Received: 15 June 2020 | Revised: 7 July 2020 | Accepted: 25 July 2020
DOI: 10.1002/lio2.440

ORIGINAL RESEARCH

Laryngoscope
Investigative Otolaryngology

Use of the medial canthal point (MCP) as a reliable anatomical landmark to the frontal sinus

Karan Jolly MBChB, MRCS (ENT)[1] | Theodoros Kontogiannis FEBROL-HNS[2] | Miran Pankhania FRCSEd (ORL-HNS)[1] | Khalid Hussain MBChB, FRCR, MRCS (ENT), MSc (PSPM)[1] | Paresh Pramod Naik MBBS, MS ENT, DNB[1] | Shahzada K. Ahmed MBChB, FRCS (ORL-HNS), PhD[1]

[1]Department of Otolaryngology, Queen Elizabeth Hospital, University Hospitals Birmingham NHS Foundation Trust, Birmingham, UK

[2]Department of Otolaryngology, Birmingham Children's Hospital, Birmingham, UK

Correspondence
Karan Jolly, 1 Redmoor gardens, Wolverhampton, WV45QS, UK.
Email: kjolly@nhs.net

Abstract

Objectives: Frontal sinus surgery is considered one of the more challenging aspects of Functional Endoscopic Sinus Surgery, due to the complex variations in normal sinus anatomy but also increased morbidity due to the close proximity of critical structures such as the anterior cranial fossa and orbits. We aim to investigate the medial canthal point (MCP) as an anatomical landmark for safe frontal sinus access.

Methods: The MCP intranasally is identified during surgery with non-tooth forceps, with one limb just anterior to the medial canthus and the other intranasally in the same coronal plane along the skull base. This point was identified on 100 paranasal sinus computed tomography (CT) scan reconstructions. The distance between the anterior cranial fossa and MCP was measured on imaging—medial canthal point distance (MCPD). The maximal anterior-posterior (AP) distance was measured on all scans.

Results: The average MCPD for males was 13.0 mm (8.7-20.4 mm) and for females 12.0 mm (6.8-22.8 mm). Mean AP distance for males was 12.0 mm (4.5-20.2 mm) and for females 10.4 mm (3.8-15.9 mm). Mean distance for all 100 patients was 12.6 mm (range 7.5-22.8 mm). In all cases, the MCP was anterior to the cranial fossa. Mixed effects modelling analysis showed a significant correlation between the MCPD and AP distance (P = .006).

Conclusion: The MCP is a consistent anatomical landmark that can serve as an adjunct to safe frontal sinus access alongside the first olfactory fiber and CT navigation systems. However, patient selection continues to be very important, with larger well pneumatized frontal sinuses being ideal to tackle earlier in a surgeon's career.

Level of evidence: NA

KEYWORDS
anterior skull base, frontal sinus, medial canthal point

1 | INTRODUCTION

Frontal sinus surgery is considered one of the more challenging aspects of Functional Endoscopic Sinus Surgery (FESS), primarily due to the complex variations in normal sinus anatomy in this region but also increased morbidity due to the close proximity of critical structures such as the anterior cranial fossa and orbits. An increased understanding of sinonasal anatomy, optical advancements as well as improved powered instruments has allowed for an evolution in the management of complex frontal sinus pathology with better outcomes.

One of the fascinating aspects of FESS is the uniqueness of the frontoethmoidal air cell labyrinth. Our knowledge of the drainage pathways continues to expand as demonstrated recently by Bolger et al, with the description of the anterior ethmoidal genu.[1] Until recently, the uncinate process and ethmoid bulla were considered separate entities; however, the two appear to fuse superiorly forming a consistent landmark medial to which the frontal sinus drains in 77% of cases.[1] The key to successful sinus surgery is the reliability and understanding of key anatomical landmarks which help guide the surgeon, especially in the presence of complex pathology that often distort common landmarks.

A number of different frontal sinus procedures have been classified by Draf depending on the access required to address the extent of underlying disease.[2,3] These may involve an inside-out or an outside-in approach. The former involves identifying the natural frontal sinus drainage pathway whereas the latter involves a median approach with early identification of the floor of the frontal sinus and first olfactory filament. The approach taken is very much dependent on surgeon experience, anatomy of the sinuses, and the pathology being managed.

Two important adjuncts to safely access the frontal sinus via the median approach have been the identification of the first olfactory filament and use of intraoperative image navigation systems. One study identified the first olfactory filament to be on average 4.0 mm posterior to the frontal sinus.[4] The authors proposed drilling at least 7 mm rostral (anterior) to the first olfactory filament would allow safe access to the frontal sinus in 91% of patients.[4] This important landmark continues to serve as a useful pointer especially when combined with image navigation. There are however limitations to this, including availability of and unpredictability of navigation systems as well as presence of disease obscuring anatomical landmarks. We aim to investigate the medial canthus and its correlation to the frontal sinus along the skull base, and assess the feasibility of using it as another fixed anatomical landmark to aid surgery to the frontal sinus. In addition, we will correlate this with different degrees of frontal sinus pneumatization, by measuring the maximal anterior-posterior (AP) distances of each frontal sinus.

2 | METHODS

During frontal sinus surgery, the surgeon uses non-toothed surgical forceps to identify the level of the medial canthus coronally along the skull base. This is achieved by placing one limb of the forceps just anterior to the medial canthus with the other limb inserted intranasally. The tip of the limb of the forceps that is placed intranasally is painted with ink or methylene blue dye to mark the corresponding level of the medial canthus intranasally in the same coronal plane—medial canthal point (MCP) (Figure 1). This point is then used to elevate a mucosal flap along the skull base. We aimed to identify the distance between the point along the skull base in the same coronal plane as the medial canthus and the anterior cranial fossa using computed tomography (CT) imaging. This point is demonstrated in Figure 2 using CT navigation intraoperatively.

We analyzed sequential CT sinus scans performed for 50 adult male and 50 adult female patients attending the rhinology clinic at a single center. For each of the scans, our radiologist performed 3D volume rendering to identify and mark a point at the medial canthus on

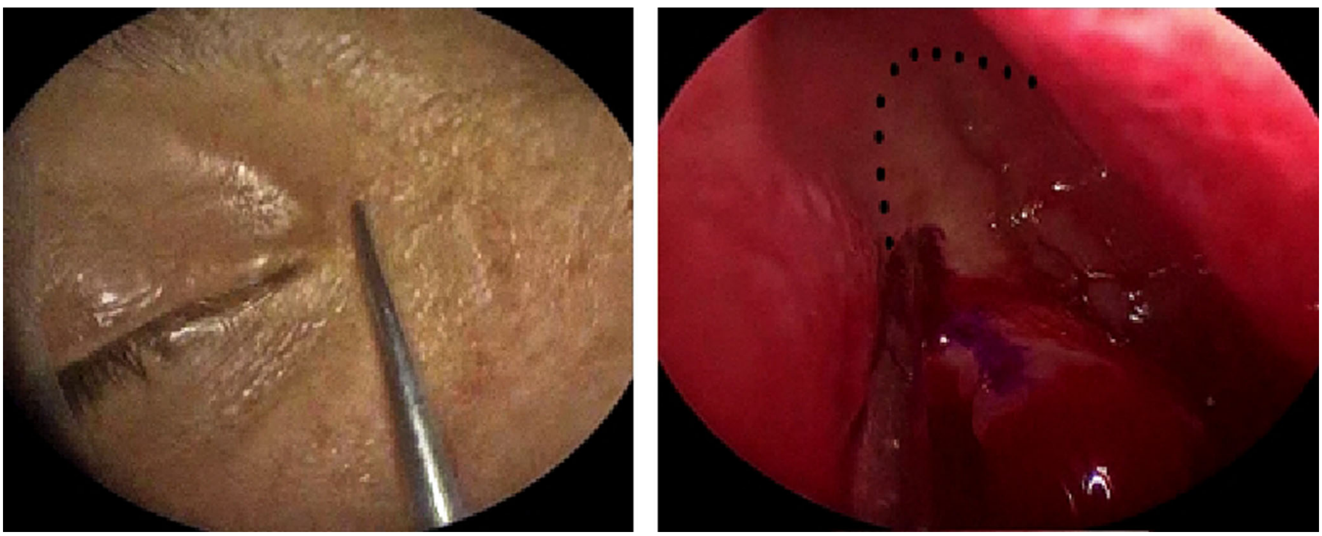

FIGURE 1 Endoscopic view of the lateral limb of the forceps on the medial canthus (left) and the medial limb stained with ink intranasally at the same coronal level along the skull base (medial canthal point). This landmark is also used in designing frontal sinus flaps (dotted line)

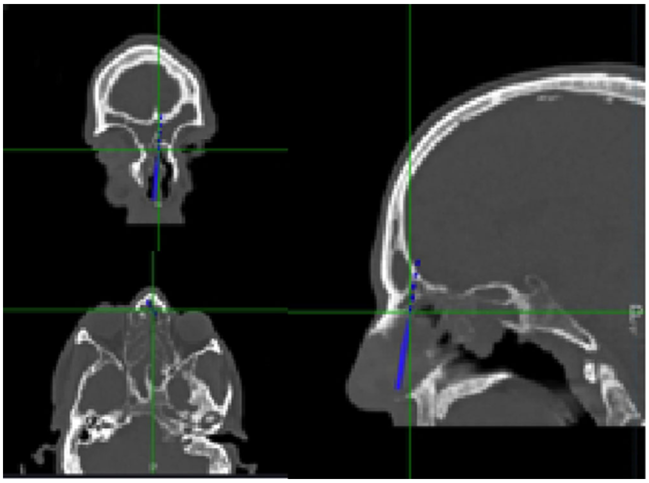

FIGURE 2 Computed tomography (CT) navigation image of the medial canthal point (MCP) along the skull base

FIGURE 3 3D reconstruction with medial canthus

the images in conjunction with the surgeon (Figure 3). This point represents the position of the lateral arm of the forceps. This mark auto-registered on corresponding axial slices allowing us to mark a point in the same coronal plane within the nasal cavity paramedian to the septum (Figure 4). Sagittal images were used to extrapolate this point cranially to the skull base in the same coronal plane as the medial canthus as would be done intraoperatively with elevation of the mucosal flap. This represents the point of drilling to access the floor of the frontal sinus. The distance between the MCP and the inner table of the anterior cranial fossa was measured along the boney skull base—the medial canthal point distance (MCPD) (Figures 4 and 5). The angle at which this distance was measured depended on the slope of the skull base which varied from patient to patient. Measurements were taken for both the right and left sides on each patient giving a total or 200 measurements. Alongside this, for each of the patients, the maximal AP distance of the frontal sinus on both left and right sides were measured. Data were presented as mean (SD) by gender and position for each variable. Mixed effects models were used to

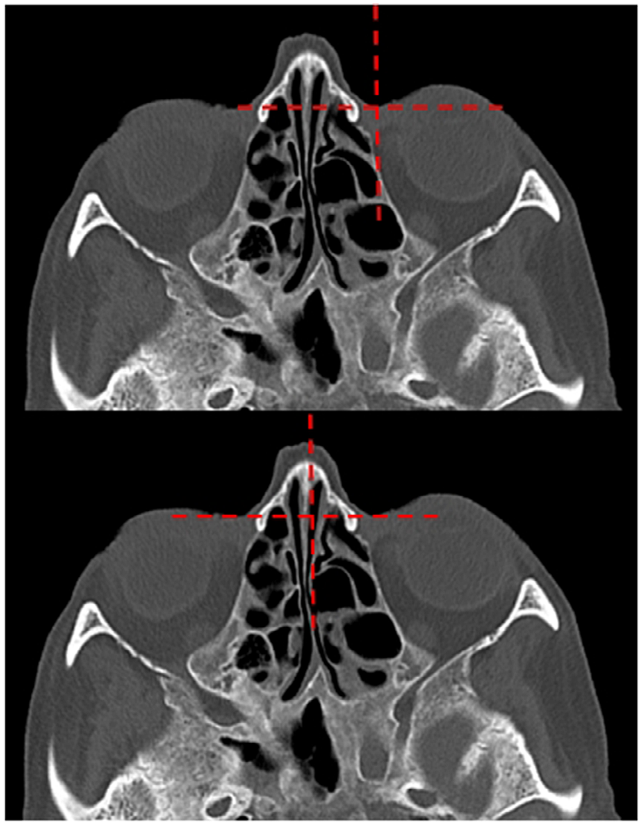

FIGURE 4 Medial canthal point (top) and corresponding intranasal point (bottom) illustrated by the intersection of the doted lines

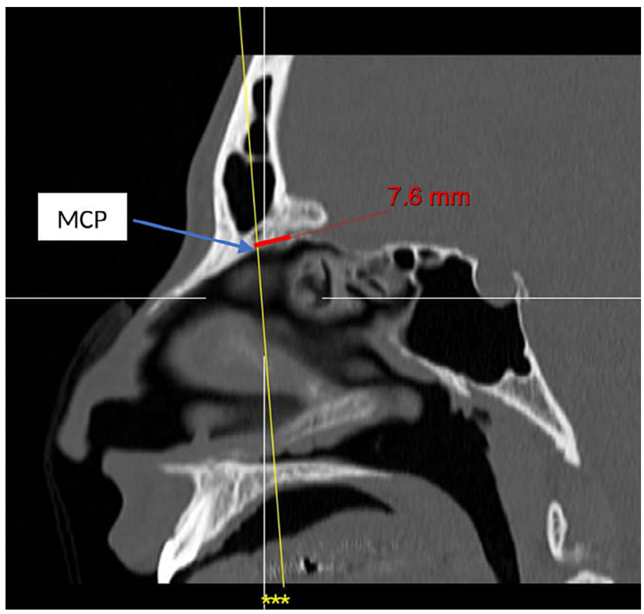

FIGURE 5 Medial canthal plane identified by yellow line (in asterisk) with arrow to medial canthal point (MCP) along skull base. Distance between ACF and MCP (red line)

estimate the mean of the pooled data and also to assess the relationship between the medial canthal distance and AP distance. The data were analyzed using the statistical software Stata version 16.1.

TABLE 1 Table showing the medial canthal point (MCD) and anterior-posterior (AP) distances in both 50 males and 50 females for right and left frontal sinuses

Variable	Position	Mean (mm)	SD	Minimum (mm)	Maximum (mm)
Male					
MCPD	Right	12.8	2.0	9.4	17.5
MCPD	Left	13.2	2.6	8.7	20.4
AP	Right	12.0	3.2	4.5	19.0
AP	Left	12.0	3.0	4.6	20.2
Female					
MCPD	Right	12.6	2.6	7.3	18.0
MCPD	Left	11.9	3.2	6.8	22.8
AP	Right	10.3	2.9	4.5	15.9
AP	Left	10.5	2.9	3.8	15.6

TABLE 2 Combined mean values for medial canthal point (MCD) and anterior-posterior (AP) distance for males and females

	Mean (95% CI)
Medial canthal point distance (MCPD)	
Male	13.0 (12.4, 12.4)
Female	12.0 (11.4, 13.5)
AP distance	
Male	12.0 (11.2, 12.7)
Female	10.4 (9.6, 11.1)

Patients were excluded if they had a history of severe facial trauma that might have distorted the position of the medial canthus or if they had a hypoplastic frontal sinus.

3 | RESULTS

Of the 100 patients included, mean age was 50 (range 17-90 years) with an average BMI of 29.7 (range 20.4-49.1 kg/m^2). The average MCPD for males was 13.0 mm (8.7-20.4 mm) and for females 12.0 mm (6.8-22.8 mm). The mean AP distance for males was 12.0 mm (4.5-20.2 mm) and for females 10.4 mm (3.8-15.9 mm). Our results demonstrate that the MCP along the skull base point was sufficiently clear of the posterior table of the frontal sinus in all of the sample patients within two standard deviations (Tables 1 and 2).

Mixed effects modelling was used to assess the relationship between the frontal sinus AP distance and the MCPD. Ignoring the effects of gender and side of frontal sinus, there was a significant relationship between AP distance and the MCPD (P = .006) with the model suggesting that for every unit increase in AP distance the MCPD increases by 0.17 mm. This also indicates a positive correlation between the two variables. The results therefore demonstrate that in patients with larger well pneumatized frontal sinuses, the MCPD will be larger and thus a more reliable marker for safe access into the frontal sinus.

4 | DISCUSSION

In recent years, there has been an increase in the surgical management of frontal sinus pathology, owed to better anatomical and physiological understanding of the paranasal sinuses. Angled endoscopes accompanied by a wide range of angled instruments and powdered tools have allowed for better visualisation allowing more complex conditions to be tackled safely.

Frontal sinus surgery has been classified by Draf based on its approach for the underlying pathology.[2] Extended frontal sinus drainage involves removal of the floor of the sinus between lamina papyracea and middle turbinate (Draf IIa) or nasal septum (Draf IIb), anterior to the anterior cranial fossa. More extensive drainage requires bilateral draf IIb procedures with resection of the superior nasal septum and the frontal intersinus septum. Sinonasal pathology can make identification of the frontoethmoidal recess challenging and inexperienced surgeons may find themselves struggling or performing an inadequate procedure in an attempt to avoid a complication. A systematic review by Scott et al reported the incidence of peri-operative CSF leak during modified Lothrop (Draf III) procedure to be higher than an osteoplastic flap approach; however, postoperative outcomes were better with an endoscopic approach.[5]

Historically, the first olfactory filament has been shown to be a useful landmark in identifying the posterior limit to drill into the floor of the frontal sinus; however, a recent study demonstrated a wide degree of variability of this point from the posterior table of the frontal sinus, making it not as reliable as previously thought.[4,6] As a result, this must be combined with image guidance to safely excise the floor of the frontal sinus. However, image guidance systems are not universally available and may not be accurate, so their reliability should be taken with caution. In addition, sinonasal and olfactory fossa pathology may distort anatomy making it difficult to identify the first olfactory filament and other key anatomical landmarks such as the axilla of the middle turbinate. Branches of the anterior ethmoidal artery and nerve may also be mistaken for the first olfactory filament[4] which highlights the advantage in having another fixed reliable landmark (the medial canthus) for safe access to the frontal sinus.

Our study determined the medial canthus to be 12.5 mm (6.8-22.8 mm) anterior to the anterior cranial fossa along the skull base on 200 readings from 100 CT scans, with all registered points being clear of the anterior cranial fossa independent of gender and side of patient. The effects of age, BMI, and height of patients on the MCPD were not explored in this study; however, over the 100 patients studied across a wide range of ages and BMI, the MCP was clear of the anterior skull base in all cases as demonstrated. In addition to this, there was a strong correlation between AP diameter of the frontal sinus and MCPD. A well-pneumatized sinus with a larger maximal AP diameter will have a larger MCPD and thus improving the safety and reliability of the MCP. Similarly a narrow frontal sinus will have a short MCPD and may therefore not be suitable for an endoscopic approach especially when less experience endoscopic surgeons are operating. Reliability of the MCP can be validated on preoperative imaging or intraoperatively with navigation imaging if available, or used alongside the first olfactory filament for increased accuracy to access the frontal sinus. Cautious drilling cranially at this point and just anterior to this point will allow for safe access into the frontal sinus. We recommend this is done with a high speed drill and plenty of irrigation across a broad front until the frontal sinus is safely entered. Once the frontal sinus is entered, dissection can safely be continued with the posterior table under direct vision.

5 | CONCLUSION

During parotid surgery, the facial nerve trunk can be safely identified by a number of different anatomical landmarks and often surgeons use a combination of these for increased reassurance. In a similar way, we propose the triad of first olfactory filament, MCP and navigation imaging to help identify the safest entry point for a frontal sinus drill out. We hope this landmark serves to be a useful consistent anatomical marker in expanded frontal sinus surgery and as with all cases, patient selection is very important, with larger well pneumatized frontal sinuses being ideal to tackle earlier in a surgeon's career.

ORCID

Karan Jolly https://orcid.org/0000-0003-1720-001X

BIBLIOGRAPHY

1. Bolger WE, Stammberger H, Ishii M, Ponikau J, Solaiyappan M, Zinreich SJ. The anterior Ethmoidal "Genu": a newly appreciated anatomic landmark for endoscopic sinus surgery. *Clin Anat*. 2019;32(4): 534-540.
2. Weber R, Draf W, Kratzsch B, Hosemann W, Schaefer SD. Modern concepts of frontal sinus surgery. *Laryngoscope*. 2001;111(1):137-146.
3. Draf W. Endonasal frontal sinus drainage type I–III according to Draf. *The Frontal Sinus*. Berlin, Heidelberg: Springer; 2005:219-232.
4. Upadhyay S, Buohliqah L, Vieira Junior G, Otto BA, Prevedello DM, Carrau RL. First olfactory fiber as an anatomical landmark for frontal sinus surgery. *Laryngoscope*. 2016;126(5):1039-1045.
5. Scott NA, Wormald P, Close D, Gallagher R, Anthony A, Maddern GJ. Endoscopic modified Lothrop procedure for the treatment of chronic frontal sinusitis: a systematic review. *Otolaryngol Head Neck Surg*. 2003;129(4):427-438.
6. Wormald PJ. Salvage frontal sinus surgery: the endoscopic modified Lothrop procedure. *Laryngoscope*. 2003;113(2):276-283.

How to cite this article: Jolly K, Kontogiannis T, Pankhania M, Hussain K, Naik PP, Ahmed SK. Use of the medial canthal point (MCP) as a reliable anatomical landmark to the frontal sinus. *Laryngoscope Investigative Otolaryngology*. 2020;5: 791–795. https://doi.org/10.1002/lio2.440