

ANTECEDENTS AND PRESENT SITUATION

Speech is the main instrument of interpersonal communication and its alteration constitutes an important obstacle to social and professional life of the affected individuals. At the present time, the number of people using speech professionally is increasing. A new big mass of telephone operators has been added to the existing traditional speech professionals such as singers, teachers or sellers. A vocal injury creates great anxiety and frustration in any of them, particularly when it cannot be corrected by speech therapy and needs repairing surgery.

Most of the usual injuries which alter the phonic dynamics of the vocal fold are benign. They can be classified into main groups: acquired injuries (vocal nodules, polyps and Reinke edema) and the congenital injuries (sulcus vocalis and sub-mucosal cyst). The only ones susceptible to recede and heal with speech therapy only and therefore without the need for surgical removal are vocal nodules and incipient polyps. There is an increased demand for laryngeal microsurgery to sort out the functional, professional and socio-economical problem that the rest of these injuries generate. This bigger demand leads to an increase in the number of patients with iatrogenic injuries in need of an efficient solution to a secondary dysphonic disorder.

The existence of a vocal fold scarring is the origin of a permanent dysphonia and its solution with the present surgical techniques is quite discouraging. This lack of success is partially due to the lack of understanding of the physiopathological characteristics implicated in the formation of the scarring in the lamina propria.

Etiology of the vocal scar

The existence of a dysphonia will make us think that independently of the original cause, one of these two physiopathological events are happening in the larynx: either an interruption of the mucosal vibrating wave in all or part of both vocal folds, or the existence of a defect in the glottis closing.

From an etiopathogenic point of view there can be three reasons for dysphonia: a) The loss of anatomic regularity of the free edge of the vocal fold. B) The paralysis of one or both vocal folds, leaving a defect in the closing or glottis hiatus. c) The existence of areas with adherences and fibrosis between the covering and the ligament of the vocal fold.

Out of these three causes, the one giving more difficulty both from a diagnostic and from a treatment point of view is the existence of fibrotic scarred areas in any area of the vocal fold. When they are located in the middle third of the fold the problem becomes more relevant as this is the area with a higher vibrating capability and a wider mucosal wave. The main causes for vocal fold scarring are laryngeal external or internal traumatism, neoplasia, inflammation and most usually iatrogenia.

Surgical procedures for treatment of the vocal fold scarring

Microsurgery started developing back in the sixties with the works of *Kleinsasser* and was later firmly established during the seventies with the works of *Jako* and team, promoting the technique of *stripping* for the extirpation of a benign lesion such as Reinke's edema. This technique implies the removal of big amounts of the vocal mucosa, leaving the vocal ligament stripped or even injured, which leads in turn to the formation of ample scarring and permanent dysphonia. Other simultaneous lines of investigation were developed in the sixties and seventies aimed to the better understanding of the anatomy and physiology of the vocal fold, such as the works of *Van der Berg* and *Hirano*. The first formulated the mioelastic theory which states that interaction between the pulmonary flux and vocal fold mass and pressure produces the vibrating movement and finally the emission of larynx sound.

Hirano describes the anatomy of vocal fold and formulates the Body-Covering Theory stating that the structure of the vocal fold can be divided according to vibrating dynamics into two functional blocks: the covering (made out of the squamous epithelium and of the superficial and intermediate layers of the lamina propria) and the body (made out of the deep layer of the lamina propria and the tiroaritenoido muscle). The vocal ligament constitutes the limit between these two blocks and is made out of the intermediate and deep layers of the lamina propria. The covering is very flexible and vibrates in a passive way in response to the passing of subglottic air flux, adopting the momentary form given by the contraction of the vocal muscle. This phenomenon contributes to the variation of rigidity and therefore of the fundamental frequency of the sound produced.

Based on these anatomical and functional principles a new concept of laryngeal microsurgery denominated phonosurgery has arisen in the Nineties. Its main objective is to obtain the extirpation of vocal superficial and deep injuries great and small, conserving the vibratory function of the vocal cords and maintaining undamaged the vocal ligament. Then authors like Bouchayer and Cornut arise, that lead two fundamental techniques: close section (for injuries of the free edge) and cordotomy (for submucous injuries). But in spite of these delicate manipulations the present percentage of iatrogenic dysphonias is high, approximately a 2%. This number increases quickly if the anatomic-physiological principles of the histological structure of the vocal cord are not taken into account, mainly not injuring the vocal ligament and maintaining the undamaged body-covering structure as much as possible.

Materials used in phonosurgery

Up to the present moment, most of the investigations have centered in the search for materials and technique of insertion that obtain an increase of the volume of the cord and a reduction of the glottal defect. Of among the many investigated materials, those that have offered better results are the autologous, specially crushed fat and muscular fascia. Both materials are introduced in the vocal cord by means of direct, medial injection to the vocal muscle, in the subepithelial, or, lateral space to the vocal muscle. The main disadvantage of this technique is that both materials are easily reabsorbed within months and only obtain an increase of volume without achieving the recovery of the vibratory mucous wave.

Therefore, the experience as far as increase of volume of the vocal cords is ample but, nevertheless, there is little experience with respect to the correction of the defects of vibration produced by iatrogenic scars, specially when a solution of continuity of the mucosa and the vocal ligament exists, which is the case in which the dysphonia is more severe and produces more professional problems in the patient.

Therefore, to solve the iatrogenic scar dysphonias in a more functional and permanent way we consider the need to find a technique and material that obtains the following objectives: a) a regularization of the free edge of the vocal cord; b) a complete glottal closing; c) a tissue integration in the structure of layers of the vocal cord; d) a recovery of the propagation of the mucous wave in the repaired zone; and, e) an effective vocal emission and of good quality.

This project has been designed with the aim to obtain these objectives. A relatively simple technique is developed in which we propose to interpose a free insert between the layers of the vocal cord or the remaining of them. The insert must be of a material that is: a) Autologous. b) Easy to obtain. c) With low energy requirements of its cellular elements, to allow its viability when inserting it in monolayer form. d) With the sufficient flexibility and malleability, so that its handling and connecting to the mucous defect is easy. e) With the sufficient firmness to be able to be sutured with reabsorbable stitches and to avoid its displacement. f) With the sufficient consistency, so that its volume remains without changes and the thickness of the cord does not change with time.

According to reviewed Literature and to the experience in our center, we thought that the material that reunites all these requirements is autologous muscular fascia. Its use in other surgical fields is very ample, especially in head and neck, with an emphasis in the surgery of the ear, where its use has been totally accepted for a long time and has demonstrated its viability even in situations of chronic infection. Since this material until now has been only used in the larynx with the purpose of increasing the volume of the vocal cord by means of intracordal injection and previous crushing, we think that a line of investigation should be developed that demonstrates its effectiveness in the repair of iatrogenic scar injuries using it as free insert in monolayer form.

With the present project we try to contribute to solution the problem of the closing defect and lack of vibration of the vocal cord motivated by the interruption of the continuity of the vocal ligament by means of the positioning of autologous fascia. The attainment of these objectives would provide more data in favor of the spreading and consolidation of an easy technique, using a material easy to obtain without rejection problems to solve a problem more and more frequent and with a great personal and social repercussion.

DESIGN AND DISTRIBUTION OF THE GROUPS

The 20 subjects distributed in 4 groups with 5 animals each one. The groups are the following ones: a) Group I: subjects with normal larynx on which any laryngeal intervention is not made. It corresponds to the healthy controls. b) Group II: subjects with iatrogenic injury of the vocal cord which is not repaired. This is the pathological control group. c) Group III: subjects with iatrogenic injury of the vocal cord which is later surgically corrected with intracordal autologous fat injection. They are the surgical controls. d) Group IV: subjects with iatrogenic injury of the vocal cord which is corrected later surgically with free insert of autologous fascia. They are the study subjects.

The performances that were made on each subject of each group are the detailed ones next in chronological order.

Group I (healthy controls)

- General anesthesia and visualization of the glottis by means of direct laryngoscopy. Objectives: To verify the morphologic normality of the vocal cords with optical microscope and photographic documentation of the normal glottis.
- Sacrifice, dissection and extraction of the larynx (according to the method described below).
- Transport of the larynx to the voice laboratory.
- In vitro study of the larynx in the Laboratory consisting of: Producing the artificial vibration of the vocal cords and obtaining the glottal sound; recording of the mucous vibration by means of videoestroboscopy; collection of the laryngeal sound produced to the vibration of the vocal cords and collection of the measures of subglottal pressure threshold.
- Acoustic analysis of the previously recorded laryngeal sound.
- Anatomopathological study of the normal vocal cords.

Group II (pathological controls)

- General anesthesia and visualization of the glottis by means of direct laryngoscopy. Objectives: to verify the morphologic normality of the vocal cords with optical microscope; production of a iatrogenic injury in the right vocal cord, according to the method described below.
- Pathologic study of the extracted tissue sample.
- Maintenance in animal home for 6 weeks.
- Second general anesthesia and direct laryngoscopy. Objectives: iconographic documentation of the injured cord; sacrifice, dissection and extraction of the larynx.
- Transport of the larynx to the Laboratory of Voice
- Study in vitro of the larynx in the Voice Laboratory: to produce the artificial vibration of the vocal cords and obtaining of the glottal sound; recording of the mucous vibration by means of strobolaryngoscopy; collection of the laryngeal sound produced by the vibration of the vocal cords and collection of the measures of subglottal pressure threshold.
- Acoustic analysis of the recorded signal.
- Anatomopathological study of the five injured and not repaired vocal cords.

Group III (surgical controls)

- General anesthesia and visualization of the glottis by means of direct laryngoscopy. Objectives: to verify the morphologic normality of the vocal cords with optical microscope and the production of a iatrogenic injury in the right vocal cord.
- Anatomopathological study of the extracted tissue fragment.
- Maintenance in animal home 6 weeks.
- Second general anesthesia and direct laryngoscopy. Objectives: iconographic documentation of the injured cord; repair of the iatrogenic injury by means of autologous fat injection, according to the technique described below.
- Maintenance in animal home for 6 weeks.
- Third general anesthesia and direct laryngoscopy. Objectives: iconographic documentation of the cord repaired with grease infiltration; sacrifice, dissection and extraction of the larynx.
- Transport of the larynx to the Voice Laboratory.
- In-vitro study of the larynx in the voice laboratory consisting of: producing the artificial vibration of the vocal cords and obtaining the glottal sound, recording of the mucous vibration by means of strobolaryngoscopy, d) collection of the laryngeal sound produced by the vibration of the vocal cords, collection of the measures of subglottal pressure threshold. Acoustic analysis of the recorded signal. Anatomopathological study of the five injured and repaired vocal cords with grease infiltration.

Group IV (subject of study)

- General anesthesia and visualization of the glottis by means of direct laryngoscopy. Objectives: to verify the morphologic normality of the vocal cords with optical microscope, to produce of a iatrogenic injury in the right vocal cord. Anatomopathological study of the extracted tissue sample.
- Maintenance in animal home for 6 weeks.
- Second general anesthesia and direct laryngoscopy. Objectives: iconographic documentation of the cord injured, repair of the iatrogenic injury by means of autóloga interposition of free graft of fascia, according to the described technique next. Maintenance in animal home for 6 weeks
- Third general anesthesia and direct laryngoscopy. Objectives: iconographic documentation of the cord repaired with autóloga free graft of fascia, sacrifice, dissection and extraction of the larynx
- Transport of the larynx to the Voice Laboratory
- In-vitro study of the larynx in the voice laboratory consisting of: producing an artificial vibration of the vocal cords and obtaining of the glottal sound, recording of the mucous vibration by means of videoestroboscopy, collection of the laryngeal sound produced by the vibration of the vocal cords, collection of the measures of subglottal pressure threshold.
- Acoustic analysis of the recorded signal. Anatomopathological study of the five injured and repaired vocal cords by means of autologous interposition of free insert of fascia.

CONCLUSIONS

1. The canine experimental model has been valid for the accomplishment of recovery studies of the laryngeal function after iatrogenic injury.
2. The free autologous insert of fascia allows to recover the structure and flexibility of the vocal cord and to obtain a useful mucous wave.

3. Comparing the technique of insertion of free autologous insert of fascia with the autologous fat infiltration, it obtains both a better recovery of the mucous wave and a better glottal closing.
4. Comparing the technique of insertion of free autologous insert of fascia with the autologous fat infiltration, it obtains better results in the following parameters of the acoustic analysis: base frequency, relation overtone-noise and subglottal pressure during the phase of opening.
5. The surgical technique of autologous insertion of free insert of fascia is useful for the correction of iatrogenic scar injuries of the vocal cord.