The Use of Laser for Cholesteatoma Surgery

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Abstract
The objective of this study was to assess the use of KTP laser in cholesteatoma surgery with regard to the rate of recurrence and preservation of the ossicular chain. This involved a retrospective analysis of cases of combined approach tympanoplasty surgery over an 8 year period. Two patients out of 13 (15%) who did not have laser used in the first stage developed recurrence observed at the second stage. Two patients out of 32 (6%) in whom the laser was used developed recurrence. The results for preservation of the ossicular chain with the use of laser in the first stage are less convincing. However, laser can be used in middle ear surgery to effectively eradicate residual cholesteatoma and potentially reduce recurrence rates.

Keywords
Laser, cholesteatoma, combined approach tympanoplasty.

Introduction
Cholesteatoma is the presence of destructive and expanding squamous epithelium in the middle ear. It is well recognised that the main aim of surgery for cholesteatoma is complete removal of disease as residual squamous epithelium leads to recurrence of cholesteatoma and potentially further middle ear destruction. Studies involving two stage surgery have quoted a rate of 20-30% residual disease identified at the second stage.[1] This most commonly occurs in the anterior epitympanum, the space medial to ossicles, posterior mesotympanum and the sinus tympani.[2] Traditionally, removal of cholesteatoma has utilised mechanical methods, transmitting kinetic energy through to the inner ear. In addition, the auditory ossicles and ear canal wall are often sacrificed to aid with complete removal of disease.

Laser (Light Amplification by Stimulated Emission of Radiation) utilises electromagnetic radiation for vaporisation of tissues. Three main types are used in ENT surgery; KTP (potassium titanyl phosphate), Er:YAG (erbium-doped yttrium aluminium garnet) and CO_2 (carbon dioxide). The potential advantages of using laser in middle ear surgery include using curved fibres for corners, haemostasis, reduced kinetic energy transmitted through the ossicles and the preservation of surrounding structures.[3]

A KTP laser has been used in our unit for middle ear surgery for a number of years. We sought to establish recurrence rates for cholesteatoma in middle ear surgery utilising the KTP laser and further outcome measures such as changes in audiological findings and the potential for preservation of the ossicular chain.

Materials and methods
This study was a retrospective analysis of middle ear procedures performed between December 2001 and December 2009 in our unit. Procedures only included combined approach tympanoplasty stages 1, 2 and 3 (CAT 1, 2 and 3). Cases with the findings of only one stage were excluded so that only cases with details of the operative findings for consecutive stages were analysed. Each of the stages were at least 10 months apart. Data collected included pre-operative details, operative findings and post operative details. Allocation of KTP laser use for each case was determined by the availability of the equipment and

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appropriately trained theatre staff on the day. Even though this was not true randomisation, allocation was not based on the type of case in any way. A fibre width of 0.2mm was used in all except 2 cases when 0.4mm was used. A power of 0.5w was utilised in all except 2 cases when 0.5 -1.0 w was used (this was for extensive cholesteatoma). The mean total energy used was 83.6J (range 23J - 222J). Details of the ossicular chain status in the first stage and whether this was preserved were also noted. Audiological data was also analysed from information taken within 4 weeks before each procedure and up to 10 weeks post procedure.

Results and analysis

92 procedures were analysed (in a total of 45 ears). The age range at first procedure was 5 – 80 years old (mean 43 years). All procedures were performed or overseen by one surgeon who was observing at all times. Details of the procedures are shown in Table 1 and the extent of cholesteatoma found is shown in Figure 1. The mean maximum follow up was 10.6 months for all procedures (range 1 - 43 months).

Procedure	Laser Cases	Non-Laser Cases
CAT 1	32	13
CAT 2	32	13
CAT 3	2	0
Total	**66**	**26**

Table 1. Laser and non-laser cases for each procedure.

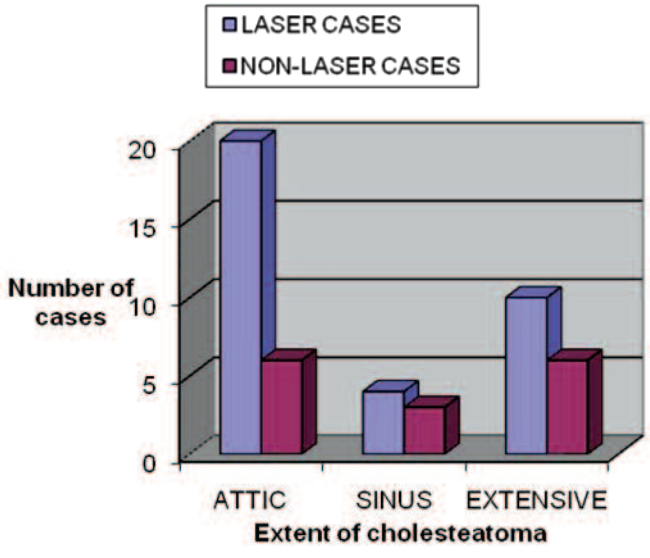

Figure 1. Extent of cholesteatoma for all first stage procedures.

Cholesteatoma recurrence

Cholesteatoma recurrence was noted in 2 second stage CATs out of 13 procedures (15%) where no laser was used in the first stage (95% CI = 0.7% - 21.1%). Cholesteatoma recurrence occurred in 2 out of 32 procedures (6%) when laser was used in the first stage (95% CI = 3.1% - 43.5%). Using Fisher's exact test this provides a p-value of 0.567. All cases of cholesteatoma recurrence were 10 years of age or below.

Preservation of the ossicular chain

In the cases in which the ossicular chain was not eroded in the first stage (29 of the 45 first stages), 8 (27%) first stage CAT laser cases remained intact and preserved at the second procedure whereas 6 (20%) first stage CAT non-laser cases remained intact and preserved at the second stage. A combination of disease itself and access to remove disease were the commonest reasons that lead to disruption of the ossicular chain.

Audiological findings

Bone conduction thresholds were not detrimentally effected in the majority of cases (Figure 2). However, increased thresholds were observed in three cases; 2 laser cases and 1 non-laser. In addition, the greatest improvement in air conduction thresholds was observed in laser CAT stage 2 and 3 procedures. The greatest improvement in air-bone gap thresholds was observed following laser CAT stage 2 cases without ossiculoplasty (mean improvement of 12 dB) and a number of individual cases with or without laser during which an ossiculoplasty was also carried out (Figure 3).

Complications

The details of the complications encountered are shown in Table 2.

Discussion

There are a number of potential applications for lasers in middle ear surgery such as tympanostomy,[4] otosclerosis[5] and cholesteatoma surgery[2,3] and ossiculoplasty.[6] The use of laser appears to be safe with regards to hearing levels[7] and the absence of mechanical force and potential for preservation of the ossicular chain[8] further add to the advantages of the use of this tool in middle ear surgery. Despite this, laser assisted cholesteatoma surgery is not widely practiced in the UK.[9]

Hamilton[1,2] has investigated recurrence rates in a prospective controlled study with 33 patients undergoing cholesteatoma surgery without laser and 36 with laser. He found a significant improvement in recurrence rate with use of the laser with a number needed to treat of 4. Our results also suggest low recurrence rates following laser surgery to the middle ear. We have found the KTP laser easy to use, safe and straightforward to set up. Two cholesteatoma recurrences were observed following the use of the laser (6%), which is well below previously quoted recurrence rates. Two recurrences were observed in the non-laser group (15%) suggesting that the use of laser improves the recurrence rate. The difference observed between the groups was not significant due to the small

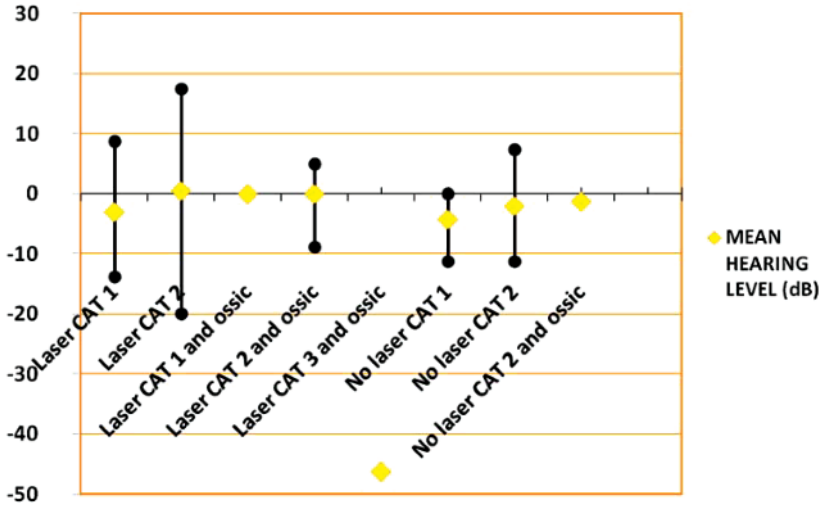

Figure 2. Change in bone conduction thresholds(dB) for each procedure.

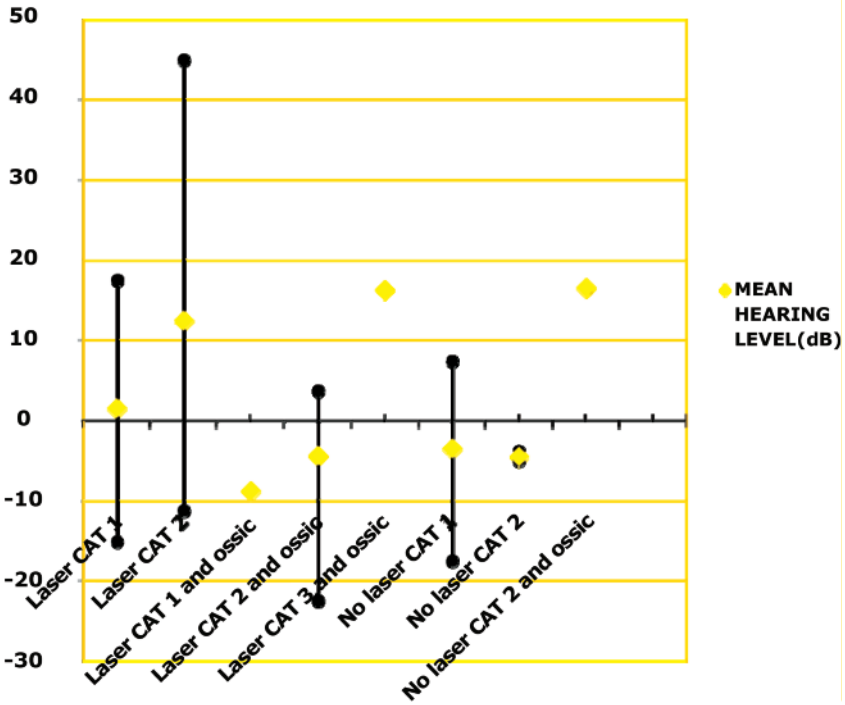

Figure 3. Improvement in Air-Bone gap (dB) for each procedure.

	Laser Cases	Non-Laser Cases
TINNITUS	1	1
FACIAL PALSY	2; 1- 1 week post op, resolved in 7 days 1- immediately post op, resolved in 10 days	0
WOUND INFECTION	5	2
PERFORATION	2	1
OTITIS MEDIA /MYRINGITIS	2	0

Table 2. Complications.

numbers included. We also acknowledge that the two groups may not be directly comparable due to the potential for bias and a prospective randomised study would reduce this problem. However, the cases were allocated to laser or non-laser based on availability of the laser in theatre each time, not on the case itself. There was also an even distribution of cases performed by the consultant and the extent of cholesteatoma found (as shown in Table 2). It is acknowledged that the results from cholesteatoma surgery are often due to the experience of the surgeon and may not just be due to the laser but we feel that it has helped to at least maintain a low recurrence rate. There is also a larger proportion of laser attic cases which would have been easier to clear and this may have biased the results.

Case reports[8] but no prospective trials with long term follow up exist with regards to the use of laser for preservation of the ossicular chain. Our study could not significantly confirm that there was an increased ability to preserve the ossicular chain due to the small numbers analysed. In theory, with less mechanical removal of tissue and the ability of the laser fibre to reach cholesteatoma in more difficult regions, more of the ossicular chain could be preserved with the potential for better hearing levels. A larger study may help to support this theory.

Er-YAG laser has been shown to not adversely affect hearing levels[7] but no data exist regarding KTP laser use in this regard. In our series, 2 laser and 1 non-laser case resulted in a deterioration in bone conduction hearing levels postoperatively. One laser case that was a revision case utilising laser at low levels (34J, 0.5w) experienced a temporary facial palsy, tinnitus and persistent ear discharge following surgery. These symptoms improved with antibiotics for a presumed middle ear infection but the sensorineural hearing loss persisted. Increased bone conduction thresholds were observed after one case underwent CAT stage 3 with laser (12J, 0.5w) and ossiculoplasty. It is unlikely that laser was the primary cause for the hearing loss in these cases. Infection and ossiculoplasty could have played a more important role for this deterioration, particularly as the laser was used only minimally. In cases where extensive cholesteatoma required larger amounts of laser energy (>200J) no deterioration in bone conduction levels was observed.

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There is no obvious reason as to the causes for the 5 post operative wound infections observed in the laser group and we feel that this is likely to be a chance event. The 2 facial palsies resolved within weeks of the procedure and a dehiscent facial nerve was observed in both cases. Care was always taken to avoid lasering the facial recess if the nerve appeared to be exposed or at risk.

Conclusion

Our experience with a KTP laser for cholesteatoma surgery suggests low recurrence rates at the second stage and little evidence of a detrimental effect on sensorineural hearing levels. Further studies may reveal whether the ossicular chain can be better preserved when laser is used.

Key Learning Points

- It is already known that the main aim of cholesteatoma surgery is to completely eradicate disease and that middle ear structures are often at risk with conventional cholesteatoma surgery
- KTP laser provides a way of eradicating cholesteatoma at the first procedure and perhaps reducing recurrence rates
- This study suggests that KTP laser is safe to use in the middle ear and does not adversely affect hearing levels
- The use of KTP laser does not appear to affect the ability to preserve the ossicular chain

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