Statico-Dynamic Island Laryngoplasty with Crossed Musculoplasty and Transmitted Dynamism (for Vocal Cord Palsy): a New Technique

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Received: 30 August 2009 / Accepted: 27 April 2011 / Published online: 13 May 2011
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Abstract Only static medialisation of the paralysed vocal cord is most commonly performed today for vocal cord palsy which does not offer very good voice post-operatively. Colledge and Balance's (1927) operation of anastomosis of the phrenic nerve to the recurrent laryngeal nerve for laryngeal palsy or Tuckers (1976) nerve muscle pedicle technique has not offered significant reanimation of the paralysed muscles of the vocal cord. Moreover, it is virtually impossible to offer dynamism to the paralysed muscles; but dynamism can conveniently be transmitted to the paralysed vocal cord by appropriate muscle transplantation as has been done in palatopharyngoplasty for rhinolalia aperta (Ghosh 1983, 1986). Isshiki's laryngoplasty operations (1977) also offer only static correction. In view of the above short comings, the present statico-dynamic operation was conceptualised. A new technique of medialisation of the paralysed vocal cord statico-dynamically for improvement of voice is described here. In one operation, such as this, both arytenoid adduction and vocal cord adduction are expected to be achieved. A rectangular island of lamina of the thyroid cartilage, attached to the inner perichondrium, on the paralysed side, is created by drilling an endless canal on the lateral aspect of the thyroid lamina to the level of the inner perichondrium. The mobile

cartilage island along with the vocal cord and the arytenoid is fixed in a medialised position. Dynamism is quintessential for normal vocal cord function. For this, superiorly and inferiorly based superior and inferior bellies of the omohyoideus are passed over the island of cartilage crossing each other, forming the 'crossed musculoplasty'. By their contractions further adduction of the island along with its attached vocal cord is brought about, thus further improving the quality of voice.

Keywords Statico-dynamic correction · Crossed musculoplasty · Island laryngoplasty · Transmitted dynamism · Differential medialisation of the vocal cord

Introduction

For vocal cord paralysis, a couple of procedures have been described in the literature. They are mostly static corrections. For animation of the paralysed muscles of the vocal cord, attempts have been made without any useful success. So a statico-dynamic correction for the paralysed cord was conceptualized where, besides static correction (medialisation of the cord and the arytenoid), a muscle transplantation (crossed musculoplasty) has been described with a view to offering dynamism to the paralysed cord. This has not been described in the literature, to the best of my knowledge. Since offering dynamism to the paralysed vocal cord has so far been largely unsuccessful, the above approach of transmitting dynamism appears to be the nearest solution to the vexed problem of energising the paralysed vocal cord (Figs. 1, 2).

A new technique of medialization of the paralyzed vocal chord statico-dynamically for improvement of voice is described here, in one operation, such as this, both

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Fig. 1 *PTN* posterior tunnels, *POH* posterior outer holes, *PIH* posterior inner holes, *SS* stainless steel wire, *F* furrow, *SSF* stainless steel wire in furrow, *AIH* anterior inner holes, *ATN* anterior tunnels, *AOH* anterior outer holes, *SSE* stainless steel wire ends, *K* knot of the ends of wire, *I* island of cartilage, *SOH* superior outer hole, *SIN* superior inner hole, *STN* superior tunnel, *IIH* inferior inner hole, *IOH* inferior outer hole, *ITN* inferior tunnels, *SH* superior horn of thyroid cartilage, *IH* inferior horn of thyroid cartilage, *EC* endless canal

Fig. 2 *SOH* superior outer hole, *SBO* superior belly of omohyoideus, *STN* superior tunnel, *SIH* superior inner hole, *IIH* inferior inner hole, *ITN* inferior tunnel, *IOH* inferior outer hole, *IBO* inferior belly of omohyoideus, *AST* anchoring silk thread, *C* crossing of muscle bellies

arytenoids adduction and vocal chord adduction are achieved. A rectangular island of lamina of the thyroid cartilage, attached to the inner perichondrium, on the paralyzed side is created by drilling an endless canal on the lateral aspect of the thyroid lamina to the level of the inner perichondrium. The mobile cartilage island along with the

vocal chord and the arytenoids is fixed in a medialized position. Dynamism is quintessential for normal vocal chord function. For this, superiorly and inferiorly based superior and inferior bellies of the omohyoideus are passed over the island of cartilage crossing each other, forming the 'crossed musculoplasty'. By their contractions further

adduction of the island along with its attached vocal chord is brought about, thus further improving the quality of voice.

Procedure

Through a horizontal collar incision on the skin, about the middle of the larynx on the side of the paralysed vocal cord, a broad piece of perichondrium is raised, extending from the front of the thyroid lamina to 2 cm behind the midpoint of the antero-posterior dimension and from the inferior margin, superiorly based at the superior margin of the thyroid lamina. With a 3 mm cutting burr, a rectangular endless canal of about 5 mm in width is drilled around a rectangular island of the laminar cartilage, in its anterior two-thirds on the paralysed side in its middle third of the vertical dimension, half of the island above and half below the vocal cord level in the mid horizontal line (Fig. 1, I). The vertical dimension of the island is about 1 cm. The drilling is done up to the inner perichondrium without perforating it. The anterior vertical limb of the canal is placed 2–4 mm behind the thyroid angle (i.e., anterior commissure of the larynx), so that the commissural region is spared and not injured. One would do well to note that there is no perichondrium here where the commissural ligaments are attached to the cartilage directly. The posterior vertical limb of the canal is situated 1.5 cm behind the midpoint of the antero-posterior horizontal line on the middle of the lamina from the thyroid angle to the posterior border of the lamina (Fig. 1) so that the posterior part of the island overlies the arytenoid. The deeper part of the canal is broadened, by undermining the canal centrifugally, lateral to the inner perichondrium, so that quite a wide area of inner perichondrium is available for tenting it medially along with the attached vocal cord when the island of cartilage is medialised and fixed. Broader the canal is, wider would be the exposed moveable inner perichondrium with resultant more adduction of the paralysed vocal cord. Through this endless narrow canal it is very difficult to elevate, with an elevator, the inner perichondrium from the intact alar cartilage all around the canal without tearing it intralaryngeally which is meticulously avoided. At the end, drilling with a diamond burr for undermining is unlikely to perforate the perichondrium; rather drilling with it would push the perichondrium inward without perforating it. It is facilitated by drilling and undermining with the above burr, the cartilage edges around the canal exposing a larger area of inner perichondrium thereby obviating the need for elevating with an elevator which is fraught with the danger of tearing it (Fig. 1, EC), thus minimizing the chance of tearing the inner perichondrium.

In case of an accidental tear, a patch of deep cervical fascia is laid on the injured site before transplanting the omohyoid muscle. This undermining also facilitates drilling of the holes and oblique tunnels for passing the stitching material through them without injuring the inner perichondrium (Fig. 1, TN). After creating the endless canal around the island of thyroid cartilage the whole of the lateral surface of the island, excepting its posterior one-fourth, is drilled more in its anterior part than the posterior one so that the anterior part will have a thickness of about 3 mm and the posterior one about 5 mm. With a 3 mm burr a shallow linear furrow, (Fig. 1, F), horizontally disposed in the middle of the island from its anterior to posterior end, is drilled on its lateral surface for lodging the stainless steel wire (Fig. 11 F, SSF) which would prevent the latter's slipping up or down in which case the medialising effect will be jeopardised. When the tie is tightened over the island, the posterior part including the arytenoids will move medially more than the anterior part thereby preventing over-adduction of its anterior part along with the anterior part of the vocal cord in which latter case there is likely to be a post operative unduly high pitched voice (Fig. 1) like a hyperkinetic one. This differential medialisation of the anterior and posterior parts of the island would make the lax paralysed margin of the rima glottidis straighter and of equal tension throughout the whole length of the rima which is conducive to producing a better voice. After the endless canal has been created a gentle tap is imparted to the island of cartilage with a blunt instrument in order to assess if the segment moves medially. If done under local anesthesia, this manoeuvre of pushing the island medially will improve the voice when the patient is asked to phonate indicating that requisite medialisation of the cord has been achieved. The pressure is then varied till the best voice is achieved and the island is fixed in that position. To do this four holes, two each on anterior and posterior to the endless canal, are drilled through the surrounding intact alar cartilage obliquely inwards towards the deeper parts of the canal, about 3–4 mm from the margins anterior and posterior to the anterior and posterior limbs of the endless canal, respectively, till these obliquely drilled tunnels open into the endless canal near the inner perichondrium (Fig. 1, POH, PIH, AIH, AOH, ATN, PTN). Then the free ends of the stitching material (stainless steel wire) are passed through the posterior holes from outside and then tunnels and recovered through the inner holes and the endless canal and passed over the cartilage island, lodging in the furrow and then through the anterior inner holes and tunnels and finally brought out through the anterior outer holes and the two ends are twisted and tightened in a knot under pressure exerted on the island of cartilage medially which will depress the island medially (Fig. 1, SSE, K). Alternatively, if the operation is performed under general anesthesia,

about 4–6 mm medialisation is adequate. This is the static correction. Dynamism in the form of active adduction of the already medialised paralysed vocal cord during phonation is imparted by the contraction of the superiorly and inferiorly based superior and inferior bellies of the omohyoideus acting on the lateral surface of the island. To do this, the intermediate tendon of the omohyoid muscle is transected and separated from each other and the surrounding tissues thereby preserving the nerve supplies to the superior belly from the descendens hypoglossi and the inferior belly from the ansa hypoglossi, situated above and below the point of section of the muscle tendon respectively. The dynamic (contractile) muscle bellies are transplanted as follows: a wide hole, (about 8 mm) is made by drilling the alar cartilage 3 mm superior to the endless canal creating a tunnel by drilling obliquely from above downwards and medially to the innermost part of the canal adjoining the inner perichondrium at the junction of the anterior and middle thirds of the superior margin of the endless canal i.e., about the junction of the anterior and middle thirds of the vocal cord (Figs. 1, 2; SOH, SIH and STN). The drilling is made easier through the overlying intact cartilage superior to the undermined endless canal. A similar hole is made about 3 mm inferior to the lower margin of the canal at the same level viz. at the junction of the anterior and middle thirds (Figs. 1, 2; ITN, IOH and IIH). The dimension of the holes and the tunnels should be such that the cut tendons with the muscle bellies can be passed through them easily without strangulating them (Fig. 2, IBO and SBO). The ends of the cut tendons with the muscle bellies are anchored with two 2-0 silk threads. The anchoring silk of the superior belly is passed through the superior outer hole, tunnel and brought out through the superior inner hole and then passed through the inferior inner hole, the tunnel and finally brought out through the inferior outer hole. Likewise, the thread anchored to the inferior tendon and belly of the omohyoideus is passed through the inferior outer hole, the tunnel and brought out through the inferior inner hole and then through the superior inner hole, the tunnel and the superior outer hole and the anchoring silk threads are tied to each other in a knot on the lateral surface of the island (Fig. 2, AST). So the muscles will cross each other on the lateral surface of the island of the cartilage, lateral to the medialising wire in the furrow, thus creating the 'crossed musculoplasty' (Fig. 2, C). The ends of anchoring silks are finally removed.

The inner holes through which the muscle bellies pass are situated deep in the endless canal which is medial to the lateral surface of the island of cartilage and hence their contractions simultaneously would further medialise/adduct the already medialised island with the vocal cord. So when they contract, the anterior part of the island is moved medially more than the posterior part i.e., the

anterior part of the vocal cord, corresponding to the anterior part of the island, which is more important for phonation, especially high pitched voice, moves more than the posterior part of the vocal cord. This is because the crossed muscle bellies are situated at the junction of the anterior and middle thirds of the vocal cord and this differential medialisation of the anterior and posterior parts of the rima resulting from both static (medialisation of the island) and dynamic (medialisation by the contraction of the omohyoid muscle) adductions of the vocal cord more in the anterior part than the posterior one accounting for expected resultant good voice post-operatively.

Discussion

Statico-dynamic correction of the paralysed vocal cord, which is extremely dynamic in its normal functioning, is brought about by this operation. This correction is expected to offer better voice quality than only static correction by medialising the cord. Because of the specific inclination of the vocal cords, the phonetic stream has a tendency to push apart and blow off the vocal cords laterally and more so if there is a lack of active muscular contraction in them. The latter (i.e., active contraction of the transplanted omohyoideus), leads to active adduction and tensing of the cords. Static medialisation is brought about by medialising the cartilage island. The arytenoid is also medialised by the displacement of the posterior part of the island of cartilage overlying the arytenoids, thus obviating the need for additional arytenoids adduction operation. This is expected to facilitate the adduction and the gliding movements of the arytenoids medially over the cricoid. Dynamic adduction is achieved by the contraction of the superiorly and inferiorly based strap muscle (omohyoideus) which would also resist and prevent the outward blowing off of the paralysed vocal cord under the impact of positive pressure during phonation, which brings about stronger voice with satisfactory modulation when the muscle complex is adequately retrained by subsequent voice therapy. Medialisation of the island of cartilage, as described earlier [6], is likely to be inadequate since the firmly attached inner perichondrium around the island would not allow its significant medial shift. In contradistinction, the present operation of undermining centrifugally the endless canal ensures a wider exposure and freeing of larger area of the inner perichondrium with greater perichondrial medialising shift, bringing about more effective static correction. Along with this, the dynamic correction by the contraction of the transplanted muscle complex, hitherto not reported in the literature to my knowledge, is expected to offer a better voice postoperatively. The crossed muscle bellies have identical action on contraction viz. rendering the bellies situated outside the

tunnels taut with swelling of the muscle masses, consequent upon contraction, with associated minute medialisation of the cartilage/vocal cord complex, especially their anterior parts. Joint action of the crossed muscle bellies superior and inferior ones, contracting in opposite directions viz. superior belly upward and inferior belly downwards, is more effective in pushing the anterior parts of the island and vocal cord medially than the action of one belly only at a time. Equal and opposite directions of the bellies' contraction makes the muscle complex more taut. Individual action of one muscle belly alone has a tendency to tilt the island viz. superior belly will tilt the upper part of the island inward around the horizontal axis and the inferior belly, lower part inward around the same axis. This is likely to produce diplophonia/hoarseness post-operatively. So the joint action would offer a better voice since there is no tilting. With a view to avoiding possible post operative development of diplophonia/hoarseness, both the superior and inferior bellies of the omohyoideus should be transplanted instead of only one belly in which case tilting of the island of cartilage leading to development of diplophonia/hoarseness, is a possibility. In order to strike a balance between the opposing muscle actions (pro- and anti-gravity ones), transplantation of both the bellies is prescribed. It is rather impossible to offer dynamism to the paralysed vocal and other adductor and tensor muscles; but dynamism can conveniently be transmitted to the paralysed muscles and hence offering requisite adduction (both static and dynamic), as mentioned in this report, appears to be the nearest approach to the solution of the paralytic voice problem as has been done in statico-dynamic palatopharyngoplasty in rhinolalia aperta ([3]; 1984). The differential adduction of the posterior and anterior parts of the rima, brought about by the static and dynamic medialisation, respectively, keeps the rima straight and evenly tense in its entire length and so is conducive to producing a better voice quality. The voice therapy is directed towards encouraging and retraining the transplanted muscle complex and in view of this, it is started with a low pitched/low intense voice e.g., humming, since this would encourage the depressor muscles of the larynx through a lesser distance than that associated with elevation of the larynx and the movements of the inferior belly of the omohyoideus, further lowering the larynx as seen under normal circumstances while producing low pitched/low intense sounds which is associated with depression of the larynx. The rationale of the therapy lies in the following. Phonating low pitched/low intense sounds is an exercise in relaxation, pro-gravity descent of the larynx, whereas phonating high pitched/high intense sounds is a strenuous one, an exercise in exertion, anti-gravity ascent of the larynx, actively elevating the larynx, putting too much pressure on the tendons and raw transplanted muscle masses. Gradually the therapy

is imparted with loud voice of high pitch also when the larynx will automatically be elevated by the elevator muscles. Additionally this elevation would put a stretch on the transplanted lower muscle complex viz. inferior belly of the omohyoideus, its origin being inferior to the larynx, which when contracts under this stretched state will lead to stronger and more effective adduction of the paralysed vocal cord. And so, as time rolls by, the voice is expected to improve further with better functioning of the retrained muscle complex.

Conclusion

Only static medialisation of the paralysed vocal cord does not offer a very good voice postoperatively. So a statico-dynamic correction was conceptualized. A rectangular cartilage island of the thyroid lamina, at the level of the paralysed cord, is created by drilling an endless canal around the island. The island is attached to the inner laryngeal perichondrium. The island with its inner perichondrium and the vocal cord along with the arytenoids is medialised by special wiring. This static correction is reinforced by the dynamic one offered by the transplanted omohyoideus bellies at the 'crossed musculoplasty' at the junction of the anterior and middle thirds of the vocal cord. This dynamism is transmitted to the paralysed vocal cords rather than reanimating the vocal cord muscles. The present operation offers three additional positive factors over the existing ones viz. (1) The centrifugal elevation of the inner perichondrium at the deepest parts of the endless canal, provides larger areas of perichondrium available for adequate medial tenting of the same along with the attached vocal cord thus resulting in its adequate and requisite adduction. (2) The island of the cartilage is medialised by special wiring, adducting both the vocal cord and the arytenoids, and (3) The transmission of dynamism of the dynamic contractions of the omohyoid muscle bellies to the vocal cord at the junction of its anterior and middle third at the site of 'crossed musculoplasty' which appears optimal for good voice production.

Acknowledgments I am thankful to Mrs. R. Bhartia, Chief, Sitaram Bhartia Institute of Science and Research for utilizing the services of the institute and Mrs. Deepti Punj for typing and formatting the article. I am also grateful to my son, Priyanko Ghosh, for helping me with the figures.

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