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HEAD AND NECK

Comparative intraindividual ablative tissue effects of diode laser 980 nm versus radiofrequency in tonsillar hypertrophy management

Effetti tessutali ablativi intraindividuali comparabili del laser diodo 980 nm rispetto alla radiofrequenza nella gestione dell'ipertrofia tonsillare

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SUMMARY

Tonsillotomy (tonsillar ablation) using diode laser and radiofrequency has been introduced for management of tonsillar hypertrophy as it is associated with fewer hazards to deep structures. We compared tissue volume and histological changes in the tonsils following radiofrequency tonsillotomy versus diode laser tonsillotomy in tonsillar hypertrophy. 40 tonsils excised from 20 patients were included in this study. Twenty tonsils were subjected to radiofrequency tonsillotomy (RFT) group 1, and the other 20 tonsils were subjected to diode laser 980 nm tonsillotomy (DLT) group 2. Both procedures were followed by cold dissection tonsillectomy for macroscopic and histological examination of tonsils. Tonsillar volume reduction was evident in both groups with a non-significant difference between groups. Histological changes were evident in both groups. In our study, both radiofrequency and diode laser were effective in tonsillar ablation in terms of volume reduction and keeping the histological pattern intact.

KEY WORDS: Hypertrophic tonsils • Tonsillotomy • Diode laser • Radiofrequency • Histological examination

RIASSUNTO

La tonsillotomia (ablazione tonsillare) usando il laser a diodi e le radiofrequenze è stata introdotta nel trattamento dell'ipertrofia tonsillare per ridurre i rischi di complicanze a carico delle strutture profonde. Questo studio si propone di paragonare il volume tissutale e le modificazioni istologiche provocate nella tonsilla ipertrofica rispettivamente dalla ablazione tonsillare con radiofrequenza e da quella con laser. Abbiamo analizzato 40 tonsille escisse a 20 pazienti. Venti tonsille (gruppo 1) sono state escisse mediante radiofrequenza (RFT), le altre venti (gruppo 2) mediante laser a diodi 980 nm (DLT). Entrambe le procedure sono state seguite da dissezione fredda della tonsilla per esame mascroscopico e istologico della stessa. La riduzione del volume tonsillare è stata evidente in entrambi i gruppi con una differenza non significativa fra i due. Le modificazioni istologiche erano evidenti in entrambi i gruppi. Nel nostro studio, sia la radiofrequenza che il laser a diodi consentono di eseguire una efficace ablazione tonsillare, mantenendo intatto il pattern istologico.

PAROLE CHIAVE: *Tonsille ipertrofiche • Tonsillotomia • Laser a diodi • Radiofrequenza • Esame istologico*

Introduction

Tonsils are aggregates of lymphoid tissue that play a large role in immunology and defense mechanisms, and especially in IgA production [1]. Tonsillectomy is performed for diverse indications including recurrent episodes of acute tonsillitis (the most common), in addition to tonsillar hypertrophy causing obstructive sleep apnoea syndrome [2].The traditional technique of "cold" dissection was introduced about 100 years ago. Since then, many different techniques have been introduced to speed up the operation, keep intraoperative bleeding to a minimum and reduce postoperative morbidity [3 4]. Besides the risk of haemorrhage, postoperative pain represents a major issue in tonsillectomised patients due to disruption of mucosa and glossopharyngeal and/or vagal nerve fibers with consecutive inflammation and spasm of pharyngeal muscles leading to ischaemia and a protracted cycle of pain [5].

As extensively studied by Hultcrantz et al. [6], risk of haemorrhage, postoperative pain and morbidity were significantly reduced, as well as accelerated recovery, when tonsillotomy was performed rather than tonsillectomy. It has been reported that in the case of laser tonsillotomy,

the tonsils are merely reduced in size and maintain their function as an immunocompetent lymphoid tissue, and also reduce the risk of bleeding, postoperative pain and morbidity [7].

Different types of lasers have been used in tonsillotomy and tonsillectomy such as kTP, carbon dioxide and NDYAG [8,9]. The diode laser has a potent thermal perifocal effect in tissues and a shallow penetration depth, and is associated with fewer hazards to deep structures. Diode laser tonsillar surgery is thus a low-complication modality with very satisfactory postoperative results [7].

Radiofrequency tonsillar ablation has been described in recent years and was introduced as an alternative ablative device for tonsillar hypertrophy, which has a lower tissue heating with the advantage of mucosal sparing and sufficient tissue reduction [10,11].

The aim of this clinical study was to introduce diode laser 980 nm as a tonsillar ablative tool and assess the volume reduction and histological outcomes compared to radiofrequency tonsillar ablation.

Materials and methods

This study was designed to examine volume reduction and histological changes in 40 tonsils excised from 20 patients between 8 and 16 years old, after being subjected to tonsillotomy. Each patient was subjected to radiofrequency tonsillar ablation on one side (group 1) and diode laser 980 nm tonsillar ablation on the other side (group 2) in order to minimise problems caused by interindividual variation. The tonsils were removed by cold dissection tonsillectomy and the procedure was performed by the same surgeon.

Inclusion criteria included patients with chronic hypertrophic tonsils and obstructive tonsillar hypertrophy with sleep apnoea that was accurately diagnosed to exclude other causes of apnoea. Inclusion criteria also met the American Academy of Otolaryngology guidelines for tonsillectomy. Tonsillotomy followed by tonsillectomy was imposed in these patients as a therapeutic necessity. Exclusion criteria were cases of unilateral tonsillar hypertrophy suspicious of neoplasms, and general contraindications for tonsillectomy such as bleeding tendency.

The local ethics committee approved the study protocol and written informed consent was obtained from parents of all children enrolled in the study.

A research assistant discussed participation requirements and completed eligibility assessment and the consent process.

All procedures were performed under general anaesthesia using the same anaesthetic and surgical technique. The standard and general safety precautions while using the laser were taken into consideration to avoid injury to the endotracheal tube and included placement of a 4 cm wide soaked saline packing around the tube. Medical personnel wore safety goggles for the appropriate wavelength and irradiation.

In radiofrequency tonsillotomy (ablation) the surgical procedure was started by using a radiofrequency surgical device (Dr. Oppel ST-501, Korea) spectrum of 4 mHz; a single RF electrode (tip exposure, 2 cm) (Fig. 1) was inserted interstitially at 5 points in the tonsil. The RF patient plate was placed in contact with the patient's body, and at a power of 10 watts and continuous mode for 30 sec, the energy was delivered with a total of 1500 joule per tonsil during the procedure.

Diode laser interstitial tonsillotomy (ablation) was performed using a Boyle Davis mouth gag and a 980 nm wavelength diode laser (Quanta, Solbiate Olona, Italy), and pulses were delivered using a bare optical fibre (320 μm) (Fig. 2). The procedure was performed by inserting the optical fibre about 2 cm interstitially in the tonsil and delivering laser pulses into five adjacent, non-overlapping spots, avoiding injury to the tonsillar bed. A continuous 10-watt power mode was used for 30 sec at 300 J/cm^2. The total energy delivered was 1500 joule per tonsil. The mean operative time was 4 min per tonsil.

After both procedures ended, the tonsils were excised by cold instrumental dissection to allow macroscopic examination of the tonsils to detect any gross changes (volume measurements, features), and histological examination of the tonsils followed both procedures.

Adequate gross dissection and sampling of tonsillar tissue at 3 mm thickness were done. Tissue sections were fixed for 24 hours in 10% neutral buffered formalin then dehy-

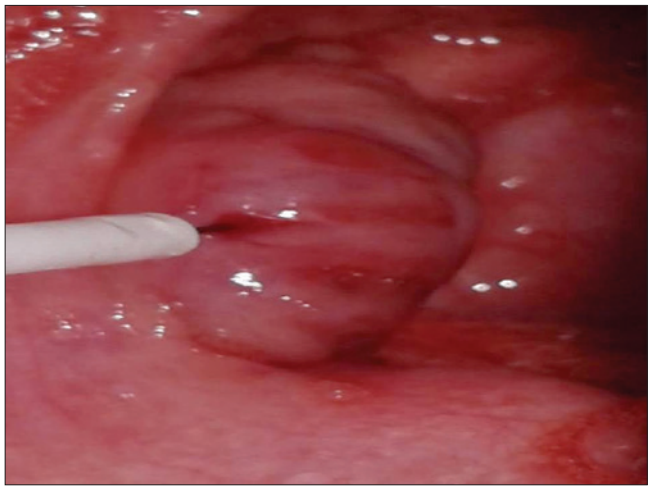

Fig. 1. Radiofrequency tonsillotomy surgical procedure.

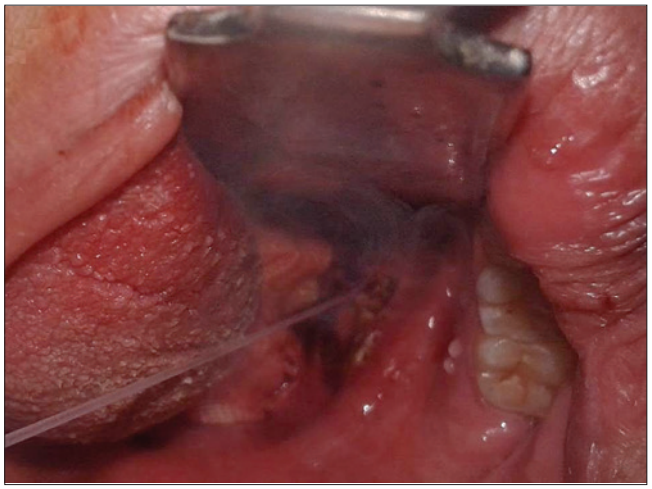

Fig. 2. Diode laser interstitial tonsillotomy surgical procedure.

drated, cleared and embedded in paraffin wax according to routine processing procedures. The paraffin wax blocks were cut in 5 μm sections and stained with haematoxylin and eosin for histopathological examination.

Statistical analysis

Data collected processed using SPSS version 15 (SPSS Inc., Chicago, IL, USA). Quantitative data expressed as means ± SD, while qualitative data was expressed as numbers and percentages. Student's t test used to test the significance of difference for quantitative variables that follow a normal distribution.

Results

We conducted this study on two tonsillotomy groups: radiofrequency (group 1) and diode laser 980 nm (group 2). The mean age of patients was 14 ± 7 years. Of the 20 patients, 18 (90%) underwent adenotonsillectomy surgery. It is noteworthy that bleeding during ablation and dissection of the tonsils was minimal in group 2 in comparison with group 1 since the diode laser is a better coagulator than radiofrequency. Also, postoperative pain perception was at the level expected after cold steel tonsillectomy. All patients were given postoperative medications and recovered normal activity after one week to 10 days.

Concerning histological analysis in group 1 (RFT), the specimens showed widespread starting necrotic foci in the form of pyknosis, karyorrhectic debris and karyolysis (faint dissolved nuclei) of cells in tonsillar tissue, and vacuolar degeneration of the tonsillar epithelium was also seen. The architecture of the lymphoid germinal centres was normal as well as the extent and type of vascularisation (Fig 3).

The histological picture of group 2 (DLT) specimens showed mild focal necrotic changes; areas of charring surrounded by zones of congestion were evident grossly (Fig. 4) and microscopically (Fig. 5). The tonsillar epithelium preserved a normal structure of the multilayer squamous epithelium, apart from focal vacuolar degeneration of the epithelium close to points of charring and haemolysed RBCs. Submucosally, there were no other abnormalities apart from focal necrotic foci and evident vascularity close to sites of charring; the architecture of the lymphoid germinal centres was also normal as well as the extent and type of vascularisation (Fig. 5).

The volume of the tonsils was calculated prior to surgery by transcutaneous ultrasound. Using a standard sonographic formula, the longitudinal, transverse and anteroposterior dimensions of tonsils was 0.523.

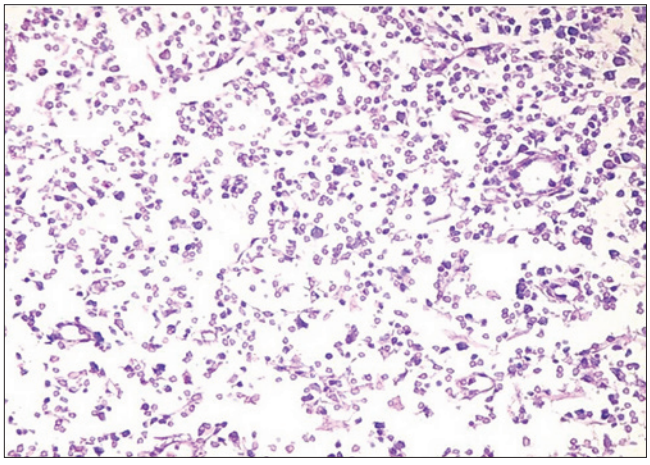

Fig. 3. Radiofrequency tonsillotomy showed karyolysis [faint dissolved nuclei] of the cells of the tonsillar tissue x200.

Fig. 4. Diode laser tonsillotomy showed areas of charring.

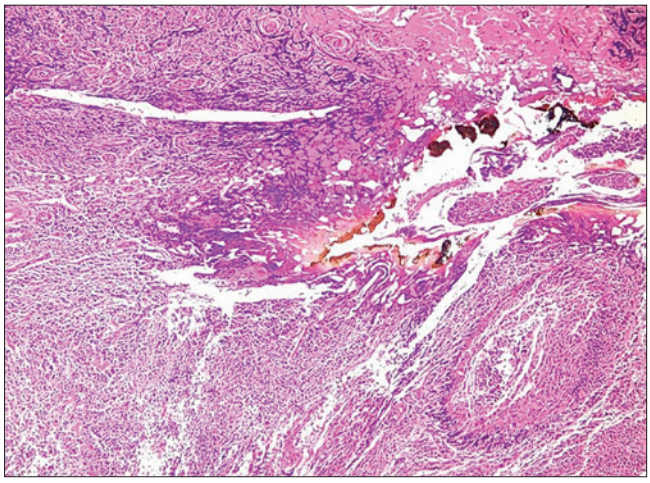

Fig. 5. Diode laser tonsillotomy showed charring and haemolysed RBCs, thermal injury of cells next to haemolysed RBCs, hyaline degeneration of tonsillar vessels (upper half of image) and degenerative changes of epithelium (lower right side) x200.

Regarding the gross picture and volume of the tonsillar specimens in group 1 (RFT), there were no superficial charring points, and the mean tonsillar preoperative volume (± SD) was 7.18 cm^3 (± 2.94), while postoperatively it was 4.9 cm^3 (± 3.14), which showed significant volume reduction.

In group 2 (DLT), the points of charring on the surface of the tonsils were evident and the mean tonsillar preoperative (± SD) volume was 7.36 cm^3 (± 2.78), while postoperatively it was 4.79 cm^3 (± 2.89), showing significant volume reduction. The results summarised in Table I show that there was no significant difference in volume reduction between the two groups.

Discussion

Tonsillectomy is still the most common operation performed in the paediatric population in order to reduce obstruction from enlarged tonsils, treat recurrent tonsillar infections, or both. There is no agreement on the ideal method for performing tonsillectomy. Various methods have been described which are frequently compared and discussed in the otolaryngology literature [3 4 12-14]. Introduction of tonsillar ablation techniques such as radiofrequency and laser has been used to achieve the ideal modality for management of tonsillar hypertrophy, hence avoiding both intraoperative and postoperative bleeding, besides preserving immunological function of the tonsils [6 7 9-11]. Friedman and Ibrahim [15] concluded that radiofrequency modality in tonsillar tissue volume reduction was efficient and safe with a low risk of postoperative morbidity. Terk and Levine [10] reported that volume reduction of tonsillar tissue by radiofrequency energy was achieved with minimal postoperative pain, which was attributed to the avoidance of mucosal interruption, in addition to the absence of fibrosis and preservation of the histological architecture of the tonsils.

On the other hand, the near infrared diode laser 980 nm has energy and wavelength characteristics that specifically target soft tissues in addition to its affinity for haemoglobin and melanin. Due to these characteristics, it is more efficient and better equipped to address soft tissue problems [16]. Besides this, we adopted the 320 μm fibre optic diameter as it was the safest due to the selectivity of minor vessel coagulation and minimal damage to surrounding tissue. The energy released by the diode laser transforms into heat, resulting in immediate tissue vaporisation [17]. The long wavelength of the diode laser furnishes a short depth of penetration and high energy density, making it more selective to interaction with water and haemoglobin, resulting in high tissue ablation properties with good homeostasis [18].

In this study, we applied a diode laser at 980 nm in tonsillar ablation, which to our knowledge has not been performed before, aiming to assess outcomes compared to the well documented efficient radiofrequency in managing tonsillar hypertrophy. The intraindividual design of this work fulfilled our goal since the same total amount of energy was delivered to the same patient either by diode laser at 980 nm or by radiofrequency, so that each patient acted as his own control, thus avoiding interindividual variation such as pain perception and bleeding tendency.

In our study, both groups, RFT group (1), and DLT group (2) showed a significant volume reduction of tonsils after ablation procedures, which were 31.6% and 34.9%, respectively. However, there was no significant difference between groups.

Table I. Comparison of tonsillar volume before and after operation in the two groups.

Tonsillar volume (ml)	Before operation		After operation			
	Mean	± SD	Mean	± SD	T test	P value
RFT (group 1)	7.18	2.94	4.91	3.14	2.17	0.033*
DLT (group 2)	7.36	2.78	4.79	2.89	2.41	0.025*

** Statistically significant; RFT: Radiofrequency tonsillectomy; DLT: Diode laser tonsillectomy*

Terk and Levine [10] reported that using radiofrequency with a power setting (2 watt) an insufficient tissue volume reduction was recorded, which they attributed to the low power setting. They concluded that energy application at a higher power setting would have affected tonsillar tissue volume reduction more. On the other hand, Nelson [11 19] reported a 30% to 60% reduction in tonsillar size depending on the energy settings applied. Regarding group 1 (RFT), our results are in agreement with the two preceding authors as 31.6% volume reduction was achieved by using 10-watt power setting.

Concerning group 2 (DLT), the comparatively greater results achieved in tissue volume reduction can be attributed to the effect of heat released by the interstitial insertion of the diode fiber into the tonsil, which resulted in faster and efficient denaturation of proteins and collagen followed by vaporisation of water molecules contained in tonsillar tissues. Our results are in accordance with Sedlmaier et al. [7], who reported sufficient tonsillar volume reduction on applying diode laser in contact mode (812 nm, continuous wave, 13 W) for tonsillotomy, and described the procedure's effectiveness in long-term results for snoring, obstructed respiration, apneoa, lack of appetite and susceptibility to infection as very good. Moreover, Havel et al. [20] concluded in their study that the coagulative and haemostatic effect of carbon dioxide laser might not be as efficient in well-perfused tonsillar tissue as that of the diode laser at 1470 nm.

Although there was no significant difference in volume reduction between the two groups, group 2 showed higher volume reduction which can be attributed to the fact that the coagulation and ablative effects of diode laser are better than radiofrequency since diode laser at 980 nm shows a high absorbance in water, which provides a better coupling to aqueous environments [21].

The histological findings showed that the tissue damage due to radiofrequency surgery was less than that due to the diode laser, which is likely to occur since radiofrequency would cause an increase in tissue temperature to a maximum of 80°C [22] compared to more than 300°C using a diode laser [23]. This was manifested by areas of charring surrounded by zones of congestion both grossly and microscopically in group.

The mucosa of the tonsillar bed showed no abnormal gross changes in either ablation procedure because both were applied interstitially. Tonsillectomy was performed immediately after the ablation procedure and excised tonsils were subsequently subjected to macroscopic examination and prepared for histological study. Otherwise, if there was time delay between tonsillotomy and tonsillectomy, the results would have differed.

Conclusions

In obstructive tonsillar hypertrophy, tonsillotomy is often preferred over tonsillectomy due to diminished postoperative pain, decreased risk of secondary bleeding and preservation of tonsillar architecture. In our study, both radiofrequency and diode laser at 980 nm were effective in tonsillar ablation with better volume reduction and less intra- and postoperative bleeding with the latter. As both techniques were submucosal, the lymphoid germinal centres were kept intact as well as the extent and type of vascularisation. thus preserving the immunological function of the tonsils. Hence, both procedures can be beneficial in management of tonsillar hypertrophy.

Conflict of interest statement

None declared.

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