Oncological and functional results of CO_2 laser cordectomy

Risultati oncologici e funzionali delle cordectomie laser CO_2

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Key words

Larynx • Glottic cancer • Surgical treatment • Laser cordectomy • Voice

Parole chiave

Laringe • Carcinoma glottico • Trattamento chirurgico • Cordectomia laser • Voce

Summary

Laser surgery represents the evolution of endoscopic surgery and, as far as concerns treatment of laryngeal tumours, CO_2 laser cordectomy is considered a valid alternative to conventional surgery (laryngofissure cordectomy) and to exclusive radiotherapy for glottic carcinomas, classified as T1a, T1b and T2. The present report focuses on personal experience with CO_2 laser cordectomy over the last 11 years, evaluating oncological and functional results. Between October 1990 and December 2001, micro-laryngoscopy has been performed with CO_2 laser, in 606 cases (benign and malignant lesions), of which 150 laser cordectomies, at the ORL Department, Eastern Piedmont University of Novara. An analysis is made of 63 patients (mean age 64.3 years) who underwent laser cordectomy for glottic carcinoma, observed at follow-up for at least 3 years. Vocal function has been studied on a sample of 20 patients. Of those who underwent CO_2 laser cordectomy for T1a and T1s, 95.8% were disease free after a minimum of 3 years follow-up. Video-larynx-stroboscopic test highlighted the presence of a "satisfying" fibrous neocord in cases treated with Type III cordectomy. The speech compensation was of the "cord-neocordal" type (35%), false cordal (40%) and with arytenoideus hyperadduction (25%). The electro-acoustical analysis of the voice highlighted a "serious dysphonia" compatible with Type IV cases according to Yanagihara (70%) and moderate-severe dysphonia (30%). Mean values of vocal parameters were 5.8% for Jitter, 12.2% for Shimmer, 0.34 for NHR. CO_2 laser cordectomy is first choice treatment for T1a glottic carcinoma, offering intra- and post-operative advantages: reduced traumatism, lack of tracheostomy, low bleeding, fast functional recovery (deglutition and speech), brief hospital stay, and low management costs. Dysphonia resulting from treatment, characterised by breathed voice, allows the patient to lead a normal life.

Riassunto

La chirurgia laser rappresenta attualmente una valida alternativa alla chirurgia tradizionale ed alla radioterapia per il trattamento dei carcinomi del piano glottico T1a, T1b e T2. In questo studio sono stati presi in considerazione 63 soggetti sottoposti a cordectomia laser per carcinoma glottico tra il 1990 e il 2001 presso la Clinica ORL dell'Università del Piemonte Orientale di Novara e presentanti un follow-up minimo di 3 anni. Su 20 di questi soggetti è stato eseguito uno studio della funzionalità vocale mediante esame videostroboscopico ed analisi acustica della voce. Il 95,8% dei soggetti sottoposti a cordectomia laser per T1a e T1s è risultato libero da malattia dopo un follow-up minimo di tre anni. Per quanto riguarda la funzionalità vocale, si è evidenziata una disfonia "grave" compatibile con quadri tipo IV sec. Yanagihara nel 70% dei casi, ed una disfonia "moderata-severa" nel restante 30% dei casi. I valori medi dei parametri vocalici esaminati sono risultati 5,8% per il Jitter, 12,2% per lo Shimmer e 0,34 per l'NHR. In conclusione vengono esposti i vantaggi del trattamento con laser CO_2 nel carcinoma T1a della glottide, considerando che la disfonia residua dopo chirurgia, seppur con le caratteristiche di una voce soffiata, permette tuttavia al soggetto di condurre una vita di relazione normale.

Introduction

Laser surgery represents the evolution of endoscopic surgery and, as far as concerns treatment of laryngeal tumours, CO_2 laser cordectomy is considered a valid alternative to conventional surgery (laryngofissure cordectomy) and to exclusive radiotherapy for glottic carcinomas, classified as T1a, T1b and T2 [1]. The validity of this therapeutic strategy is confirmed by many reports in the literature which almost agree in evaluating the overlapping of the oncological results obtained with these methods [2-6].
Compared with open surgery, CO_2 laser cordectomy presents many clinical and anatomical advantages, e.g., less surgical trauma, lower incidence of intra- and post-operative complications, rapid functional recovery and shorter hospital stay [7-11].
In the past few years, the importance of maintaining adequate speech function in patients treated for glottic cancer has been highlighted in the literature [12-16]. Results of electro-acoustic analyses of the voice following treatment (both surgery and exclusive radiotherapy) have been discussed; obviously, cordectomies present a variable degree of dysphonia depending upon the type of glottic dissection, scarring and the resulting glottic insufficiency [17-20].
In this report, clinical experience over the past 11 years, in the field of CO_2 laser cordectomy, is analysed and oncological and functional results are evaluated.

Materials and methods

Between October 1990 and December 2001, microlaryngoscopy with CO_2 laser has been performed, in 606 cases – both benign and malignant lesions (150 laser cordectomies) – at the ORL Department.
In this study, 63 patients (60 male, 3 female; mean age 64.3 years, range 41-83) who underwent CO_2 laser cordectomy, for glottic carcinoma, are analysed. All have been observed at follow-up for at least 3 years. Of these cases, 20 were Ca in situ, 29 T1a, 9 T1b, 2 T2 and 3 had previously undergone exclusive radiotherapy without success.
Laser cordectomies have been classified according to the "Nomenclature Committee of the European Laryngological Society" of 1999 [21]. A total of 23 Type III, 29 Type IV, 9 Type Va, 2 Type Vb cordectomies (Table I) were performed in our Department.
The surgical technique used for these cases consists in the systematic exposure of the neoplasia by excising the false homolateral cord, with the exclusion of small superficial cord injuries (T1s). Dissection with the laser-beam is performed on healthy tissue (at least 3 mm from the visible limits of the injury) by excising the cancer *en bloc*.
In type IV - type V cordectomies, dissection starts from the petiolus of the epiglottis, at the level of the insertion of the excised ventricular band and is performed below the internal perichondrium without interruption.
Posteriorly dissection starts from the vocal process, which is sometimes ablated and extends laterally to the thyroid cartilage. In none of the cases presented here were the arytenoids excised, as we exclude from the selection, glottic cancers with a posterior evolution which, at computed tomography (CT) present a possible infiltration of the paraglottic space.
Below, the dissection extends to the higher edge of the cricoid ring.
All patients have been observed at follow-up for a mean period of 64.9 months (range 36-120).
Vocal function has been evaluated in a sample of 20 patients (19 male, 1 female, mean age 67.5 years).
For control purposes, studies were carried out on a group of 20 patients (19 male, 1 female; age range 50-84 years), submitted to exclusive radiotherapy for glottic T1a, at doses between 66 and 70 Gy, distributed in 33-35 fractions, at the Clinical Department of Radiotherapy of Novara during the period 1990-2001. The mean time elapsing between treatment and this study was 62 months (range 36-100 months).
None of these patients was a professional of the voice (singer, actor, teacher …) or following logopaedic sessions during the evaluation.
The study on vocal function was performed with fibre optic video-larynx-stroboscopy aimed at evaluating, at glottic level, anatomic and compensation outcomes adopted by the individual while speaking. The examination was performed with Mediastrobo video-software support (Atmos Endostroboskop).

Table I. Relation between phase and treatment.

Type	T in situ	T1a	T1b	T2	T1a post-rt	Total
III	20	3	–	–	–	23
IV	–	26		–	3	29
Va	–	–	9	–	–	9
Vb	–	–	–	2	–	2

The recording and electro-acoustical analysis of vocal samples was performed with Kay MDVP4003 CSL50 devices (Speech Lab. Model 4300 B, Kay Elemetrics Corp.): we evaluated the Narrow spectrographic traces according to the Yanagihara Classification [22] and analysed the vocal parameters relative to fundamental frequency (F0), frequency micro-perturbation (Jitter) and intensity (Shimmer), noise/harmonics relationship (NHR) and dysphonia degree (DSH).
To create the Narrow trace, we sampled the word "AIUOLE" (*flower beds*, in English), while for the vocal analysis of the patient, we used a 3 seconds "A" vowel.

Oncological results

Of the patients who underwent CO_2 laser cordectomy for T1a and T1s, 95.8% resulted free from disease after a 3-year minimum follow-up; 3 patients died from causes unrelated to the neoplasias of the respiratory system, whereas 2 died from metachronal heteroplasia in the lung.
A case of CO_2 laser cordectomy for Ca in situ that developed on larynx papillomatosis underwent contralateral laser cordectomy for micro-invasive T1a 1 year after the first treatment; the patient showed no signs of relapse at 23-month follow-up.
A case of micro-invasive T1, lost at follow-up, came to our attention again after 3 years with a contra-lateral glottic carcinoma classified as T3N0; the patient underwent total laryngectomy. At present, the patient is disease free at 30-month follow-up.
Only 36.4% of T1b and T2 were found to be disease free after laser endoscopy treatment.
Two cases of T1b glottic carcinoma extended to the anterior commissure and the T2 cases were treated for cancer relapse with total laryngectomy and bilateral neck dissection; since these were relapses and high grade neoplasias, we performed post-surgical adjuvant radiotherapy. No patients presented metastatic lymphadenopathy at staging. At present, the patients are disease free with a mean follow-up of 20 months.
Three patients presenting T1b were treated with post-cordectomy radiotherapy due to cancer infiltration of the edges of the surgical wound. These patients have not shown signs of relapse at a minimum 3 years follow-up. None of the T1s presented infiltrations of the edges of the resection, whereas in 5 cases of T1a, the lesion was near the edges: these patients were, therefore, monitored at monthly follow-up for one year.
After a minimum 3-year follow-up, T1s showed an overall survival, after surgical and/or radiotherapy recovery, of 91.2% (Fig. 1) and, overall, 84.6% of patients with glottic cancers were disease free after 3 years (in the cases where the larynx was saved after endoscopic treatment with/without adjuvant radiotherapy).
The mean length of hospital stay after CO_2 laser cordectomy is 4 days, feeding starts again 48 hours after surgery.
In one case, bleeding occurred in the immediate post-treatment period, and revision of the haemostasis in direct micro-laryngoscopy with monopolar coagulation of a perforating crico-thyroid arteriole was necessary. In another case, emergency tracheotomy was necessary due to onset of acute dyspnoea caused by laryngeal oedema; the patient was de-cannulated and discharged after five days.

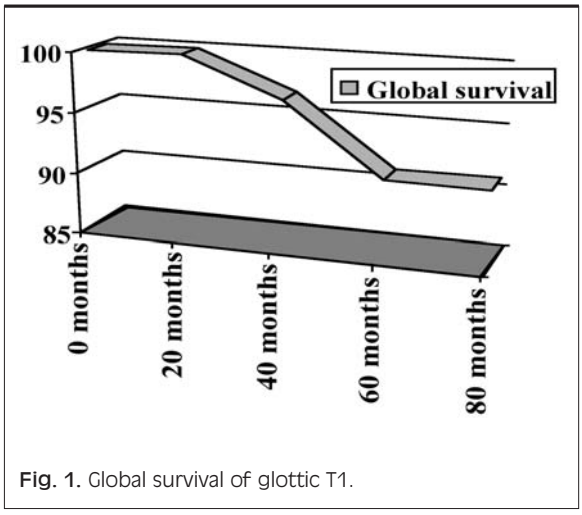

Fig. 1. Global survival of glottic T1.

Functional results

Of the 20 cases evaluated for vocal function, 7 had undergone intra-muscular laser cordectomy (Type III) while the other 13 had undergone total laser cordectomy (Type IV).
The video-larynx-stroboscopic test highlighted the presence of a fibrous neocord which was well formed in those cases treated with Type III cordectomy, while it was insufficient in subperichondrial cordectomies, where only 30.7% of the cases present a scar neocord; of these cases, 3 show fixed homolateral arytenoid at the place of intervention.
We found three main types of speech compensation. After laser cordectomy, speech compensation is "cord-neocordal" in 35% of cases, false cordal in 40% and with arytenoid hyperadduction in 25%.
The patients treated with exclusive radiotherapy presented, at laryngeal stroboscopy, a bilateral reduction of the diffusion of mucosa wave in 81% of cases, while 25% showed severe glottic insufficiency in speech.

After surgery, the electro-acoustic analysis of the voice highlighted a severe dysphonia compatible with Type IV case, according to Yanagihara, in 70% of patients and "moderate-severe" dysphonia in 30%. Fundamental frequency (F0) has been reduced to less than 130 Hz in 75% of patients; the mean values of the examined vocal parameters were 5.8% for Jitter, 12.2% for Shimmer, 0.34 for NHR, furthermore, diplophonia, with mean DSH values of 2.6%, was found in 5 patients. In 3 patients presenting severe aphonia, it was impossible to analyse the vocal parameters of the electro-acoustic signal (Table II).

In those patients who underwent exclusive radiotherapy (Table III), the spectrographic analysis showed "moderate-severe" dysphonia compatible with Type III cases of the Yanagihara classification in 56% of the cases, "severe" dysphonia (Type IV) in 25% and slight dysphonia (Type II) in 19%.

The F0 was reduced to less than 140 Hz in 43.7% of the patients examined, with mean value of 167.81 Hz; the mean values of vocal parameters were 8.42% for Shimmer, 2.32% for Jitter and 0.21 for NHR.

The statistical comparison between the two groups, performed using Student test applied to the mean values of the vocal parameters and a χ^2 test for the degree of dysphonia according to Yanagihara, highlighted a statistically significant difference, which justifies the observation of a lower degree of dysphonia in the patients treated with exclusive radiotherapy (Figs. 2-5).

Discussion

Since the Eighties, various scientific studies, focused on CO_2 laser surgery, have been aimed at underlining the validity of this procedure in the treatment of glottic cancers [23-27].

In selected cases, the oncological results, at specific times after CO_2 laser cordectomy, can be compared to conventional surgery and exclusive radiotherapy [28-30] (Table IV).

Reports in the literature confirm that the disease is brought under control, 3 years after the actual treatment, in 83%-97% of T1a cases. In general, a wound which extends to the anterior commissure must be thoroughly evaluated, both clinically and radiologically (spiral CT), before performing laser endoscopy [40].

Controversial data have been published in the literature; in 1989, Krespi and Mutzen presented a report on treatment failures in patients who suffered from cancers extending to the anterior commissure and treated with laser cordectomy. In 1988, Hirano and Hirade reported a series of unfavourable results with T1b of the anterior commissure [11].

Moreau [41], on the contrary, recently described some

Table II. Sonographic results of sample submitted to CO_2 laser surgery.

Initials	Sex	Age (yrs)	Site	Type of cordectomy	DSH (%)	Shimmer (%)	Jitter (%)	NHR	Yanagihara (type)	F0 (Hz)
TG	M	70	left	IV	0.00	11.04	2.57	0.26	IV	122.748
CT	M	76	rt	III	7.14	8.29	0.98	0.17	III	129.605
ZGP	M	75	left	IV	0.00	6.99	5.15	0.25	IV	175.656
MC	M	71	rt	III	0.00	5.36	3.22	0.15	IV	165.626
SM	M	68	rt	III	6.38	10.05	2.17	0.27	III	186.413
NP	M	61	left	III	0.00	7.94	0.89	0.12	III	100.932
RA	M	76	left	IV	15.56	23.42	18.89	0.77	IV	129.901
SG	M	79	rt	IV	0.00	12.86	5.87	0.28	IV	128.287
CG	M	80	left	IV	0.00	12.30	17.55	0.79	IV	182.145
GF	M	56	left	III	0.00	6.43	1.44	0.16	III	209.371
BA	M	79	left	IV	0.00	8.86	1.96	0.23	IV	137.708
DE	M	68	rt	IV	0.00	15.07	5.82	0.36	IV	125.869
CM	M	53	left	III	0.00	8.55	3.61	0.18	III	178.126
PF	M	64	left	IV	0.00	9.73	1.97	0.29	III	120.251
NF	M	61	left	IV	0.00	18.89	5.75	0.51	IV	125.975
CL	F	71	left	IV	16.67	21.98	7.22	0.48	IV	208.956
SM	M	63	rt	III	0.00	8.45	2.41	0.25	IV	178.599
GM	M	64	left	IV	7.22	12.49	4.21	0.36	IV	195.715
MA	M	58	rt	IV	0.00	23.58	19.87	0.70	IV	116.545
CA	M	57	rt	IV	0.00	12.20	5.80	0.34	IV	128.357

Table III. Sonographic results of sample submitted only to radiotherapy.

Initials	Sex	Age (yrs)	Site	Therapy (total Gy)	DSH (%)	Shimmer (%)	Jitter (%)	NHR	Yanagihara (type)	F0 (Hz)
GF	M	74	rt	66	6.35	9.36	3.46	0.29	IV	153.066
BI	M	67	rt	64	0.00	8.43	2.37	0.23	IV	103.574
IA	M	70	left	66.6	0.00	8.37	1.02	0.18	III	112.472
SG	M	56	rt	66	0.00	8.55	1.06	0.17	III	193.435
AC	M	58	rt	60	0.00	5.50	1.80	0.15	III	131.334
FF	M	76	rt	70	21.69	6.61	3.35	0.22	III	274.81
VI	M	78	left	64	0.00	14.47	1.99	0.29	III	111.643
LGC	M	75	left	60	0.00	5.60	0.90	0.15	II	133.822
CR	M	50	rt	66	4.65	8.18	2.46	0.20	II	178.157
MB	M	66	rt	68	0.00	5.41	1.35	0.14	III	210.876
MO	M	68	left	63	0.00	7.92	3.38	0.27	III	176.292
CS	M	84	left	70	0.00	5.72	0.77	0.16	III	120.002
BM	M	82	rt	60	0.00	6.27	1.69	0.22	III	213.977
MM	F	79	left	66	6.38	9.08	4.28	0.25	IV	307.299
LGM	M	77	rt	66	26.47	17.86	4.04	0.23	IV	160.636
PO	M	81	left	60	0.00	7.45	3.20	0.21	II	103.657
LUC	M	66	rt	60	0	3.97	0.36	0.15	III	105.302
LOR	M	68	left	66	1.19	1.75	0.4	0.12	III	153.62
MUS	M	75	left	70	0	2.8	0.76	0.16	III	106.857
FER	M	58	rt	68	1.82	7.16	1.31	0.17	III	157.582

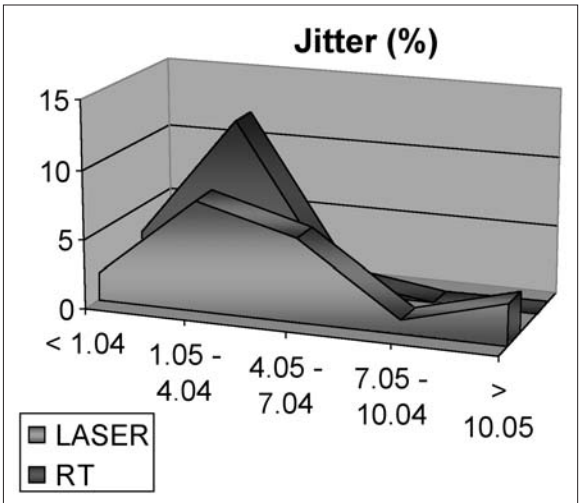

Fig. 2. Jitter curve in the two groups.

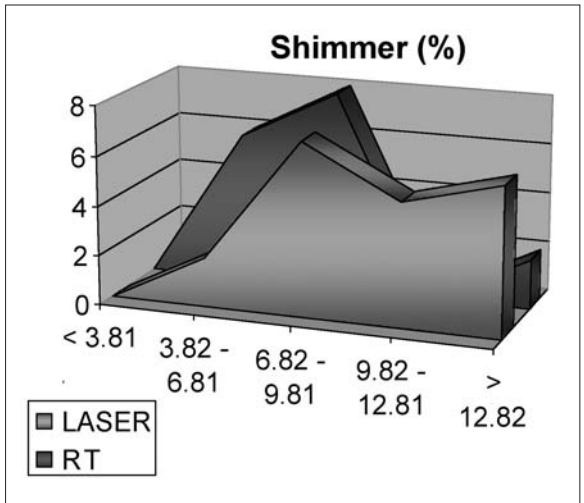

Fig. 3. Shimmer curve in the two groups.

cases of carcinoma involving the anterior commissure in which he obtained oncological radicality with laser microsurgery, without performing a rescue total laryngectomy.

However, the role played by laser in the treatment of glottic larynx carcinoma is still controversial in the literature. Steiner, in 1993 [43] and 1998 [25], advised the use of laser microsurgery for all T1 and T2 glottic carcinomas and also for selected T3 and T4 pharynx-larynx cancers; in the same years, Eckel and Thumfart considered laser cordectomy the treatment of choice for glottic T1 and T2, but not for T3 of the larynx [42 43]. In 1997, Motta et al. presented 516 cases of laser cordectomy for T1-T2-T3 with total observed

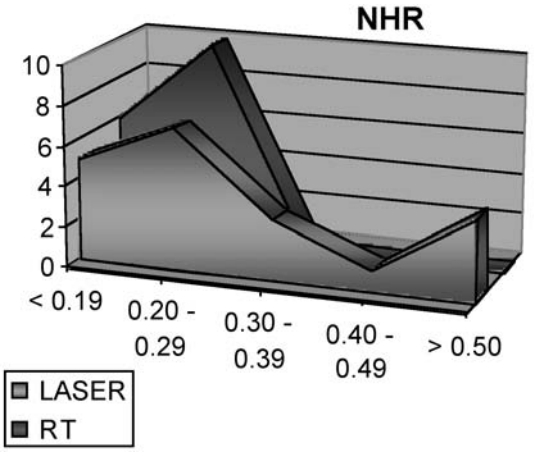

Fig. 4. NHR curve in the two groups.

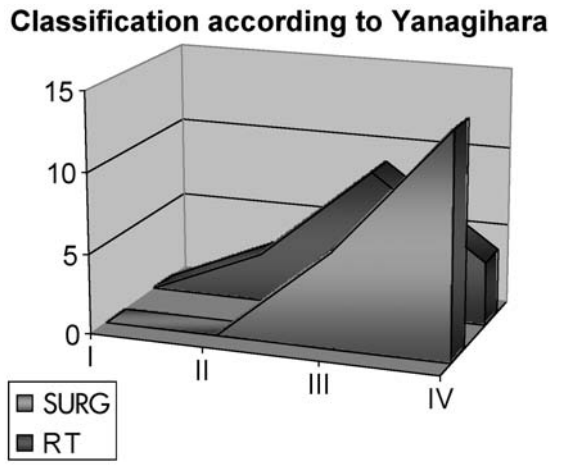

Fig. 5. Level of disphonia in the two groups.

Table IV. Results of treatment of T1 glottic carcinomas: literature data.

First Author, yr (ref.)	T classification	Treatment	DC (%)	Survival (%) 3 yrs	5 yrs
Piquet 1984 (6)	T1	C	–	92	–
Calearo 1984 (31)	T1	C	–	93.7	86.2
Nicolai 1988 (32)	T1	C	–	–	86.2
Glanz 1989 (33)	T1	C	–	99	–
Olsen 1993 (34)	T1	C	–	–	79
Alajmo 1994 (35)	T1	C	–	–	95
De Campora (9)	T1	L	–	93	–
Saetti 1995 (24)	T1	L	–	91.4	–
Motta 1997 (36)	T1	L	–	93	–
Czigner 1994 (8)	T1	L	–	95	–
Harwood 1980	T1	RT	95	–	–
Fletcher 1980	T1	RT	96.5	–	–
Wang 1983 (37)	T1	RT	94	–	–
Million 1994	T1	RT	100	–	–
McLeod 1988 (38)	T1	RT	94	–	–
Lusinchi 1989	T1	RT	90	–	–
Gabriele 1994 (39)	T1a	RT	96	92	–
	T1b	RT	93	89	–

C: thyrotomic surgery; L: CO_2 laser surgery; RT: radiotherapy; DC: local final control (with rescue surgery for cases treated with radiotherapy).
(Modified from Magnano M, et al. [3]. *Surgery or radiotherapy for early stages carcinomas of the glottic larynx)*

survival of 79% after a 5-year follow-up; more recently, the same Author presented the oncological results for T1a and T1b with a corrected actual survival of 97% and 96% after 5 years [36 44].

We prefer to limit the indications of laser endoscopic surgery to T1 in situ, T1a, glottic T1b and selected glottic T2 only; in the most advanced stages, we use open surgery techniques, more extended and radical interventions. At present, the classical thyrotomic cordectomy finds a specific indication in those cases which show a difficult anatomic exposure at endoscopy.

Increasing attention is currently being focused on the

quality of life for oncological patients and on the possibility to maintain speech function with a satisfying voice. In the past few years, the literature has frequently dealt with phonatory analyses in patients with treatment outcomes for glottic carcinomas [17-19 45-48].
Radiotherapy leads to the possibility of achieving very good vocal sound in a large percentage of cases [13 15 19 49].
Voice quality, after laser intervention, depends on the dimensions of the muscular resection, on the conformation of the neocord and on the glottic and supraglottic compensations, performed by the patient, in order to compensate his/her glottic insufficiency [5 17 20 47]. The presence of a well conformed scar neocord is related to the type of cordectomy and to the individual scar reaction [20 47].
According to our observations, Type I-II-III CO_2 laser cordectomies led, as expected, to the formation of a better fibrous neocord compared with subperichondrial total cordectomy (Type IV). Furthermore, in total cordectomies a false cord and/or arytenoid hyperadduction compensation is often performed which is less favourable, from a phonatory viewpoint; moreover, supraglottic compensation lowers the fundamental frequency.
The qualitative and quantitative evaluation of the voice highlighted a situation of "severe" dysphonia in those patients treated with Type IV cordectomy, in which a supracordal pathological compensation is present, due to the inadequacy of the neocord, whereas the patients who underwent intramuscular cordectomy show moderate-severe dysphonia similar to Type II Yanigihara traces.
In conclusion, CO_2 laser cordectomy is first-choice surgical treatment in T1a glottic carcinoma, offering great intra- and post-intervention advantages: reduced traumatism, lack of tracheostomy, lack of, or negligible, bleeding, quick functional recovery of the patient (deglutition and speech), short hospitalisation times, low management costs; valid oncological results must be added to these.
The dysphonia resulting from the intervention (although with the characteristics of a breathed voice) allows the subject to live normally, and a vocal/sound improvement can certainly be achieved with early logopaedic rehabilitation.

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Received: April 22, 2002
Accepted: June 4, 2004

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