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Feasibility of coblation versus laser resection in recurrent nasal polyps

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ABSTRACT

Introduction: Chronic sinusitis with nasal polyps is one of the commonest diseases of the upper airways, with a recurrence rate of about 15%. Minimally-invasive endoscopic laser procedures have been established to reduce the need for conventional revision surgery whenever medical follow-up fails. However, laser surgery requires special considerations for surgical, safety and economic aspects. This study evaluates the feasibility of coblation versus laser resection for recurrent nasal polyps. **Material and methods:** 6 nasal polyps were harvested each from the ostiomeatal complex of patients undergoing microscopic endonasal surgery for chronic sinusitis. 3 were dissected using a Neodymium:YAG laser system (Dornier MediLas 5060N) set at 10, 20 and 30w in cw mode with a 600µm bare fiber in contact mode with negative feedback power control, while further 3 polyps were dissected using a Coblation system (ArthroCare® Coblator® I) with a 30° angled and a 0° straight probe with 2.4 mm outer diameter. The specimens were examined histologically for carbonization and coagulation as well as unaltered tissue. **Results:** Laser resection resulted in a carbonization zone of 30µm in depth plus a coagulation zone of about 100µm, depending on the water content and type of tissue. While the carbonization zone was smaller with coblation, coagulation zones were comparable, leaving ample amount of unaltered tissue available for further diagnosis. **Conclusion:** Both resection techniques are generally feasible to be used in day case surgery for recurrent polyps. While the coblation system required no special safety requirements, accessibility of the sinuses was limited by the rigidity of applicators that are available.

Keywords: Nasal Polyps, Sinusitis Surgery, Laser, Neodymium:YAG, Coblation

1. INTRODUCTION

Chronic rhinosinusitis with polyps is one of the most common disorders of the upper respiratory tract. The prevalence of nasal polyps with and without underlying chronic rhinosinusitis was estimated by Tos and co-workers¹ between 1 and 4% in the general population. Naclerio and Gungor² quoted a figure of 11.4 % for the prevalence of chronic rhinosinusitis among the western population, while polyps were not expressed in all cases. Yet a great variety of risk factors has been established, e.g. acetyl salicylic acid intolerance, allergic and / or toxic reaction to nasal and sinusoidal fungi, nasal allergy, systemic allergy, chemical irritants, sudden climate changes, indicating that nasal polyp formation is probably the end-stage of a multifactorial disease process. Post-operative medical treatment following functional endonasal sinus surgery (FESS) has shown limited success, even if targeted at individual pathogens in each case that are presumed to trigger recurrence of the disease. Although all potential risk factors that have been elicited preoperatively may have been addressed, the recurrence rate of chronic rhinosinusitis with polyps can not be substantially reduced below 15%, which corresponds to the recurrence rate without specific medical post-operative follow-up³. As for these cases revision surgery is the only remaining option, we have implemented a post-operative follow-up regime since 09/01/1996, in which revision surgery is performed with a Neodymium:YAG laser on an out-patient basis, by which diseased sinuses and specifically a blocked middle meatus are cleared of obstructing polyps with an endonasal resection technique. Surgical safety is achieved by applying laser energy in contact mode only to a power setting of 10W in general and 20W maximum, while a negative feedback loop integrated in the laser system ensures that no excessive amount of heat builds up in the tissue especially close to the periorbit or the anterior skull base. Further refinements of this procedure include the introduction of 200µ quartz glass fibers, and the use of a *jilgner@ukaachen.de; phone ++49 241 80-88946; fax ++49 241 80-82523; www.ukaachen.de

purpose-built applicator⁴, which facilitates access to remote parts of the ethmoid and maxillary sinus. With this technique, we have been able to operate on 170 patients from 09/01/1996 until 12/31/2004. However, there are certain disadvantages of laser techniques in general: Laser-specific safety measures must be adhered to, and although the procedure is tolerated well by most patients under local anesthesia, the amount of heat building up in deeper tissue layers may create discomfort. In addition, laser systems are costly to build and to maintain, while the use of laser fibers generates additional costs.

During the last years, a new generation of therapeutic radiofrequency devices has been introduced to surgery by the name of "coblation®"⁵. In contrast to conventional electrosurgical systems they generate a highly energized electric field over a small space, thereby creating a plasma zone that dissects tissue while generating limited heat. Thus temperatures adjacent to the resection edge range between of 50 to 70°C. So far, the device has been used in Otolaryngology particularly in tonsil surgery, such as tonsillectomy and tonsillotomy^{6,7}, but also in volume reduction for nasal turbinates⁸, the soft palate as well as the tongue base. To our knowledge, none of the present studies addresses the potential these devices bear in conjunction with endonasal revision surgery for recurrent polyps. The motivation for this in-vitro study was to evaluate the feasibility of radiofrequency ablation compared to laser surgery in resecting recurrent nasal polyps in chronic rhinosinusitis.

2. MATERIAL AND METHODS

From a conventional endonasal sinus operation, we acquired six human nasal polyps, half of which was allocated to the laser surgery procedure and the other half to the coblation procedure. The material was kept unfixed for less than 6 hours in 0.9% saline solution. Laser surgery was performed using a Neodymium:YAG laser (Dornier® Medilas® 5060N, Dornier GmbH, Germering, Germany) in conjunction with a 600µm bare fiber. Laser settings were 10, 20 and 30 w continuous wave (cw) in contact mode. With each setting, a negative feedback power supply loop was active, thereby reducing the power distribution to the tissue to an average of 40% compared to the nominal setting, i.e. 4, 8 and 12w. Each laser ablation procedure was simulated by applying multiple strokes along the same path into the polyp tissue, leaving a distance of at least 3mm between different laser areas.

For coblation surgery, all procedures were performed with a Coblator® I system (ArthroCare® Corp. Sunnyvale, CA) with a ReFlex Ultra 45 probe. This probe is angled 30° in 40mm distance from the tip while the effective electrical field spans between the two tip electrodes over a distance of 1.8 mm and a diameter of 1.4 mm of the outer electrode, while the outer isolation distant from the electrode is 2.4 mm wide. The electrode remained unaltered during the ablation process, although it can be bent to a certain degree. The polyp tissue was covered superficially with hydrophilic gel in all cases to ease the coblation process.

All tissue samples were then fixed in 3.5% formaldehyde solution and stained with hematoxylin-eosin. Macroscopic photographs were taken from the exterior aspects of resection. As parameters for resection effects, we looked for the width of the carbonization zone next to the resection margin, the coagulation zone and criteria of healthy tissue in relation to the resection margin.

3. RESULTS

Aspects from both specimens under the operation microscope are displayed in fig. 1. Resection margins are visible at all laser power settings with very little carbonization at 10w, and moderate to marked carbonization at 20 to 30w respectively. While the original resection canal corresponds to the laser fiber diameter of 600µm, as seen with the 10w cut (fig.1a, cut "A"), subsequent drying of adjacent tissue pulls the resection margins apart, thereby leaving the impression of a broader resection canal (fig.1a, cut "B" and "C"). The same effect applies to coblation resection at step 6. Here the superficial carbonization layer resembles the amount as seen with the Nd:YAG laser resection at 20w (fig.1b, cut "F"), while step 2 and 4 showed no apparent features of resection (fig.1b, cut "D" and "E").

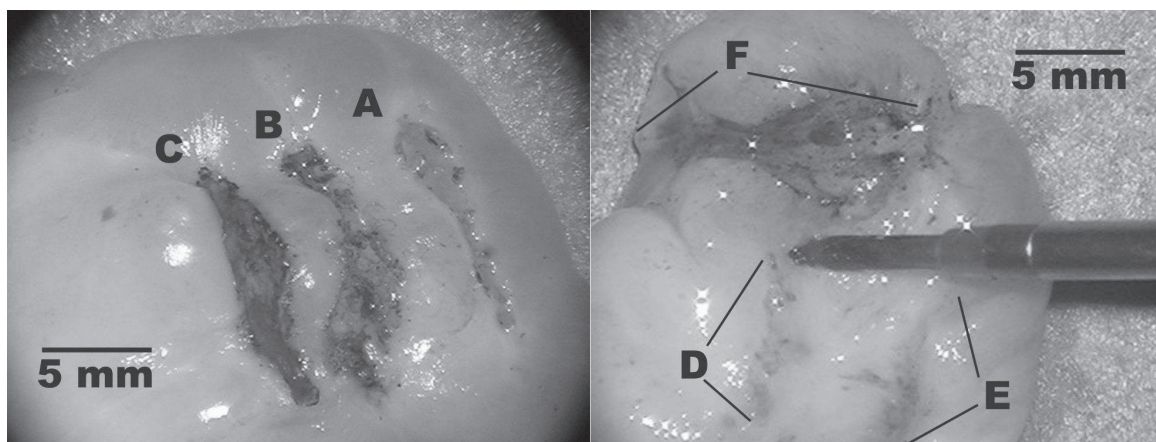


Fig.1a (left) and b (right): Aspects of polyp tissue under the operation microscope.

Fig.1a (left) displays Nd:YAG laser ablation in cw and contact mode with negative feedback power delivery at 10w (A), 20w (B) and 30w (C).

Fig.1b shows coblation effects with Coblator I settings at step 2(D), step 4(E) and step 6(F)

Histological examination reveals that the epithelium is disrupted at 10w Nd:YAG laser resection with a cutting depth of 700 μ m with no carbonization visible under light microscopy, while the coagulation zone displays a width of 200 μ m laterally and 100 μ m or less at the base (fig.2a). The epithelium next to the cutting margins appears intact. Fig 2b (20w Nd:YAG laser resection) shows traces of carbonization with a wider coagulation zone of homogenous width (300 to 500 μ m) over the whole resection margin. Setting the Nd:YAG laser to 30w (fig. 3a and b) increases the coagulation zone to a range between 400 and 600 μ m over all areas with a carbonization layer of 30 μ m width. The resection depth increases to several millimeters while the epithelium next to the resection edge shows no alteration beyond the coagulation zone.

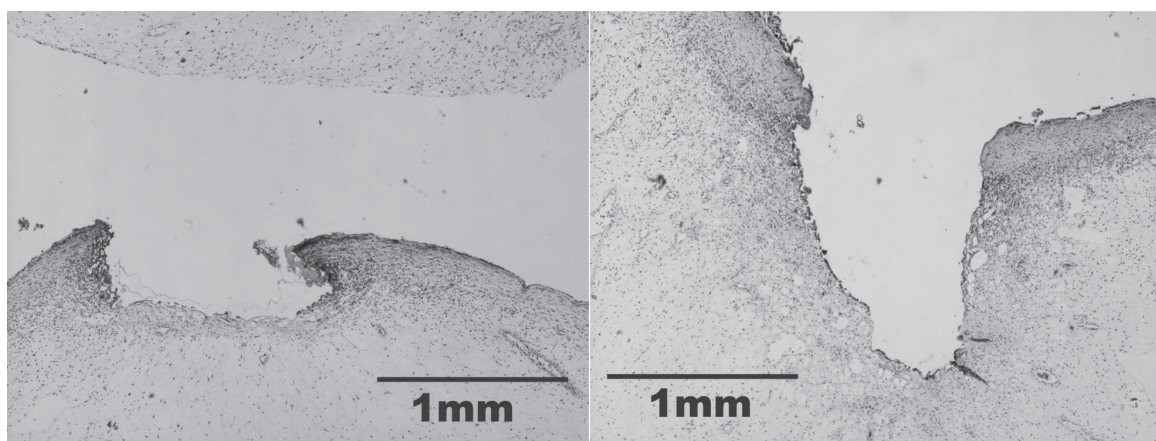


Fig.2a (left) and b (right): Histological specimen under light microscopy, 4x magnification, hematoxylin-eosin staining.

Fig.2a: Nd:YAG laser ablation at 10w cw, contact mode, shows coagulation zones of approx. 200 μ m width at the edges and 100 μ m at the base without visible traces of carbonization.

Fig.2b: Nd:YAG laser ablation at 20w cw, contact mode, shows a carbonization zone of 20 to 30 μ m width with a coagulation zone 300 to 500 μ m wide

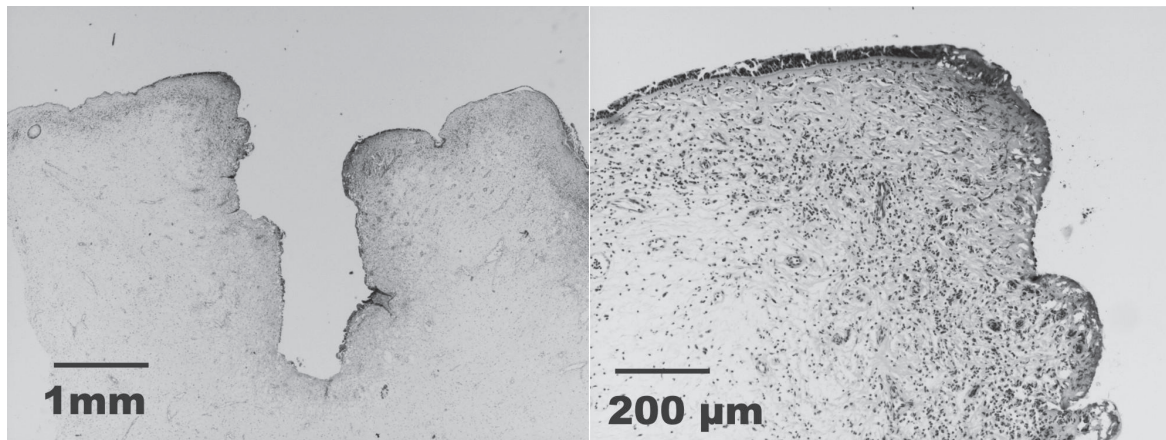


Fig.3a (left) and b (right): Histological specimen under light microscopy, hematoxylin-eosin staining, 2x magnification (left) and 10x magnification (right).

Fig.3a: Nd:YAG laser ablation at 30w cw, contact mode, shows coagulation zones of approx. 400-600µm width next to all resection areas.

Fig.3b: The same specimen shows a carbonization zone of 20 to 30µm width.

The ablation experiments with the Coblator I system at different power settings revealed that with low power (i.e. step 2 and 4), there were no signs of resection at all. Even after applying a hydrophilic gel to facilitate the creation of a plasma zone, the tissue does only display histological signs of exsiccation, with a higher density of nuclei, and some shrinking of the subepithelial stroma. However, the mucosa remains undisrupted and there is neither coagulation nor carbonization (fig. 4a and b).

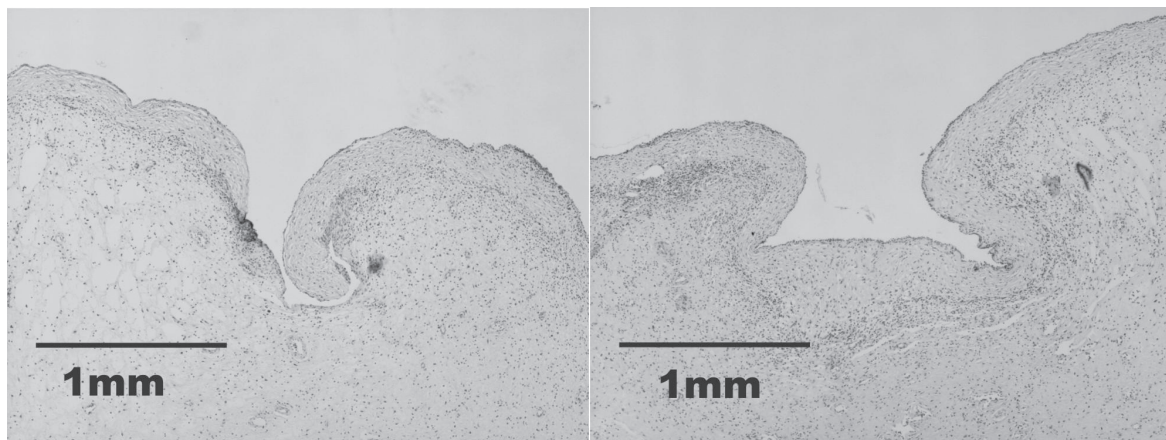


Fig.4a (left) and b(right): Histological specimen under light microscopy, hematoxylin-eosin staining, 4x magnification.

Coblation with a 1.4 mm probe (ReFlex Ultra 45) at step 2 (left) and step 4 (right): No visible signs of tissue dissection.

While the coblation system is set at step 6, resection starts immediately and cutting margins display a coagulation zone of 350 to 500µm width with a carbonization layer of about 30µm thickness. In contrast to laser resection experiments, the cut itself is narrower in deeper layers but shows a conical shape in superficial sections about 1.5 mm from the surface. This may be related to the fact that the probe itself has a wider shaft (2.4mm) in comparison to the active tip (1.4mm). In any case, the coagulation zone shows a denser aspect in relation to the 20w laser resection

experiment which is similar in respect to energy-tissue interaction, but remains homogenous over the whole resection margin. Furthermore, although the coagulation zone is relatively wide, a superficial seromucous gland (fig. 5b) shows unaltered epithelium even next to the resection edge.

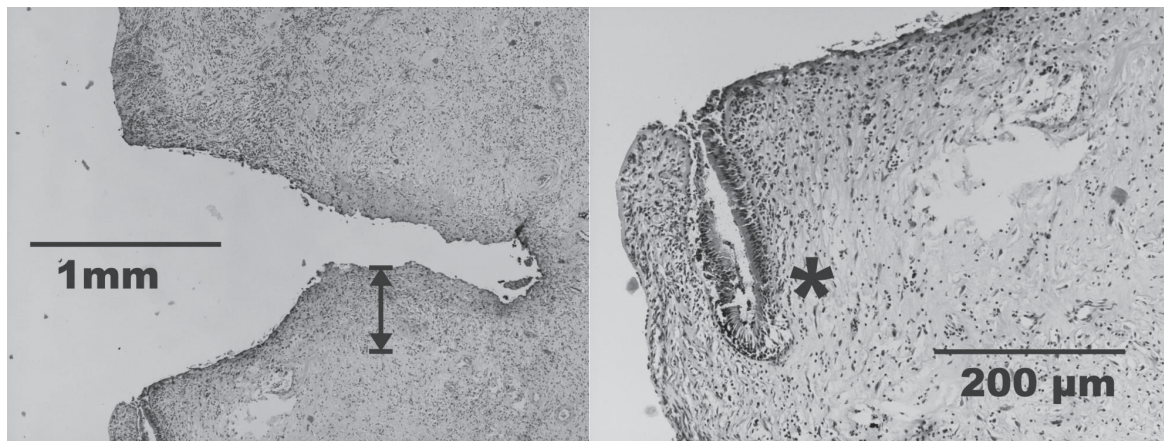


Fig.5a (left) and b(right): Histological specimen under light microscopy, hematoxylin-eosin staining, 4x magnification (left) and 10x magnification (right).

Fig.5a: Coblation with a 1.4 mm probe (ReFlex Ultra 45) at step 6 shows coagulation zones of 350-500μm width next to all resection areas. A continuous carbonization layer with a thickness of 20 to 30 μm covers all resection margins

Fig.5b: The same specimen at 10x magnification shows an intact seromucous gland in close proximity to the resection margin.

During the laser ablation process it was noted that especially with the lower power settings (10 to 20w) the bare fiber tip tended to stick to the polyp tissue. To our experience, this effect is less pronounced in vivo, where polyps are attached to deeper layers of submucous tissue and eventually to bony structures of the anterior skull base and periorbit. This sticking effect is probably related to the ablation process, in which there is coagulation in direct contact to the bare fiber tip. In 30w this effect is less pronounced as we could observe a superficial carbonization layer which separates the fiber from the coagulated tissue. In coblation, on the other hand, the tissue could not stick to the probe as the plasma zone prevented direct contact of the probe to coagulating tissue.

4. DISCUSSION

This in-vitro study shows that both the Neodymium:YAG laser in conjunction with a bare fiber and power regulating features as well as the novel electrosurgical plasma ablator system are able to perform surgical removal of nasal polyp tissue. There is a minimum setting for the Coblator system below which no plasma formation and thus no resection effect will occur. With plasma ablation in effect, the coagulation zone showed a higher density compared to 20w Neodymium:YAG laser resection while the coagulation zone width and the carbonization layer was about the same. In clinical practice we have been using lower power settings of 10w for the Neodymium:YAG laser system, although we found no damage to adjacent structures with 20w laser power either, provided that contact mode is maintained and negative feedback power supply regulation enabled throughout the operation. Concerning wound healing following laser resection, we could not find any marked difference in our series⁹ after three months following Nd:YAG laser revision surgery compared to conventional revision surgery. However, the laser revision cases temporarily showed a greater extent of edematous swelling in the laser revised areas. These results confirm those from a study performed by Metson¹⁰, in which 32 patients had been operated by conventional FESS on one side compared to Holmium:YAG endoscopic sinus surgery on the other side. While there was no difference in wound healing in long-term outcome, Metson found widespread edema in the laser-treated areas about 7 to 14 days following laser surgery. Concerning Coblation, it can be assumed that with coagulation zones of 500μm maximum in vitro, tissue necrosis in vivo will be

limited to superficial layers as well. However, whether the higher coagulation zone density as noted with the coblation experiment indicates a different course in wound healing, cannot be judged from this single observation. Consequently, further in-vivo studies are needed to confirm the feasibility of coblation in endonasal sinus surgery regarding long-term effects of wound healing and disease recurrence control. If these studies prove to be successful, Coblation could provide an alternative to conventional revision surgery as well as to laser revision procedures. It has the advantage to control bleeding during surgery, which can be a nuisance to the surgeon as well as the patient, thereby making this procedure favorable for day case surgery. No special safety precautions as for laser surgery are required although patients with electrical implants such as cardiac pacemakers or cochlear implants may be unsuitable for this type of surgery. At the moment, the probes that are available limit the range of treatment to the anterior and posterior ethmoid and the ostiomeatal complex. Two further drawbacks are the compulsory use of single-use equipment in both cases, laser ablation as well as coblation. In Europe, the cost of a single use 600µm bare fiber is about 120.-€ while a ReFlex 45 or 55 probe costs about 130 to 140.-€. In some health care systems, day case surgery does not cover these costs adequately, although conventional revision surgery usually entails a several days' hospital stay including higher risk of post-operative bleeding, discomfort and longer time off work.

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