Laser surgery in the management of sinonasal disease

SK Kaluskar

Better understanding of the pathophysiology of sinus disease, and improved technology and imaging modalities have changed nose and sinus surgery in recent years. Precise surgery of the ethmoid sinuses is now possible, improving ventilation and drainage of the sinuses. Newer technology has enhanced the scope of surgery and helped make sinus surgery safer.

Several different types of lasers, including carbon dioxide (CO_2), neodymium-yttrium aluminium garnet (Nd-Yag), holmium-Yag (Ho-Yag) (Kautzky et al, 1992), diode and potassium titanyl phosphate (KTP)/532, have been used in the field of nose and sinus surgery. This has involved everything from simple laser reduction of the inferior turbinate to more advanced applications in revision endoscopic sinus surgery (RESS) working near the skull base and orbit. With the development of new instrumentation lasers have been used for a variety of conditions including removal of benign tumours of the nose and sinuses. Among the different types of lasers, KTP/532 is the more versatile laser for the various applications in nose and sinuses.

WHY USE A LASER?

Lasers are precise tools which have the ability to cut, coagulate and vaporize the tissues with minimal trauma and postoperative morbidity. This makes them well suited for use in nose and sinus surgery. In the past CO_2 lasers have been used to achieve vaporization and coagulation of the inferior turbinate. Further applications of the CO_2 laser in the nose have been restricted mainly because the laser could not be delivered deep into the nasal cavities or in the sinuses as a result of the inability of the laser to be delivered through an optical fibre. The deep tissue penetration of the Nd-Yag laser results in thermal damage to important structures such as the medial rectus, optic nerve and thin anterior skull base. Since the introduction of Ho-Yag and KTP/532, which are transmitted through a quartz fibre, it has been possible to apply laser energy anywhere into the nasal cavity and paranasal sinuses.

Mr SK Kaluskar is Consultant Ear, Nose, Throat and Head and Neck Surgeon, Department of Ear, Nose, Throat and Head and Neck Surgery, Tyrone County Hospital, Omagh BT79 0AP

KTP/532 LASER

The KTP is a solid crystal laser produced by passing a Nd-Yag laser through a KTP crystal. This results in the emission of laser energy half its wavelength (532 nm), a process known as frequency doubling. The KTP/532 laser is in the visible range of the electromagnetic spectrum and so does not need an aiming beam like that used with a CO_2 laser. This ensures high surgical accuracy in the tissues in the nasal cavity when the laser energy is applied, which is particularly important when working close to the skull base and orbit. The tissue penetration of KTP/532 laser into the pigmented tissue is much less than Nd-Yag, enabling the laser to be used safely near vital structures.

Hand in hand with the development of the KTP/532 laser, the development of newer instruments has made it possible for the laser fibre to be passed through a channel along with the nasal endoscope. Alternatively, a quartz flexible fibre can be passed through a hand-held instrument, making it feel like a conventional instrument in the surgeon's hand. The quartz endostat fibre is available in various sizes, from 200 to 600 μm. This provides different power density and various tissue interactions to allow cutting, vaporization and coagulation effects in the tissues.

One of the important advantages of the KTP/532 laser is the ability of the endostat fibres to cut in contact mode. This gives important tactile feedback to the surgeon, unlike the CO_2 laser which can only cut in non-contact mode. The quartz fibre tips are unsharpened and remain cool which prevents accidental trauma and thermal burns, both to the patient and the surgeon. Moreover the fibre tips remain cool in contact mode, causing less adherence to the tissues and therefore removing the constant need for cleaning the fibre during operation. Above all, the surgeon needs a relatively bloodless field, particularly in the vascular tissues of the nose and sinuses. The wavelength of the KTP laser (532 nm) is selectively and highly absorbed in blood pigments such as haemoglobin, and melanin in the mucous membranes, making it an excellent coagulator and resulting in minimal bleeding during nose and sinus surgery (Kaluskar, 1999).

The laser beam of the KTP is a divergent beam when emerging through a quartz fibre. This creates several temperature gradients on the target tissue from the tip of the laser fibre, enabling the surgeon to cut, vaporize and coagulate the vascular tissues of the nose and sinuses simultaneously. The surgeon has to learn a new skill of forward and backward movements of the laser fibre on the target tissue to achieve cutting, vaporization and coagulation effects. The vaporization mode of the KTP laser is particularly useful in the presence of polyps in the nasal cavity which can obscure important surgical landmarks such as the middle turbinate and uncinate process.

Ikeda and Takasaka (1996) used a KTP/532 laser to perform endoscopic sinus surgery in 80 patients suffering from chronic sinusitis and mucoceles. They demonstrated excellent results, showing reduction of postoperative polyps and granulation tissues around enlarged maxillary sinus ostium. In addition, patients with chronic sinusitis showed enhanced healing of the polypoid degeneration of the maxillary sinus. The average power ranged between 5 and 9 W and the laser energy was delivered through a 600 μm spot size. There were no complications encountered in this series, and the authors concluded that the KTP/532 laser is a promising tool in endoscopic sinus surgery.

LASER PARAMETERS FOR KTP/532 WAVELENGTH AND OPERATIVE TECHNIQUE

The author recommends different power settings (Kaluskar, 1997) at various stages of nose and sinus surgery, depending upon the type of tissue targeted and the effect that the surgeon is aiming for. The soft tissue structures that the surgeon commonly encounters are polyps, thickened mucosa, and fibrous tissue of anterior and posterior fontanelle. In addition there is the thin bone of the ethmoid cells, ground lamella, anterior wall of the sphenoid (*Figure 1*) and thin 'eggshell' of agger nasi cells. However, in the majority of patients 6–8 W power in a continuous or pulse mode with a 600 μm spot size is satisfactory. In cases of vaporization of nasal polyps higher power of 10 or occasionally 12 W is needed.

The quartz optical fibre is always calibrated in excess of 80% (the laser fibre is prepared with a small device to enable transmission of at least 80% of laser energy to the target tissue). The laser is used in all three modes, i.e. contact, near contact and non-contact mode, to achieve cutting, vaporization and coagulation of the tissues respectively. If char is formed on the tissue surface this is removed using either suction or forceps. This is important, as lasering on the charred surface will result in further secondary thermal damage to the surrounding tissues and possible injury to the deeper vital structures.

When cutting tissue, for example when performing uncinectomy, the fibre is in contact mode, whereas when simply withdrawing the fibre away from the tissue surface, the surgeon can achieve either vaporization, for example of a polyp or a thickened mucosa, or coagulation of a bleeding point by further withdrawing the fibre (in defocused mode) away from the tissue. The greater the distance between the fibre and the tissues, the lesser the laser energy imparted to the tissues, reducing the chances of damaging surrounding vital structures.

INDICATIONS FOR KTP/532 IN SINONASAL SURGERY

The following are the main indications for the use of KTP/532 laser in nose and sinuses:

1. Endoscopic sinus surgery for chronic recurrent sinusitis – especially revision cases

Figure 1. Right sphenoidotomy – meticulous vaporization of thin anterior wall of the sphenoid sinus (SP).

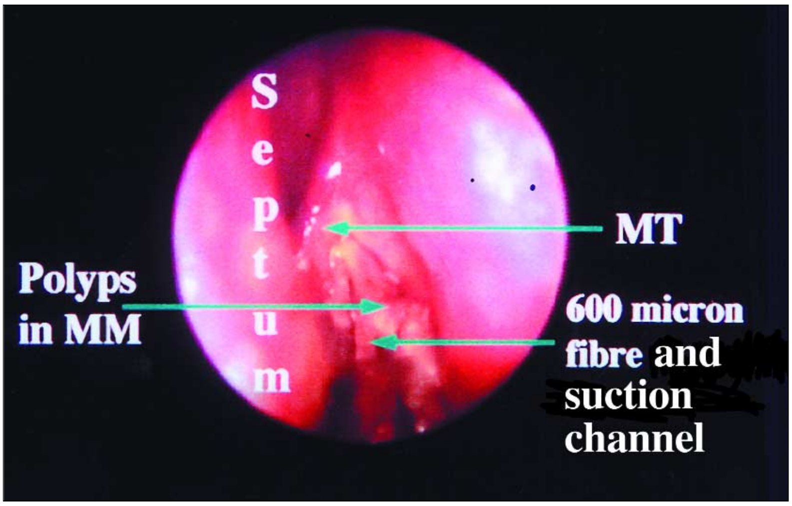


Figure 2. Left nasal cavity showing vaporization of nasal polyps with KTP (potassium titanyl phosphate) laser. Note almost bloodless field. MM = middle meatus, MT = middle turbinate.

Figure 3. Right nasal cavity showing division of dense adhesions with KTP (potassium titanyl phosphate) laser. mt = middle turbinate; S = septum.

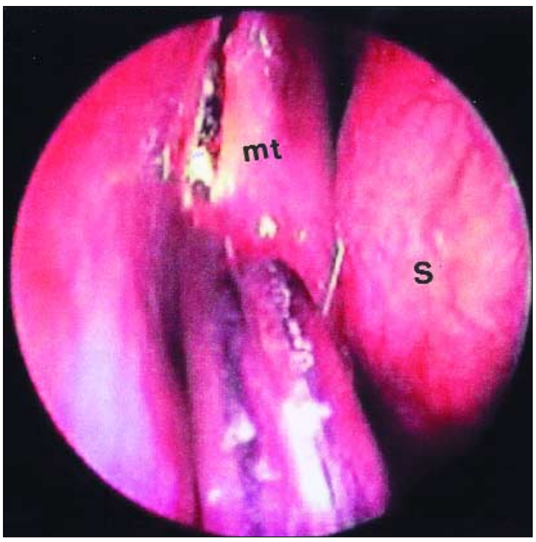
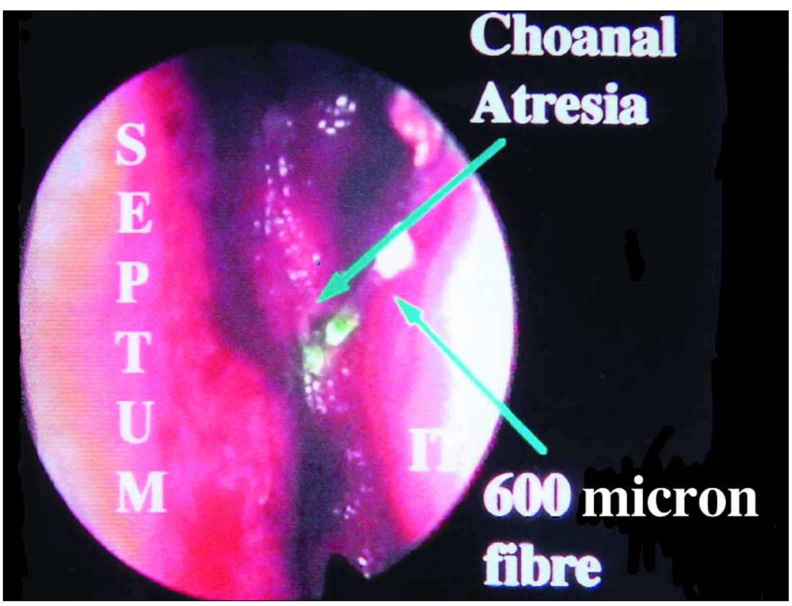


Figure 4. Left nasal cavity showing vaporization of choanal atresia with KTP (potassium titanyl phosphate) laser. IT = inferior turbinate.



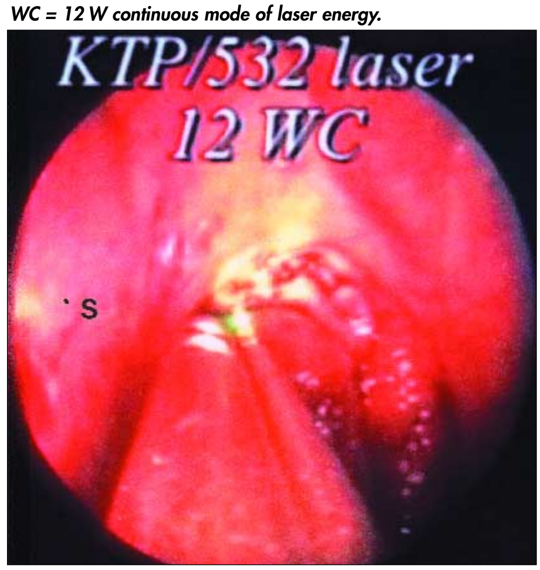
2. Nasal polyposis (*Figure 2*)
3. Haemangioma
4. Adhesions (*Figure 3*)
5. Inverted papilloma
6. Hereditary haemorrhagic telangiectasia
7. Removal of choanal atresia (*Figure 4*)
8. Antral part of the antrochoanal polyp through middle meatal antrostomy
9. Vaporization of intranasal lymphoid tissue (*Figure 5*)
10. Ablation of grossly enlarged posterior end of inferior turbinate (mulberry end).

In recent years functional endoscopic sinus surgery has become a well-established procedure throughout the world. Although successful outcomes in the region of 76–98% are common, there is a failure rate of primary surgery of 2–24% and in these cases RESS is needed (Kaluskar et al, 2003).

The surgeon's knowledge of anatomy is critical and RESS challenges the surgeon's skill and experience. The usual anatomical landmarks are often absent or distorted by previous surgery and scar tissue, which can result in significantly higher incidence of serious intracranial and/or intraorbital complications. The tissues are often chronically congested and oedematous because of infection and this results in excessive bleeding, obscuring important surgical landmarks which can cause serious complications.

Diligent preoperative evaluation, including surgical landmarks, by high resolution computed tomography (CT) imaging in all coronal, axial and sagittal views, is mandatory. A meticulous atraumatic operative technique and thorough

Figure 5. Left nasal cavity showing vaporization of intranasal lymphoid tissue attached to posterior choana. Note minimal bleeding. KTP = potassium titanyl phosphate; S = septum; 12 WC = 12 W continuous mode of laser energy.



postoperative care of patients undergoing RESS is needed. The author (Kaluskar and Sachdeva, 2002) has now performed over 250 operations for various indications in nose and sinuses. The most common indication in the author's experience has been the use of KTP/532 laser in RESS. The parameters used with KTP/532 laser during RESS are detailed in *Table 1* (Kaluskar, 1997).

The common anatomical sites of residual disease are:

1. Upper and lower third of uncinate process
2. Upper segment of bulla ethmoidalis
3. Agger nasi cells (*Figure 6*)
4. Anterior extension of ground lamella
5. Posterior ethmoids and sphenoid
6. Frontal recess and sinus.

PREOPERATIVE EVALUATION

A thorough history with analysis of the patient's symptoms, including the differential diagnosis, is mandatory. Systemic diseases involving sinuses such as primary or secondary ciliary dyskinesia, cystic fibrosis or Sampter's syndrome should be excluded and aggressive medical treatment should be used before embarking upon RESS. The surgeon must find out why the first operation failed by detailed analysis on nasal endoscopy (Kaluskar and Patil, 1992), and 'thin cuts' of the CT scan should be used to reveal any residual disease.

COMPLICATIONS SPECIFIC TO THE USE OF LASER IN NOSE AND SINUSES

These include general complications of the use of lasers and are entirely avoidable if adequate safety rules are observed in the theatre. Injury to the eye is avoided by use of laser-specific glasses by theatre personnel and use of a special filter on the endoscope for the surgeon (*Figure 7*). Aggressive lasering of the mucous membrane should be avoided at any cost, as this will result in destruction of the mucoperiosteum. This in turn will lead to chronic osteitis and formation

TABLE 1.
Laser parameters used with KTP/532 laser during revision endoscopic sinus surgery

Parameter	Indication
Contact mode (6 W with 600 μm fibre) in continuous mode	Uncinectomy
	Opening of the bulla ethmoidalis
	Removal of the ground lamella, anterior wall of the sphenoid sinus, agger nasi cells
Near contact mode (6 W with 600 μm fibre) (vaporization)	Polyps
	Thickened mucosa
	In case of polyps interstitial application of laser energy can also be delivered to shrink large polyps during surgery
	8–10 W of KTP laser power has also been used to vaporize the base of the antrochoanal polyp once the main antral and choanal part has been removed by middle meatal antrostomy. Removal of the base of the polyp further reduces the chances of recurrence
Non-contact mode (6–8 W with 600 μm fibre) (coagulation)	Overall haemostasis during surgery. Occasionally the power may need to be raised to 8 W if bleeding is significant

From Kaluskar (1997). KTP = potassium titanyl phosphate

***Figure 6.** Right nasal cavity – vaporization of agger nasi cells with KTP (potassium titanyl phosphate) laser with minimal bleeding. mt = middle turbinate; S = septum.*

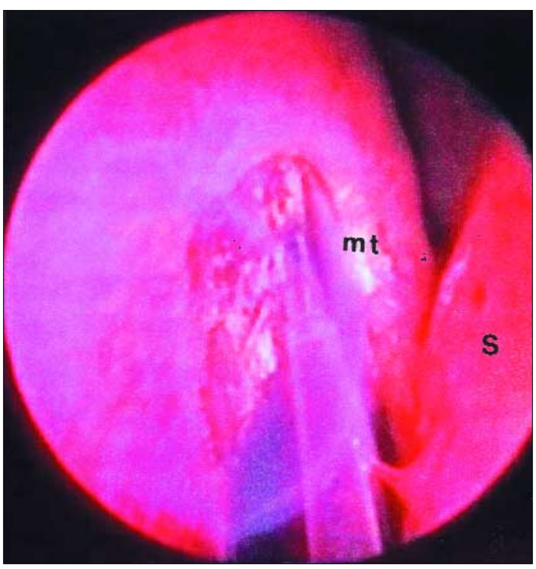
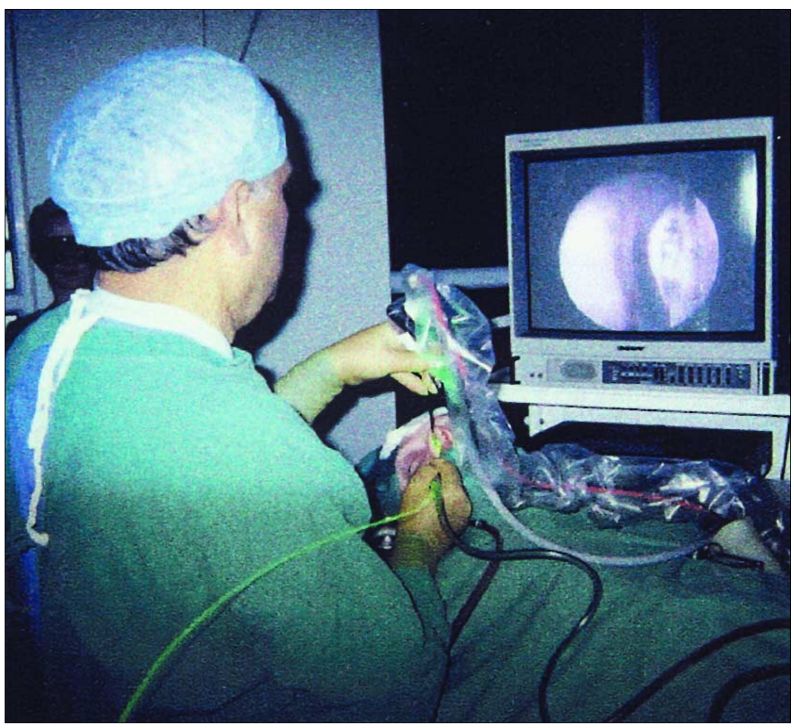


***Figure 7.** Surgeon operating 'off' the monitor with KTP (potassium titanyl phosphate) laser with a microstat in one hand and 4 mm 0 degree endoscope with a special laser filter in the other.*



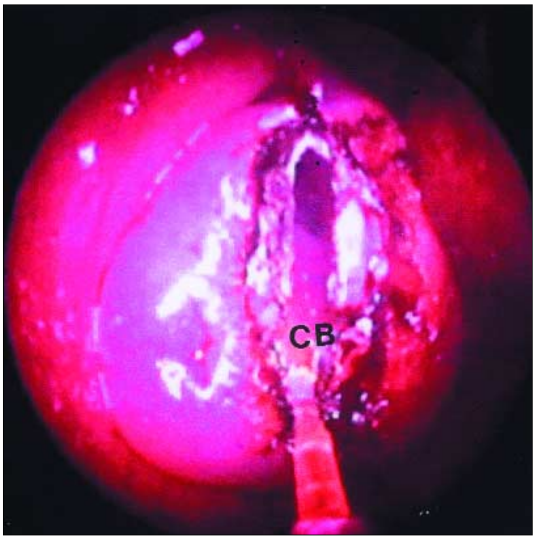


Figure 8. Left nasal cavity. Turbinoplasty with KTP (potassium titanyl phosphate) laser to treat concha bullosa (CB) (pneumatization of the middle turbinate).

of granulations, leading to recurrent infections and excessive crust formation in the nasal cavity.

CONCLUSIONS

The wavelength of the KTP/532 laser is well suited to its use in the vascular cavities of the nose and sinuses for a variety of conditions. This results in significantly less bleeding, less morbidity and safe surgery as the anatomical landmarks are not obscured by excessive bleeding (*Figure 8*). Proper training in the safe use of specific lasers is of utmost importance. HM

Conflict of interest: none.

KEY POINTS

- The diagnosis and management of chronic sinus disease has changed significantly with the improved understanding of pathophysiology of sinus disease in recent years.
- The development of diagnostic nasal endoscopy and computed tomography imaging has made sinus surgery safer. It is now carried out under direct vision as opposed to conventional surgery which used a head light.
- The development of new lasers with optical fibre transmission of laser energy has made surgery more precise and safer in nose and sinuses.
- A thorough knowledge of surgical anatomy, diligent preoperative evaluation and proper training in the use of lasers is mandatory before embarking upon surgery.

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