The Journal of Laryngology & Otology

cambridge.org/jlo

Local anaesthetic techniques in endoscopic sinonasal surgery: a contemporaneous review

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Main Article

Mr S Ahmed takes responsibility for the integrity of the content of the paper

Cite this article: Watts E, Thompson A, Pankhania M, Okonkwo O, Ahmed S. Local anaesthetic techniques in endoscopic sinonasal surgery: a contemporaneous review. *J Laryngol Otol* 2022;**136**:683–691. https://doi.org/10.1017/S0022215121003583

Accepted: 19 March 2021
First published online: 24 November 2021

Key words:
Local Anesthetic Endoscopic Sinus Surgery

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Abstract

Objective. Endoscopic endonasal surgery is a minimally invasive technique that has revolutionised the management of complex neurosurgical, otolaryngological, skull-base and craniofacial lesions. Traditionally performed under general anaesthetic, this study explores the growing role of local anaesthetic techniques.
Method. A contemporaneous review of modified dental techniques and intraoral anatomy provides a supportive guide for performing endoscopic sinus surgery under local anaesthetic.
Results. The practical procedures for four midfacial nerve blocks are described with relevance to endoscopic surgery under local anaesthetic. Anatomy, surgical technique and potential complications are discussed for the incisive foramen block, sphenopalatine ganglion block (via endonasal approach), maxillary nerve block (via the greater palatine foramen and the transoral lateral pterygoid plate approach) and transcutaneous approach to the pterygomaxillary fissure.
Conclusion. Ultimately, such techniques may extend the safety and efficacy of endoscopic sinus surgery, limit surgical risk and increase satisfaction for patients, surgeons and healthcare managers alike.

Introduction

Endoscopic sinus surgery and skull base surgery have evolved dramatically since they were popularised by Walter Messerklinger and David Kennedy in the late 1970s, owing particularly to the development of the rigid Hopkins rod endoscope and bespoke instruments. Over the subsequent 40 years, endoscopic endonasal surgery has developed to allow treatment of complex neurosurgical, craniofacial and skull base lesions that would otherwise require extensive open-approach surgery for access.

Topical and injected local anaesthetic techniques in nasal surgery are well established, developing from the historical use of cocaine (2–3 mg/kg), which is both a potent vasoconstrictor and anaesthetic agent.[1] Injected local anaesthetic preparations of lidocaine are typically combined with adrenaline to offer a short acting anaesthetic effect with simultaneous vasoconstriction and higher dose toxicity (7 mg/kg) because plain local anaesthetic would result in vasodilatation and a significantly lower limit of dose toxicity (3 mg/kg). Longer acting agents like levobupivacaine do not confer an advantage with regards to dose toxicity despite being available in preparations combined with adrenaline.[2]

This contemporary review of local anaesthetic techniques, focusing on the use of lidocaine with adrenaline as an injectable block, is specifically directed towards endonasal surgery and emphasises the potential role in endoscopic sinus surgery using local anaesthetic midfacial nerve blocks. A review of the contemporary literature and combination of modified dental techniques and intraoral anatomy is combined with *in vivo* surgical experience to provide an up-to-date guide for the endoscopic sinus surgeon wishing to perform surgery on suitable patients.

Materials and methods

Relevant anatomy

The nasal cavity is innervated by four systems: sensory, motor, autonomic and parasympathetic. Although a large number of nerves contribute to the sensory supply of the nasal cavity, they predominately originate from the ophthalmic (V1) and maxillary (V2) division of the trigeminal nerve. The ophthalmic division exits the skull via the superior orbital fissure, providing sensation to structures derived from the frontonasal prominence via three main branches (Table 1). The majority of sensory innervation to the nasal cavity is supplied by the maxillary division (Figure 1). It emerges from foramen rotundum and innervates structures derived from maxillary prominence of the first pharyngeal arch via nine sensory branches (Table 1). Key areas manipulated during endoscopic sinus surgery include the sinuses, nasal vestibule, columella, lobule, nasal septum and the turbinates

Table 1. Sensory branches of the trigeminal nerve

Parameter
Sensory branches of the ophthalmic division of trigeminal nerve
– Frontal
– Lacrimal
– Nasociliary
Sensory branches of the maxillary division of trigeminal nerve
– Superior alveolar nerve (anterior, posterior and middle)
– Middle meningeal nerve
– Infraorbital nerve
– Zygomatic nerve
– Inferior palpebral nerve
– Superior labial nerve
– Pharyngeal nerve
– Greater and lesser palatine nerves
– Nasopalatine nerve

(Table 2). Good understanding of pertinent local innervation is essential to enable effective local anaesthetic surgery.

The sensory branches of V2 (Table 3) which supply the nasal cavity can be effectively reached via the pterygopalatine ganglion, situated within the pterygopalatine fossa. This small-volume, cone-shaped space is located between the maxilla, sphenoid and palatine bone. It has seven foramina (Table 4), the most clinically relevant of which include the sphenopalatine foramen, the greater palatine foramen and the pterygomaxillary fissure.

The sphenopalatine foramen is located at the junction between the palatine bone and the sphenoid bone. The cristae ethmoidalis protects this foramen and forms a consistent feature in the unoperated patient. Typically, the sphenopalatine foramen is found just posterior to the maxillary antrum, at the posterolateral edge of the middle turbinate between the middle and superior meatus (Figure 2). This conduit transmits the nasopalatine nerve, posterior superior nasal nerve and the sphenopalatine artery and vein.

The greater palatine foramen is situated along the posterior aspect of the hard palate of the greater palatine canal, formed between the articulation of the maxillary bone and the palatine bone. Clinically, it is identified between the second and third molars approximately one centimetre towards the midline of the palate from the gingival margin (Figure 3). It transmits the descending palatine vessels and greater palatine nerve.

Finally, the pterygomaxillary fissure is the narrow gap between the infratemporal surface of the maxilla and the lateral pterygoid plate (Figure 4). Located posterior, superior and medial to the maxillary tuberosity, it connects the pterygopalatine fossa with the infratemporal fossa and transmits the terminal part of the maxillary artery and the posterior superior alveolar nerve.

Patient selection

Patient selection is a vital aspect of successful local anaesthetic endoscopic sinus surgery and pre-operative assessment may form an unwitting part of the consultation. Patients who are stoical and have had previous procedures performed under sedation or local anaesthetic may better tolerate local anaesthetic endoscopic sinus surgery. Similarly, those who are tolerant of dental procedures may be familiar with the anaesthetised mid-face and may tolerate local anaesthetic endoscopic sinus surgery better than those who are dentally and surgically naive. Patients tolerating endoscopic assessment during out-patient clinic may be more co-operative during local anaesthetic endoscopic sinus surgery, particularly when inspecting sensitive areas such as the middle meatus. Local anaesthetic endoscopic sinus surgery may be of particular worth in patients with multiple cardiorespiratory comorbidities who are deemed unfit for general anaesthetic. Simultaneous electrocardiogram and oxygen saturation monitoring is recommended throughout.

The authors recommend initial use of 4.4 ml Lignospan® (2 per cent lidocaine +1:80 000 adrenaline) applied endonasally on neuropatties. This permits mucosal anaesthesia and decongestion, meaning subsequent instrumentation is less stimulating in the event of a partial or non-functional block. Next, a dental syringe is loaded with Lignospan. These cartridges have the advantage of being self-aspirating by virtue of the elastic recoil of the rubber end piece; when pressure is removed from the plunger, the cartridge will aspirate. A variety of gauges and lengths are available for dental anaesthetic needles; however, most authorities recommend a 27-gauge needle in order to reduce the risk of non-aspiration.[3] The preferred local anaesthetic blocks of the individual authors are described below.

Results

Nasopalatine foramen block

Anatomy

The incisive nerve is the terminal branch of the nasopalatine nerve which receives its name as it emerges from the incisive foramen. It communicates with the anterior palatine nerve and supplies sensation to the upper incisors, adjacent gingivae, anterior palate and pre-maxilla as well as the surrounding mucosa.

Technique

The incisive papilla is the pear-shaped, midline mucosal fold situated on the palatal surface between the central incisors.[4] This should be compressed using a cotton swab and then a 27 G short dental needle should be inserted just lateral to the papilla at 45 degrees. Local anaesthetic solution should be deposited slowly until the needle has penetrated approximately 5 mm, directly over the nasopalatine foramen. A small volume of less than 0.5 ml is usually enough to anaesthetise this area. Once blanching has been observed independent of that produced by direct pressure from the cotton swab, this volume of infiltration would be deemed sufficient (Figure 5).

Sphenopalatine ganglion block (endonasal)

Anatomy

The sphenopalatine nerve and artery emerge from the sphenopalatine foramen. Endoscopically this can be located during sphenopalatine artery ligation by elevating the middle meatal mucosa at the posterior fontanelle until the crista ethmoidalis is identified, behind which the vessels emerge. The posterior end of the middle turbinate is therefore a useful endoscopic landmark in identifying the mucosal region in which the nerve emerges. The natural ostium of the maxillary sinus

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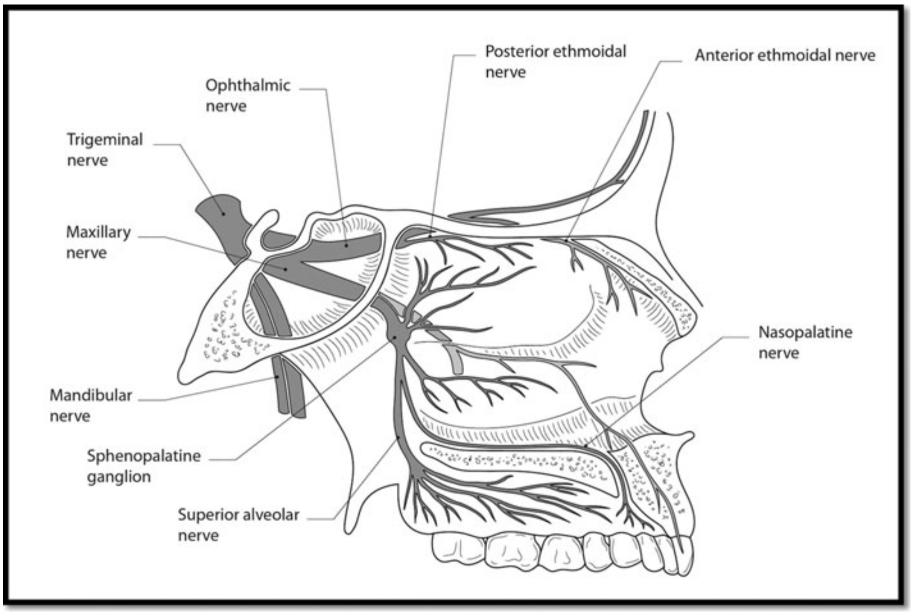

Fig. 1. Schematic diagram of sensory innervation of the nasal cavity.

Table 2. Sensory innervation of the nasal cavity

Structure	Nerve supply
Turbinates	Nasopalatine nerve (V2)
Septum	Nasociliary nerve (V1)
	Nasopalatine nerve (V2)
Nasal vestibule	Infraorbital nerve (V2)
Lobule	Nasociliary nerve (V1)
	– Anterior ethmoidal nerve (V1)
Frontal sinus	Nasociliary (V1)
	– Anterior ethmoid nerve
Anterior ethmoids	Nasociliary nerve (V1)
	– Anterior ethmoid nerve
Maxillary sinus	Infraorbital nerve (V2)
	– Greater palatine nerve (V2)
Posterior ethmoids	Nasopalatine nerve (V2) Nasociliary nerve (V1)
	– Posterior ethmoid nerve (absent in 30%)
Sphenoid sinus	Nasopalatine nerve (V2) Nasociliary nerve (V1)
	– Posterior ethmoid nerve (absent in 30%)

Table 3. Boundaries of the pterygopalatine fossa

Pterygopalatine fossa boundaries
– Anterior: posterior wall of the maxillary sinus
– Posterior: pterygoid process of the sphenoid bone
– Inferior: palatine bone and palatine canals
– Superior: inferior orbital fissure of the eye
– Medial: perpendicular plate of the palatine bone
– Lateral: pterygomaxillary fissure

may also serve as a landmark as the maxillary artery can be located in the posterior maxillary sinus wall endoscopically and traced medially to identify the level of the sphenopalatine foramen and artery.

Table 4. Foramina of the pterygopalatine fossa

Pterygopalatine fossa foramina
– Pterygomaxillary fissure
– Foramen rotundum
– Pterygoid canal
– Pharyngeal canal
– Inferior orbital fissure
– Greater palatine canal
– Sphenopalatine foramen

Technique

Under endoscopic guidance, the middle turbinate is carefully medialised in order to visualise the posterior attachment of the middle turbinate at the lateral nasal wall. A spinal needle can be attached to a 2 ml Luer lock syringe and carefully introduced into the middle meatus to inject into the area described, placing the sphenopalatine artery into vasospasm as well as anaesthetising the septum, inferior and middle turbinates, anterior face of the sphenoid, and nasal floor.

Maxillary nerve block via greater palatine foramen

Anatomy

The greater palatine foramen transmits the greater palatine branches of the sphenopalatine nerve to supply the bony and mucosal structures of the hard palate excluding the incisors and pre-maxilla. The upper teeth are supplied by the superior alveolar nerve and are not supplied by the greater palatine nerve. More proximally, the foramen communicates with the pterygopalatine fossa and pterygomaxillary fissure, where the maxillary nerve gives off the pterygopalatine nerve. The greater palatine foramen and canal are utilised in this block for retrograde injection resulting in a more proximal block, the effects of which can be assessed by asking about hard palatal sensation.

By comparison, the nearby lesser palatal foramen transmits the lesser palatine nerves which supply the soft palate, uvula

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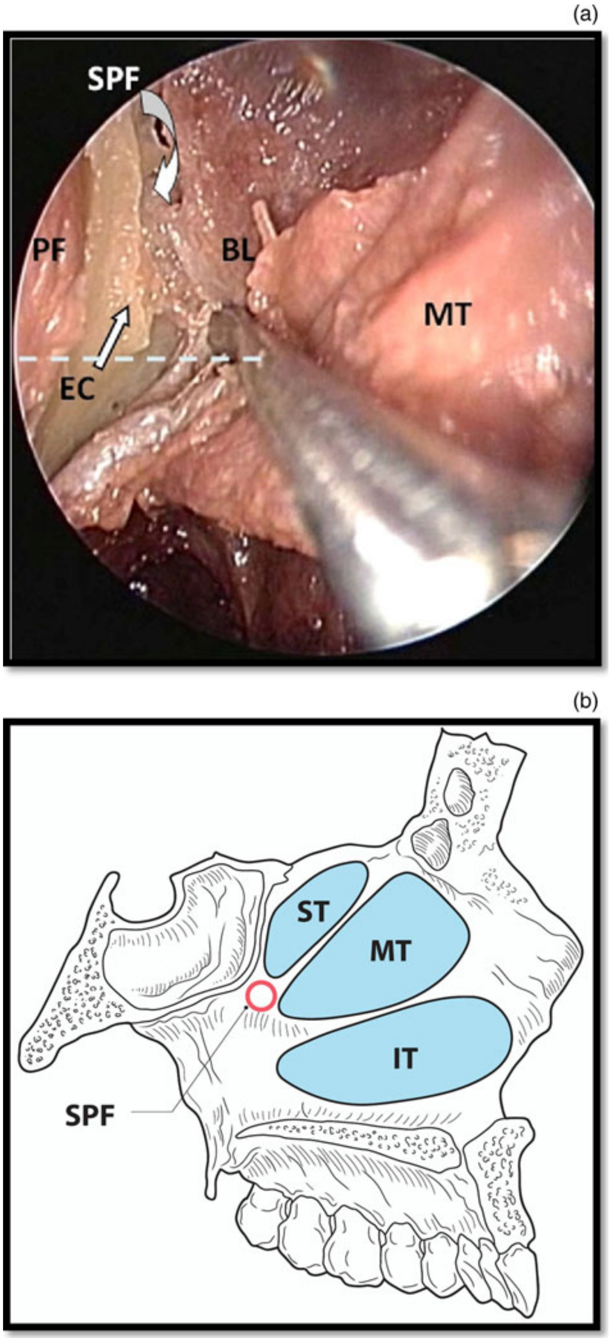

Fig. 2. (a) Endoscopic view of the right sphenopalatine foramen and (b) schematic diagram showing the anatomy of the sphenopalatine foramen. SPF = sphenopalatine foramen; PF = posterior fontanelle; BL = basal lamina; MT = middle turbinate; EC = ethmoid crest; ST = superior turbinate; IT = inferior turbinate

and the majority of the tonsillar fossa above the tongue base, so an inadvertent block here results in diminished oropharyngeal and velopharyngeal sensation but with preservation of the gag reflex.

Technique

A 27-gauge needle is inserted perpendicular to the mucosa, 1 cm medial to the upper second molar. A cotton bud may aid identification of the greater palatine foramen. The swab will sink slightly into the depression of the foramen, enabling firm pressure to be applied. This pressure anaesthesia helps reduce the pain of injection.[5] The needle should be directed slightly superolaterally to follow the canal for at least 10 mm before injecting local anaesthetic to ensure penetration into the pterygopalatine foramen. This will block the greater palatine nerve as it enters the greater palatine foramen (Figure 6).

Maxillary nerve block via transoral lateral pterygoid plate

Technique

Close assessment of the intra-oral anatomy is pivotal as this block is relatively deep and therefore blind. Ultrasound guidance has been described in cadaveric studies but is not utilised by the authors.[6]

Palpation of the hamulus identifies the anterior-most extent of the lateral pterygoid plate. A 27-gauge, 35 mm dental needle is angled at 45 degrees prior to infiltration. The cheek is laterally retracted, and the patient encouraged to relax the mouth enough to create some mucosal slack, improving access to the buccal sulcus. The needle is inserted lateral to the hamulus in the deepest aspect of the posterosuperior buccal sulcus, aiming to infiltrate in a plane parallel to the lateral pterygoid plate. The pupil can be used as a surface landmark for the maxillary nerve and foramen rotundum. The needle should be inserted to the hilt to allow it to reach as close to the pterygopalatine fossa as possible. The resulting block provides entire midfacial anaesthesia and places the maxillary artery into vasospasm. This can occasionally cause midfacial blanching which is reversible (Figure 7).

Discussion

Endoscopic sinonasal surgery is indispensable in managing a spectrum of conditions from intractable rhinosinusitis to complex neurosurgical pathology.[7] Originally, this procedure was performed under topical local anaesthesia but was typically limited to nasal polypectomy and septal surgery, leaving remaining nasal anatomy largely intact. Evolving surgical techniques permitted more extensive resection, necessitating general anaesthetic to achieve adequate airway protection, immobilise the surgical field and maximise patient comfort.[8] However, increasingly comorbid and ageing populations have more systemic risks of general anaesthesia such as myocardial infarction,[9] venous thromboembolism,[10] aspiration[11] and delirium.[12] Local anaesthetic endoscopic sinus surgery may be of particular worth in patients with multiple cardiorespiratory comorbidities who are not fit for general anaesthetic and would otherwise be denied a surgical management option.

Endotracheal intubation itself is not without complication, ranging from a mild sore throat,[13] minor bleeding[14] and dental damage[15] to laryngotracheal injury[16] and pneumothoraces.[17] Moreover, direct laryngeal stimulation during endotracheal intubation promotes a sympathetic response contributing to haemodynamic instability.[18] Thus, the principle advantage of local anaesthetic techniques is in enabling substantive surgery to be performed without positive pressure ventilation or airway instrumentation as the patient maintains their own airway.[19]

The increasing prevalence of congestive cardiac failure[20] and obesity[21] has consequently increased rates of orthopnoea, rendering many patients physiologically unable to lie flat for procedures. Non-intubated patients can be positioned more upright; for example, the reverse Trendelenburg position provides 15° of head elevation.[22,23] This increases venous drainage of the head and neck as blood pools in the lower extremities.[24] Every 2.5 cm elevation above the level of the heart corresponds with a 2 mmHg reduction in mean arterial blood pressure.[25] Accordingly, more upright positioning together with the

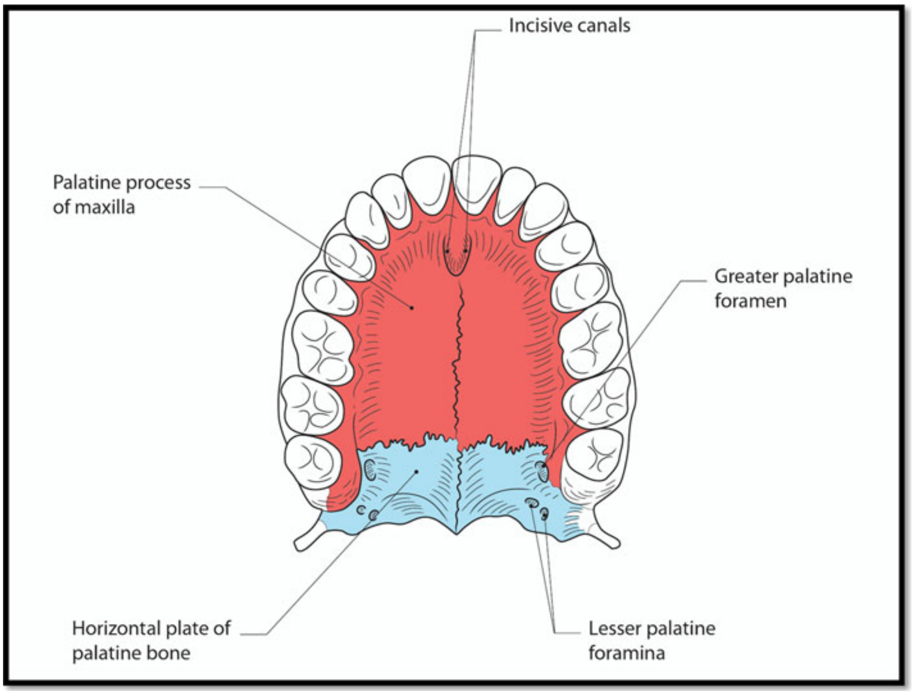

Fig. 3. Schematic diagram demonstrating the greater palatine foramen.

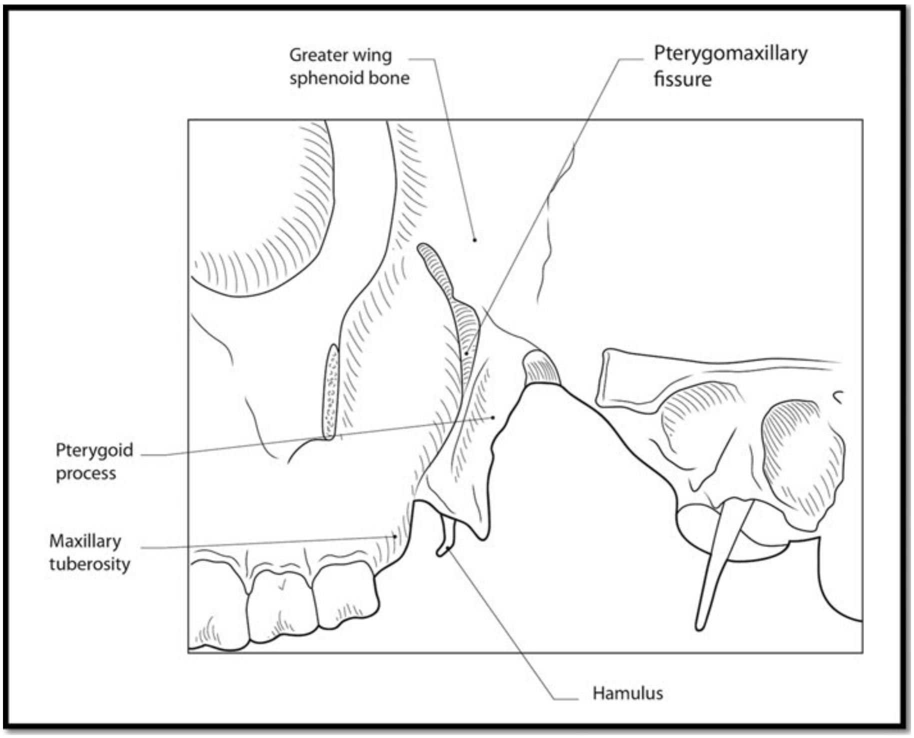

Fig. 4. Schematic diagram demonstrating the pterygomaxillary fissure.

vasoconstrictive properties of local anaesthetic improves the surgical view.[26] In turn, this reduces operative time by decreasing rod cleaning and suctioning.[8]

Adverse events in endonasal sinus surgery remain rare, but significant,[27] including cerebrospinal fluid leak, haemorrhage, orbital trauma, epiphora, optic nerve damage and meningitis.[28] Under local anaesthesia, patients remain conscious throughout and are therefore able to signal any pain or discomfort, which theoretically minimises complications like orbital breach.[8,19,29] However, local anaesthetic endoscopic sinus surgery does not universally reduce the risk of intra-operative complications.[30]

Vascular supply to the nasal cavities is extensive and anastomotic. Haemorrhage substantially disrupts visibility during endoscopic sinus surgery,[31] potentiating the risk of orbital, vascular or intracranial damage.[32] Hypotension is deliberately achieved during general anaesthetic. The mean arterial blood pressure is lowered[33] in order to reduce intra-operative blood loss by up to 141 ml,[34] thereby improving the surgical visual field.[35] Although rare, intentional hypotension is not without consequence and theoretically may engender cerebral thrombosis, renal hypoperfusion and myocardial infarction.[23,36,37] The techniques outlined in this paper recommend the initial use of Lignospan (2 per cent lidocaine + 1:80 000 adrenaline).

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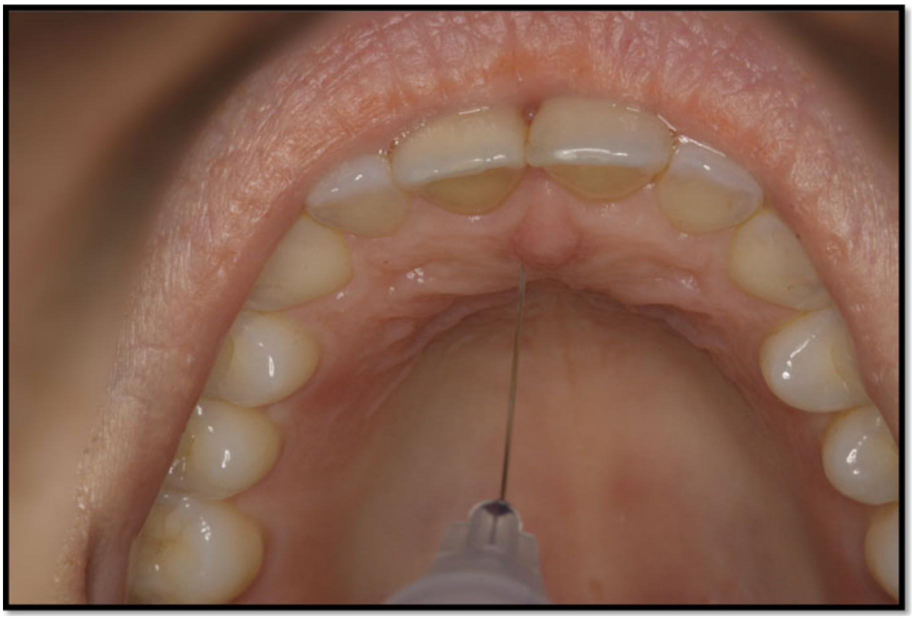

Fig. 5. Image showing nasopalatine foramen block.

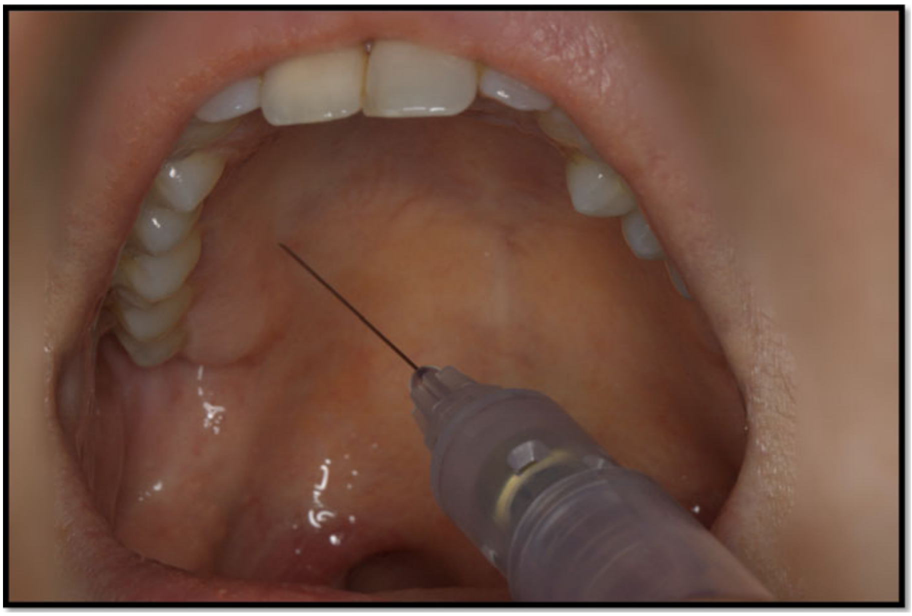

Fig. 6. Maxillary nerve block showing greater palatine foramen approach.

In addition to providing topical anaesthesia, this decongestant acts as a potent vasoconstrictor which aids mucosal decongestion and reduces haemorrhage, mitigating the hypotensive benefits seen in general anaesthesia.[38] Caution must be exercised as systemic absorption can result in hypotension,[39–41] hypertension,[42] tachycardia[38] and arrythmias[43,44] depending on the anaesthetic agent selected. However, Cohen-Kerem *et al.*[45] demonstrated systemic absorption to be rare, and haemodynamic observations remained within normal range. Furthermore, although adrenaline theoretically reduces tissue perfusion,[46] the study by Hafner *et al.* of 10 000 patients undergoing ear and nasal surgery reported no cases of tissue necrosis.[47] Procedures performed under local anaesthetic may induce fear, stress and pain, with consequent catecholamine release.[48] In turn, systemic stress hormones can cause hypertension and arrhythmias.[49,50]

In addition to providing nasal anaesthesia, local vasoconstriction, mucosal decongestion and enhanced haemostasis, endonasal surgery performed under local anaesthetic permits early patient mobilisation and long-lasting post-operative analgesia.[38,51–53] The initial discomfort associated with local anaesthetic blocks in the awake patient can be mitigated through slow infiltration and use of a fine 27-gauge needle.[19,54] Procedures performed under local anaesthetic permit shorter total operative and recovery times[19,23] and help release anaesthetic capacity for other operating theatres.[51] Fedok *et al.*[29] reported local anaesthetic procedures reduced total operative time by up to 22 per cent when compared with general anaesthetic. This was particularly noted for shorter, less extensive procedures (such as anterior ethmoid and maxillary sinus surgery), where the anaesthetic component forms a larger proportion of the total operative time. Although the absolute time saved was only 17.5 minutes, cumulative benefit by process of marginal gains may confer practical, clinical significance.

Overall, the substantial reduction in recovery time for local anaesthetic procedures proves more critical to patient flow and hospital efficiency than the slight reduction in operative duration. Patients recovering from general anaesthetic require

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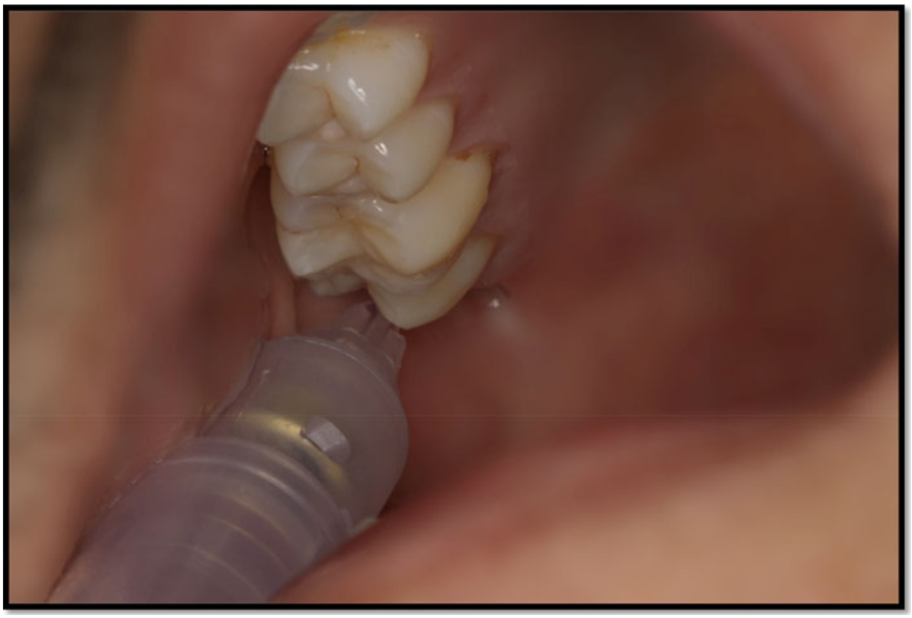

Fig. 7. Maxillary nerve block showing transoral lateral pterygoid plate approach

higher-intensity, first-stage recovery which is more expensive and labour intensive. Faster recovery combined with reduced admission rate and lack of anaesthetist therefore reduces the procedure costs of local anaesthetic.[19,23] Patient preference is perhaps even more important; Caner *et al.* found 89 per cent of patients would choose to reselect future procedures to be performed under local anaesthetic.[51] A dedicated time-and-motion study looking at local anaesthetic endoscopic sinus surgery may help quantify the relative cost-benefits over and above operating under sedation or general anaesthetic.

Endoscopic sinonasal surgery performed under local anaesthetic presents surgical challenges for analgesia, airway protection and immobilisation. Total nociceptive anaesthesia requires good knowledge of local anatomy, and some advocate the use of titrated sedation (such as midazolam, fentanyl, remifentanil or propofol infusion).[8,29,55,56] When used, sedation does provide the advantage of retrograde amnesia.[8] However, caution should be advised as this experience can be disorientating and requires a dedicated sedation-trained healthcare professional. Airway evaluation must be scrupulous if sedation is planned, especially if an anaesthetist will not be present. Indeed, some endoscopic procedures performed under sedation have reported fatalities.[57]

Other papers describing local anaesthetic techniques for endonasal surgery focus predominantly on topical mucosal anaesthesia, as opposed to regional nerve blockade, to achieve nasal anaesthesia. For example, Lee *et al.*[8] describe topical application of 25 per cent cocaine paste to progressively anaesthetise nasal mucosa. Although topical anaesthesia permits some endonasal procedures, including uncinectomy and exploration of sphenoid sinuses, it does not offer the formal regional block, as described in this paper. A variety of studies have assessed the role of local anaesthetic blocks with concomitant general anaesthesia.[58–61] For example, Shamil *et al.*[62] demonstrated a statistically significant reduction in post-operative pain following anterior ethmoidal and sphenopalatine ganglion blocks with 0.5 per cent Bupivicaine and 1:200 000 adrenaline. Crucially, all patients underwent general anaesthetic prior to endoscopic sinus surgery. Techniques outlined for the sphenopalatine ganglion block reflect our maxillary nerve block via the greater palatine foramen approach, whereas the anterior ethmoidal nerve block only blocks the anterior lateral nasal branch of the nerve. Although Jespersen *et al.* assessed the analgesic effects of a sphenopalatine ganglion block in patients receiving epidural blood patches, they successfully demonstrated that this technique can be plausibly performed under local anaesthetic.[63] Sphenopalatine artery ligation can be performed under local anaesthetic using a maxillary nerve block via greater palatine foramen approach.[64] Thus, for appropriately selected patient cohorts, the techniques outlined in this paper should provide sufficient analgesia to obviate the need for general anaesthesia or sedation as required by Lee *et al.*[8]

- Endoscopic sinus surgery can be performed under local anaesthetic using modified dental techniques
- Local anaesthetic blocks can target nasopalatine, greater palatine, sphenopalatine and maxillary nerves
- Benefits of local anaesthetic techniques include increased safety and efficacy with limited surgical risk

A combination of shrewd patient selection and good local anaesthetic technique should hopefully negate the need for sedation. Stoical patients may better tolerate local anaesthetic endoscopic sinus surgery if they have had previous experience of dental procedures or surgery performed under local anaesthetic. Tolerance of endoscopic nasal examination in an outpatient setting may indicate likelihood of successful local anaesthetic endoscopic sinus surgery. Patients should be co-operative, following precise instruction and remaining awake for the duration of the procedure. If applicable, preoperative counselling should inform patients of the potential risk of conversion to general anaesthetic. However, Lee *et al.* found conversion was only required in 1 of 554 patients undergoing local anaesthetic endoscopic sinus surgery.

Conclusion

This contemporary review of local anaesthetic midfacial nerve blocks presents an alternative option for suitable patients undergoing endoscopic sinus surgery. Although such techniques present surgical challenges for analgesia, airway protection and immobilisation, these are potentially offset by increased cost-effectiveness, reduced operative duration,

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shortened in-patient stay and improved patient satisfaction and safety. Ultimately, such techniques may be extended to additional nasal procedures and contribute to enhanced patient recovery and optimal utilisation of the operating theatre, increasing satisfaction for patients, surgeons and healthcare managers alike.

The authors recommend careful patient selection to facilitate local anaesthetic endoscopic sinus surgery when initially undertaking the practice and suggest liaison with dentally qualified colleagues or maxillofacial surgeons to familiarise themselves with intra-oral anaesthesia if this is an unfamiliar practice. Peripheral venous cannulation is an essential component in ensuring safety in the unlikely event of resuscitation and the authors would advise surgeons to have oxygen and monitoring available and an anaesthetist on standby for patients with multiple comorbidities.

Competing interests. None declared

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