtained by Simmen et al. (93% vs 68.5%) and is largely in concordance with our experience in our clinical practice.

Conclusion

There appears to be a significant ethnic difference in the width of the pre-lacrimal recess between Oriental and Occidental populations consistent with previous observations of a higher incidence of sphenoid–ethmoid cells in Oriental paranasal sinuses suggesting a higher pneumatization rate of Oriental paranasal sinuses. PLWA is feasible in a larger percentage of our Oriental patients (93.5%) than in a previous study involving an Occidental population. (68.5%). This is consistent with our clinical experience with the PLWA.

Author contributions JKS and PSXL contributed to the design of the study and wrote the paper. GWS, KA and JPN Goh collected and analyzed the data. PSXL performed the statistical analysis.

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Compliance with ethical standards

Conflict of interest None of the authors have conflict of interest to declare. There are no financial disclosures for the above authors.

Ethics approval This study has been approved by the Hospital Doman Specific Review Board (DSRB) and approved as per hospital ethics protocol.

Informed consent As this is a retrospective study, and the data used are non-identifiable, patient consent was not required as per institutional ethics protocol.

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