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Laryngeal Microsurgery With Scanner-Assisted CO_2 Laser

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Introduction

Since the early 70's when Strong and Jako first introduced the CO_2 laser for treating laryngeal lesions, this surgical technique has evolved on a par with laser systems and special accessories. The ongoing technological progress of the CO_2 laser and the development of pulsed emission modes now make it possible to ablate tissues while limiting thermal damage and ensuring optimal preservation of the treated anatomical structures. The introduction of a robotic laser beam scanning system that works in synergy with the pulsed laser mode enables safer and more accurate laser applications in laryngeal surgery.

In parallel with this technological development, there has also been an increase in the basic knowledge about the microanatomy, the physiology of speech and the pathophysiology of vocal cord disorders.

The use of CO_2 laser in endoscopic laryngeal operating techniques offers considerable advantages, namely:

- Surgery performed through natural routes (transoral in direct micro laryngoscopy)
- Reduced tissue trauma
- Reduced local and general morbidity
- Rapid post-op recovery (shorter hospitalisation)
- Functional results comparable with those obtained with phonosurgical techniques using cold instruments
- With correct indications, oncological results comparable with those obtained with external surgery.

Figure 1. Ablation figures that can be selected

Smartxide, the Evolution of CO_2 Laser

New goals can now be attained with the introduction of new innovative CO_2 laser sources with high peak powers and pulse management that ensure complete and flexible control of ablation depth, minimising heat damage to the surrounding tissues.

The new frontier in CO_2 laser microsurgery is represented by the combination of a pulsed emission mode and dedicated scanning system capable of moving the beam in the tissue at a controlled speed with dwell times reduced to a few microseconds, further limiting lateral heat damage to healthy tissues. In effect, the HiScan Surgical scanner produces surface cutting or ablative figures that guarantee a precision impossible to achieve freehand, in addition to restricting lateral heat damage as a result of the reduced dwell time. The cutting and ablation depth can also be preset and controlled from the LCD panel, maximising preservation of healthy tissues and enhancing control and safety during surgery.

Materials and methods

In order to assess the potential and benefits of this new CO_2 laser and robotic scanning system, 36 patients were treated, 23 suffering from benign laryngeal lesions and 13 from malignant laryngeal lesions. All were subjected to CO_2 laser treatment with direct micro-laryngoscopy using the SMARTXIDE laser system, EasySpot micromanipulator and robotic HiScan Surgical system at the Otorhinolaryngology Department of Fermo Hospital (Italy).

In the pre-op work-up all patients underwent:

- A complete ENT examination
- Video laryngostroboscopy
- A phoniatric assessment.

Surgery was performed under direct micro-laryngoscopy with general anaesthesia via oraotracheal intubation using anaesthesiological tubes for laser surgery, and in full compliance with all current protection standards.

Analysis of surgical case studies

Benign lesions:

The CO_2 laser was used in the same way as classic phonosurgical techniques with "cold" instruments. A further aim was to acquire specific experience with the SmartXide model and robotic laser beam system in order to assess its use in these diseases. In order to limit the thermal damage to tissues, a power of 6-8W in emission mode SP (Super Pulse) was used. This can generate peak powers of hundreds of watts with pulse lengths of a few microseconds. The HiScan Surgical scanning system was also used in order to increase the speed and precision of execution thanks to the controlled movement of the beam. An application time on the tissue (dwell time) of 0.2 ms was used to further reduce the thermal effect of laser, enabling a faster and better functional recovery after surgery. Under certain conditions the use of the scanner allows safer use of lasers, with the ability to predetermine and control the depth of ablation. In fact, in 6 cases of laryngeal edema, the use of a predetermined depth of ablation per pass of 0.15 mm and a dwell time of 0.6 ms produced a very precise and controlled excision of the lesion, preventing the risk of complete ablation of all tissues, including the healthy ones. Phonosurgical patients were managed in compliance with a pre- and post-op rehabilitation protocol.

Type of lesions treated:

Total number of patients : 36

BENIGN LESIONS: 23 (63%)

- Polyps: 7 (30%)
- Oedemas: 6 (27%)
- Leukoplakias: 4 (17%)
- Nodule: 2 (9%)
- Papillomas: 2 (9%)
- Cysts: 1 (4%)
- V.C. paralysis in adduction: 1 case (4%)

MALIGNANT LESIONS: 13 (37%)

Squamous cell carcinomas 13

T1: 9 cases

- Type I cordectomy: 2 cases
- Type II cordectomy: 5 cases
- Type III cordectomy: 2 cases

T2: 3 cases (N0)

- Type V cordectomy: 3 cases

T3: 1 case (N0)

- Enlarged hemilaryngectomy

Assessment of the results:

The phonatory results were fully compliant with those obtained in similar situations using the classic phonosurgical technique. The laser also enables closure of small-medium blood vessels during cutting, thus creating a bloodless operating field.

Limited oedematous reaction and rapid functional healing times were also clearly evident.
In one case of cordoarytenoidectomy for treatment of a bilateral cordial paralysis in adduction, the result was positive with removal of the protective tracheotomy on the second day, with immediate and significant functional improvement (motor fatigue, functional respiratory tests) without any problems linked to post-op oedema.

Malignant lesions:

Use of the SP mode with average power of 6-8W in surgical oncology, has been useful in order to maximize the effect of ablative laser thanks to high peak power. The use of the scanning system HiScan Surgical, has made faster and more precise surgical sessions with the ability to use the figure of a linear scan with an adjustable size (6.3 mm max) in each case. In cases where it was necessary to use the laser near the surgical instruments or near the laryngoscope, the figure of an arch curve scan (3 / 10) proved to be useful to preserve more healthy tissue and prevent any consequential exposure and incidental reflections from the laser. A total of 13 patients were treated of whom 9 T1, 3 T2 and 1 T3.

Case T3 was an elderly patient (78) with a left cordo-ventricle-commissural carcinoma and laryngeal hypomotility. A pre-op CT scan with medium contrast was performed in all patients. In cases of significant tissue excision and/or unfavourable anatomy of the patient's head and neck, a protective cervicotomy was performed (tracheotomy incision with preparation of the anterior tracheal wall, without opening it). AllThe patients underwent a post-op video laryngostroboscopic ENT examination, and phoniatric assessment at gradually increasing intervals with a follow-up varying from 5 to 23 months.

Assessment of the results:

There was no evidence of the disease (NED) in all T1 patients. In two cases, a surgical revision was performed on hyperplastic lesions that had reformed and the results were histologically negative. Of the three T2 patients, one is NED (8 months). In another case (right cordo-commissural carcinoma), after six months there was evidence of a malignant left hypopharangeal carcinoma, treated with total hemipharyngolaryngectomy followed by radiotherapy. This patient is now NED (8 months). One patient (female, 63, right vocal cord and arytenoid laryngeal surface) developed a relapse on the residual arytenoid four months after laser type V cordectomy and was treated with supracricoid hemipharyngolaryngectomy, omolateral neck dissection and radiotherapy. This patient is now NED (12 months), without tracheotomy and eating normally. The T3 patient is NED (15 months).

Conclusions

The absence of any intra- and post-op complications and the clinical results obtained with the CO_2 SmartXide laser, the micromanipulator of the EasySpot series and Surgical HiScan, demonstrate the safety, ease of use and efficiency of this surgical system in Transoral Laryngeal Microsurgery (TLM). The scanning system, HiScan Surgical, has allowed the use of lasers in a simple and secure way with the ability to predetermine and control the depth of ablation (0.1 mm to 2mm) and to reduce the lateral thermal damage due to reduced application time on the tissues (0.2 ms min.). The unique and intrinsic ability of the laser to close small-medium diameter blood vessels during cutting significantly reduces bleeding, thus making the operation simpler and faster and also minimising the risk of relapses in the case of oncological surgery.

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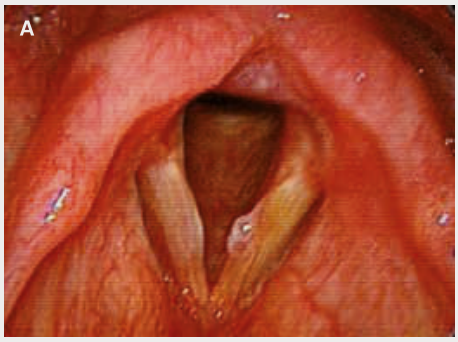

Figure 2. **(A)** Polyp of the left vocal Fold

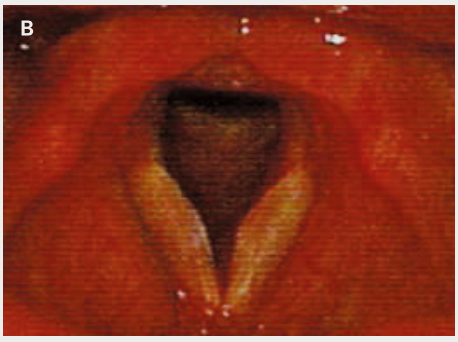

Figure 3. **(B)** 3 months follow-up

Figure 4. **(A)** Squamocellular carcinoma (T3)

Figure 5. **(B)** 6 months follow-up

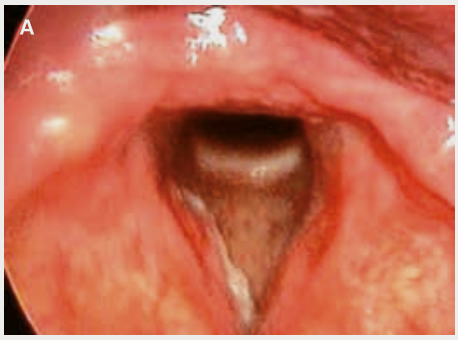

Figure 6. **(A)** Squamocellular carcinoma (T1a)

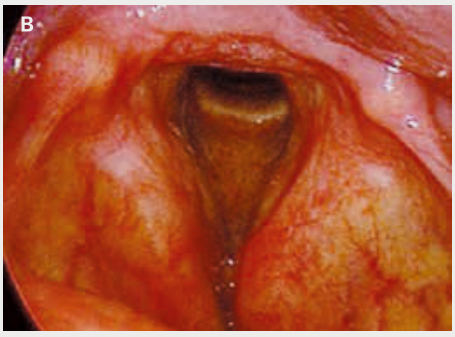

Figure 7. **(B)** 12 months follow-up