Sandwich Thyroplasty: A Novel Technique for Simplifying Medialization of Vocal Fold Using Silicone Implant in Paralytic Dysphonia with Modification of Thyroplasty Window

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Abstract A novel technique of thyroplasty—Sandwich thyroplasty—described, with modification of Isshiki's thyroplasty window to overcome the problems of securing and stabilising the silicone implant in the window thus simplifying the medialization of the vocal fold. Seventy five patients diagnosed with paralytic dysphonia of varied etiology, attending Sri Sathya Sai Institute of ORL, Guntur, India from January 2005 to January 2012, were subjected to this new technique. Medialization of vocal fold was achieved by sandwiching and stabilising a silicone implant between a superiorly based cartilaginous hinged door and the inner perichondrium of the modified thyroplasty window. Results were analysed based upon pre and postoperative voice handicap index, maximum phonation time readings and video-stroboscopic findings. The results were statistically significant with no untoward complications. Sandwich thyroplasty technique facilitated easier fixation and stabilization of silicone implant avoiding difficult and time consuming, techniques involving flanges or sutures.

Keywords Thyroplasty · Phonosurgery · Unilateral vocal fold paralysis · Paralytic dysphonia

Abbreviations

ML	Medialization laryngoplasty: Type-1 thyroplasty
AAT	Arytenoid adduction technique
VHI	Voice handicap index

MPT	Maximum phonation time
GRABS	Grading of roughness, aethenic, breathy, strained
H&N ratio	Harmonic to noise ratio
PDA	Patent ductus arteriosus

Introduction

Isshiki et al. [1] first introduced the concept of thyroplasty for medialization of vocal fold with silicone implant. It was later popularised by Koufman and Isaacson [2] in United States as medialization laryngoplasty (ML). Several authors have reported modifications of the Isshiki's approach primarily for the purpose of “simplifying” the procedure. The modifications include division or retraction of the strap muscles, creation of external perichondrium flap, removal of the window cartilage, use of fiber optic visualisation of the larynx intra operatively and incision of the inner perichondrium [3]. The most significant modifications were concentrated on designing different types of flanges on the silicone implant for fixation in the window or use of its substitutes [4–8]. Although substitutes for the silicone implant, or prefabricated implant system, provide decreased operative time and gross medialization of the vocal fold, they do not allow for small adjustments in the implant shape to fine-tune voice results. These materials are deemed to be reliable by those who have designed them however prospective clinical trials using a variety of implant materials have not been carried out and would be difficult to conduct due to the significant variability in glottal configuration associated with either vocal fold paralysis or vocal fold paresis [9]. The different sizes available for most prefabricated implants do not cover the

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range of what is required for an optimal voice result in every patient [10]. Some authors prefer Gore-Tex over silicone because it is more pliable however Gore-Tex has the potential for migration within the paraglottic space, either acutely or over a period of time [9]. Gore-Tex sheet enables less direct control over the degree and area of medialization than an individually carved silicone wedge or plug [10].

Silicone has been widely used by otolaryngologists and is accepted as the implant of choice for type-1 thyroplasty or ML. Silicone has inherent advantages of custom carving and cost effectiveness. Its main disadvantage is difficulty in securing and fixing it in the thyroplasty window. One case of allergic reaction to silicone only has been reported till now from the available literature [11]. Earlier methods described for securing the silicone implant were not only technically difficult but also time consuming. These methods included making flanges in the implant as described by Koufman and Isaacson [2] or suturing the implant to the margins of the laryngeal window of the thyroid cartilage with non absorbable sutures. Flanges in the implant are also likely to increase the size of implant than the actual size of the window requiring more manipulation in the paraglottic space and violation of inner perichondrium leading to bleeding into the window or subsequent migration [2]. Various reasons for prosthesis extrusion have been described by several authors in their respective series [12]. These include suboptimal prosthesis placement [13] violation of inner perichondrium during fixation of flanges, and mucosal penetration [14]. The larynx is a constantly moving organ both during speech and swallowing [15]. Earlier attempts made by surgeons to stabilize the silicone implant by suturing it to the edges of the window by non absorbable sutures, led to loosening or cutting through of the sutures resulting in gradual lateralization of the vocal fold in the constantly moving larynx.

To overcome these problems of fixation of silicone implant, we designed a simple technique, sandwich thyroplasty, involving modification of the thyroplasty window with a hinged door for an easy, fast and efficient way of securing the silicone implant in the thyroplasty window without any need for flanges or sutures. This may be the first attempt to innovate and improvise a modification of thyroplasty window after its inception by Isshiki for medialization of vocal fold using silicone implant.

Materials and Methods

Seventy five patients with unilateral vocal cord paralysis of different etiology (Table 1), attending Sri Sathya Sai Institute of ORL and Research Centre for Voice Disorders, Guntur, A.P. India, from January 2005 to January 2012 were

selected. All patients underwent the new technique of sandwich thyroplasty under local anaesthesia. The study was based on a clinical trial of patients undergoing thyroplasty surgery with the new technique of hinged door sandwich thyroplasty. Informed consent was obtained from the patients in addition to permission from the ethical committee of the institute. Among the 75 patients subjected to this new technique, 45 were males and 30 were females in the age group of 20–70 years. 28 patients underwent type-1 thyroplasty (ML), 45 patients underwent type-1 thyroplasty with arytenoid adduction technique (AAT) and 2 patients underwent bilateral type-1 thyroplasty with arytenoid adduction (Table 2). Assessment of the results was based on subjective judgment of voice by the patients using the voice handicap index (VHI) [16] and by pre, intra and post operative maximum phonation time (MPT) measurements (Table 3). Lundy et al. [17] confirmed that MPT was a good functional and objective measure of glottal competence, suitable for predicting the postoperative outcome of medialization thyroplasty. They also recommended intra-operative measurement of MPT, which was an adequate predictor of postoperative outcome. All patients underwent assessment by pre and post operative Video-Laryngostroboscopy (Xion Endostrob GH), perceptual voice analysis (GRABS Scale) by voice team (based on digital audio and video voice recordings) and Acoustic voice analysis (jitter, shimmer, Phonetogram, MPT, harmonic and noise ratio spectrogram) using Vaghmi software. Patients who underwent type-1 thyroplasty were discharged 24–48 h following surgery. Patients who underwent type-1 thyroplasty and arytenoid adduction were discharged 1 week after the procedure. Sutures were removed on the seventh post operative day. Post operatively, all the patients were followed at intervals of 3, 6 months and 1 year. All patients received pre and post operative voice counseling and voice therapy.

Technique

All patients had surgery under local anaesthesia with optimum sedation under the supervision of an anaesthetist. After exposing the thyroid lamina, marking of the thyroplasty window was done on the side of paralysed vocal fold (Fig. 1). Perichondrium over the anterior, inferior and posterior margins of the window was incised with a sharp knife leaving the superior margin intact. Window margins were cut to the level of inner perichondrium either with a knife or otologic drill using both cutting and diamond burs over the anterior inferior and posterior margins of the window. The cut cartilage fragment of the window was then fractured along its superior margin and lifted superiorly as a hinged door based on the outer perichondrium (Fig. 2a, b).

Table 1 Sandwich thyroplasty—Aetiology pattern of patients with unilateral vocal fold paralysis

Aetiology	Number of patients
Post thyroidectomy	35
Idiopathic	26
Post vagal neurectomy	5
Post PDA surgery	3
Post carotid artery aneurysm excision	1
Post bypass surgery	4
Post jugular foramen mass excision	1

Table 2 Sandwich thyroplasty—combination with other procedures

Procedure	Number of patients
Type-I thyroplasty	28
Type-I thyroplasty with arytenoid adduction	45
B/L type-I thyroplasty with unilateral arytenoid adduction	2

Table 3 Sandwich thyroplasty—parameters

	MPT			VHI	
	Pre-op	Intra-op	Post-op	Pre-op	Post-op
Mean	4.08	10.06	16.78	83.46	48.5
Median	4	10	17	81.5	47.5
Mode	3	10	16	70	43
Standard deviation	1.31	1.84	2.91	11.89	9.01

Fig. 1 Marking of thyroplasty window for sandwich thyroplasty

The thickness of implant to produce sufficient medialization of vocal fold for optimum voice production was decided on the basis of distance measured from the undersurface of the window margin to the level of inner

a **Fig. 2** **a** Diagrammatic representation showing thyroplasty window with superiorly based hinged door. **b** Thyroplasty window with superiorly based cartilage hinged door (intraoperative photo)

perichondrium with a measuring device designed by the author. This was done while monitoring the patient's voice. The patient's voice was tested using both vowels and connected speech by counting numbers at optimum voice levels. MPT was considered as important parameter for improvement of voice, intra operatively.

A silicone implant of appropriate thickness and size was introduced into the thyroplasty window (Fig. 3a, b). The superiorly based hinged door was closed into the window with a snap, sandwiching and securing the implant between the inner perichondrium and the cartilage of the hinged door, thus simply medializing the paralysed vocal fold (Fig. 4). The accuracy of medialization was based in all cases on intra-operative testing of patient's voice. Trans-nasal fiber-optic laryngoscopy was carried out only in five cases. When thyroplasty was combined with arytenoid adduction the implant was fixed after completion of arytenoid adduction procedure. The same procedure was adopted in two cases of bilateral thyroplasty. The wound was closed in layers leaving a small drain. Skin was closed using subcuticular prolene suture.

Fig. 3 **a** Diagrammatic representation showing silicone implant introduced in thyroplasty window. **b** Silicone implant introduced into the thyroplasty window with superiorly based hinged door (intraoperative photo)

Fig. 4 Diagrammatic representation showing secured silicone implant between the inner perichondrium and the cartilage of the hinged door

All patients were given parenteral antibiotics for the first 48 h followed by oral antibiotic therapy for the next 5 days. Corticosteroid was prescribed following the surgery at tapering doses in all cases for 4 days. Voice rest was advised 5–7 days following the surgery. All the patients were subjected to voice therapy 15–20 days after the surgery.

Results

75 patients with unilateral vocal cord paralysis of different etiology, from January 2005 to January 2012, underwent the new technique of sandwich thyroplasty under local anesthesia. Of these 45 were males and 30 were females in the age group of 20–70 years with mean age of 35 years. Of the 75 patients who were operated, 2 patients failed to attend follow up. All 73 patients had postoperative voice outcomes assessed in the voice clinic at regular interval of 3 months for 1 year.

Primarily assessment of the results of the present technique was based on pre, peri and post operative MPT measurements. Reduction in VHI and improvement in MPT were statistically significant ($P < 0.0001$) in all 73 cases, calculated by two sided paired *t* test (Table 4). All the cases underwent pre and post operative video-laryngostroboscopy (Xion Endostrob GH), Perceptual voice analysis (GRABS Scale) done by voice team and Acoustic voice analysis (Jitter, Shimmer, phonetogram, MPT, H & N ratio spectrogram (Vaghi software). The results were almost on par with earlier techniques of silicone thyroplasty described for medialization of vocal fold (Tables 5, 6). The surgical procedure was very well tolerated by all patients and there were no intraoperative or postoperative complications.

Discussion

Medialization thyroplasty has been accepted as a safe surgical method for the treatment of vocal fold paralysis. The success of medialization depends on creating the thyroplasty window in the correct place and crafting a suitable implant that can be secured in the window to maintain the three dimensional contour of the vocal fold [18].

From the time Isshiki et al. [1] first conceptualized thyroplasty for medialization of the vocal fold, silicone has been widely accepted as implant of choice with its inherent nature of custom carving and cost effectiveness. Many modifications have been made to the technique of external medialisation thyroplasty to simplify the procedure and to increase it's efficacy. Several authors suggested prefabricated implant system as substitutes for silicone implant [4–

Table 4 Sandwich thyroplasty—results

Parameter	Number of patients	Pre operative	Post operative	P value
Maximum phonation time (MPT) (s)	73	4.08 ± 1.31	16.78 ± 2.91	0.0001
Voice handicap index (VHI)	73	83.4 ± 11.89	48.5 ± 9.01	0.0001

Table 5 Sandwich thyroplasty—comparison of results with other methods of silicone thyroplasty—mean—maximum phonation time (MPT) values

Authors	Pre-op	Post-op
Atsushi Suehiro et al.	5.1	10.6
Chrobok et al.	6.5	12.5
Nora van Ardenne et al.	8.3	11
Viktor Ch et al.	6.5	12.5
Sasaki	5.5	9.3
Sridhara	4.87	12.07
Virgilijus Uloza et al.	8.1	16.8
Current authors (ourselves)	4.08	16.78

Table 6 Sandwich thyroplasty—comparison of results with other methods of Silicone thyroplasty—mean voice handicap index (VHI) values

Authors	Pre operative	Post operative
Nora van Ardenn et al.	57	43.6
Virgilijus Uloza et al.	87.9	28.6
Grøntved et al.	82	40
Current authors (ourselves)	83.5	48.5

8] Although these provide decrease operative time and gross medialisation of the vocal fold, many of them are not only expensive but also do not allow custom carving of the implant for tuning of voice outcome intra operatively. From the available literature it was found that these other materials were deemed to be reliable only by those who have designed them. Moreover, some of these pre carved implants need special instruments and two or three implants of different sizes (45,678) which naturally increase the cost of the procedure.

Silicone implants are preferred by many surgeons who practice thyroplasty for medialization. But the main disadvantage was difficulty in securing and fixing the implant in the thyroplasty window. Methods described for securing the silicone implant include making flanges in the implant or suturing it to the margins of the laryngeal window. We found that these earlier methods not only technically difficult but also time consuming during surgery. Flanges are also likely to increase the size of the implant than what is needed leading to violation of inner perichondrium due to manipulation in the window [18] resulting in bleeding or

more chances for internal migration of the implant. Moreover as larynx is a constantly moving organ both during speech and swallowing about 600–1,000 times per day [15] the chances for loosening or cutting through of the sutures is quite possible leading to dislodgement or migration of the implant. From the available literature it was found that most of the modifications experimented or developed for simplifying medialization of vocal fold were confined to alterations either to the shape or type of the implant. Till now no attempts were noticed in the available literature for simplifying the technique of thyroplasty by modifying the thyroplasty window.

To overcome these difficulties of stabilizing the silicone implant in the thyroplasty window, we designed a fast, easy and simplified technique of sandwich thyroplasty.

In the present technique of sandwich thyroplasty, instead of modifying the silicone implant we modified the thyroplasty window with a superiorly based hinged door. The innovative design of the hinged door in the cartilage window ensures optimal fixation and stabilisation of the silicone implant and prevents lateral displacement or migration of the implant. The silicone implant was sandwiched between the inner perichondrium and the hinged door of the thyroplasty window, thus easily securing it firmly in the window and medializing the vocal fold.

To accomplish arytenoid adduction and medialization thyroplasty surgery in a patient under local anesthesia a time limit of 1.5 h is allotted to prevent complications like intra operative laryngeal edema [18]. When medialization thyroplasty is supplemented with AAT, medialization of vocal cord is done after completion of arytenoid adduction. Arytenoid adduction is a comparatively difficult procedure, particularly for beginners. Most of the time is consumed by the arytenoid adduction procedure during medialization process leaving very little time for stabilisation of the implant. In our present technique of sandwich thyroplasty, the fixation of silicone implant is done very fast by simply introducing a silicone block of suitable thickness into the window and fixing it in position by simply closing the hinged door of thyroplasty window without any need for making time consuming procedures like flanges or sutures. The internal migration of the implant was prevented by avoiding flanges and violation of inner perichondrium due to their manipulation in the window. The firm hinged door of the thyroplasty window could prevent lateral displacement of the implant. There were no intra-operative or post

operative complications with this technique. The immediate and long term results of voice out come after this new technique were found to be almost on par with the earlier techniques of silicone thyroplasty.

Conclusion

The technique of hinged door sandwich thyroplasty is aimed to describe a simple, easy and fast way of securing the silicone implant in the thyroplasty window. From the time Isshiki first introduced the concept of thyroplasty, securing of the silicone implant in the thyroplasty window was remained as a technically challenging issue. All the earlier methods described in the available literature for firmly securing the silicone implant were based on either making different types of flanges in the implant or suturing it to the margins of the laryngeal window which were found to be not only technically difficult but also time consuming during surgery. Our present technique is based on the modification of conventional thyroplasty window instead of modifications in the implant. Sandwich thyroplasty-a simplified new technique designed by us with modification of thyroplasty window ensures a firm fixation and stabilization of the silicone implant without any need for making flanges or sutures. The silicone implant fixation technique and handling in sandwich thyroplasty are faster and simpler even for beginners who want to practice thyroplasty. The present technique avoids manipulation in the paraglottic space during the surgery, prevents violation of inner perichondrium and internal migration of implant. The firm hinged door of thyroplasty window prevents external migration of the implant and gradual lateralization of the paralysed vocal fold. The implant could be easily removed if vocal cord function returns, or if a change to a different-size implant is indicated in redo cases. The post-operative results are encouraging, almost on par with the results of the earlier techniques of silicone thyroplasty. The technique is cost effective and does not require any special instruments.

Conflict of interest The authors declare no conflict of interest in the submission of this manuscript.

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