Resorbable Plate for Reconstruction in Cases of Laryngeal Trauma

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The management of laryngeal trauma represents one of the most challenging problems for an ENT surgeon. The alternatives vary from a "wait and see" approach to extensive and immediate reconstructive interventions, but in all cases the risk of laryngeal stenosis remains high. This translates into a poor quality of life for the patients and increased costs for the health system. The use of a resorbable plate for the reconstruction of the affected cricoid has the advantages of requiring a single intervention and enabling the patient to return to his normal activities in a shorter period of time. It is why we present this method of approach, which can be a viable alternative in managing these difficult cases.

Key words: cricoid, resorbable plate, reconstructive surgery

The most common causes for laryngeal trauma include external trauma, intubation injury or prolonged intubation, foreign bodies or chemical toxins. The symptoms may vary from voice disorders and coughing to respiratory obstruction or even death [1]. The correct management of the patient is crucial from the first moments.

The first step consists of life support measures. Once a patent air way has been established and the patient is stable, the laryngeal trauma must be assessed. This requires both an endoscopic and an imagistic evaluation [2]. A fiberoptic nasal endoscopy is the first investigation we must perform, as it is non-invasive and it allows the surgeon to properly evaluate the patency of the airway. A CT examination represents a necessary step in the evaluation of the extension of the lesion [3, but an MRI may show better the damage of soft tissues, when available.

Once the patient has been completely evaluated, the decision of performing a surgical intervention or not must be assessed [4]. This must take into account the extension of the lesions. In order to have a common system of evaluation, several systems of classification are in use. One of the most commonly encountered is the Schaefer-Fuhrman classification of laryngeal trauma (table 1).

Another specific situation is that of patients with posttraumatic laryngeal stenosis, which require surgery in order to avoid permanent tracheostomy. Once the stenosis is constituted, the options vary from endoscopic interventions to an open approach with reconstruction.

In all cases, the surgical approach is an elaborate one, with no universally accepted standard. Each intervention is *custom tailored* according to the lesion and the state of the patient [5]. In such cases, all options must be taken into account.

Table 1
THE SCHAEFER-FUHRMAN CLASSIFICATION OF LARYNGEAL TRAUMA

Group 1	Minor endolaryngeal hematomas or lacerations No detectable fracture
Group 2	Edema, hematoma, minor mucosal disruption without exposed cartilage Nondisplaced fracture Varying degrees of airway compromise
Group 3	Massive edema, large mucosal lacerations, exposed cartilage Displaced fracture(s) Vocal cord immobility
Group 4	Same as group 3, but more severe with: -severe mucosal disruption -disruption of the anterior commissure -unstable fracture, two or more fracture lines
Group 5	Complete laryngotracheal separation

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Experimental part

In the management of patients with laryngeal trauma, or even stenosis, the purpose is to obtain a clear airway with minimum comorbidities for the patient. Of course, a tracheostomy is the fastest way and may be required in a state of emergency. But once the patient is stable, reconstructive surgery is the gold standard. In this way, the patient obtains a normal quality of life, with perfect reintegration in the social and working environment.

We propose an innovative method of reconstruction, using a resorbable plate with screws made of the same material. Preferably, this can be used as a primary intervention, but if needed, it is available for cases of secondary reconstruction as well.

The plate consists of a horizontal segment and a vertical triangular one, which will be fixed onto the first tracheal rings.

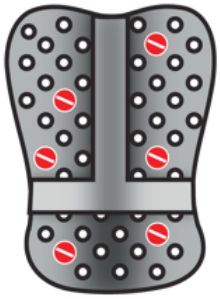

Fig. 1. The resorbable plate

This offers stability to the laryngotracheal structure following reconstruction. The screws which fix the plate and the fractured segments into position are made of the same material.

An intraoperative endoscopic examination is mandatory in order to evaluate the position of the screws. These must be placed in a position in which do not harm the vocal folds.

We considered absorbable materials to be the best option, considering the multiple advantages. The patient will not develop any long term complications caused by foreign bodies and no secondary intervention for extraction will be needed. The absorbable materials we considered are polylactic [6] and polyglycolic acid [7].

The polylactic acid is an off-white semi-crystalline polymer, that has a boiling temperature of 174-184^0 C. It transforms into translucent products at 57^0 C. Two forms may be found. The poly L lactic acid (PLLA) consists only of the L-isomer of lactic acid, while the steriopolymer form contains also the D-isomer of lactic acid and is called poly D,L lactic acid (PDLLA). The material is hydrophobic and resistant to hydrolysis due to the presence of a methyl radical.

Still we consider that the polyglycolic acid is the best choice of material we can use to manufacture the reconstructive resorbable plate. It is a dark brown polymer with high consistency crystals. The melting point is at 224-228^0 C, but it turns transparent at about 36^0 C. The rate of degradation is faster then that of the polylactic acid, due to it's hydrophilic nature.

These materials will undergo biodegradation in a variable period of time. First water molecules will invade the polymer lysig links, then macrophages will cause a phagocytosis process of the polymer fragments. The resulting products will consist of lactic acid and glycolic acid, which will be in turn metabolized to water and carbon dioxide, which will be excreted thru urine and breath.

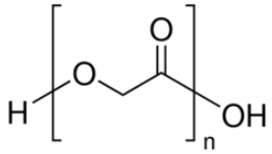

Fig. 2. The chemical formula of the polyglycolic acid

There is a significant difference in the resorbtion time of the two materials, due to the hydrophilic nature of the polyglycolic acid. It will loose it's mechanical properties in about 6 weeks and it will be completely absorbed in 3-12 months, unlike the polylactic acid, that retains it's mechanical properties for about 48 weeks and will be completely absorbed in 5-7years after surgery.

The material may not resist to a force higher then 200 N, but considering the dynamics of the laryngeal region, we do not consider this to be a problem. The implant will not be subject to higher forces, not even during swallowing or when rotating the head.

The materials will be melted and cast into a mold, which will allow us to obtain a device of the desired shape. This will be rigid, and if ribbing is added, it will have mechanical properties similar to those of metal. Absorbable screws will be made of the same material, but the device in which they will be poured will the possibility of compressing the material, thus adding increased rigidity.

Before using it, the device must be dived into a heated bath of water at the temperature of 70^0 C for 10 s, which will make the material malleable for about 10-15 s. The surgeon must use this time to curve the device into the desired shape, according to the curvature of the patient's cricoid and thyroid cartilage. Afterwards, the device will become rigid again.

The approach is according to each specific case. The intervention consists of a cervical incision, which exposes the damaged cricoid and the first tracheal rings. The thyroid lobes must be ligated and the isthmus sectioned, in order to obtain access to the area. If we are dealing with a primary intervention, first the debris of soft tissue or the foreign bodies must be removed. After achieving perfect hemostasis and evaluating the damage, if possible, the fractured fragments must be placed in their anatomical position. Afterwards, these fragments must be fixed in their position using the resorbable plate and self-tapping microscrews of 1.5 mm made of the same material. Using the same screws, the structure is anchored to the trachea, thus rendering the complex stable.

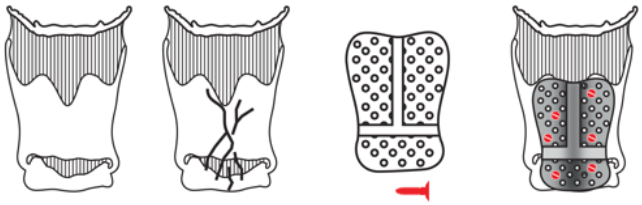

Fig. 3. The reconstruction using the resorbable plate and screws

Tissue adhesives will help seal the structure. Afterwards, the fascia and the muscular structures are sutured and the natural anatomical structure is rebuilt. As the reconstructed complex is stable and the normal anatomical structure has been regained, we do not consider necessary the use of an intra-tracheal mentor. The intervention requires tracheostomy, but after the edema disappears and the wound heals properly, this may be closed in about 6 weeks. Repeated endoscopic examinations and effort tests will show the patency of the airway.

The same type of intervention may be performed for patients who underwent emergency tracheostomy. In cases where we are dealing with extensive soft tissue damage, we may consider a vascularized sterno-cleidomastoid flap in order to cover the reconstruction area.

If needed, this may be harvested with skin at the distal end as well. The superior pedicle from the occipital artery ensures the viability of the flap.

Results and discussions

The original method of using a resorbable device in the treatment of cricoid and thyroid fractures ensures a good quality and lasting reconstruction. The desired final position of the fractured fragments will be obtained from the first intervention, which means the patient will have to wear a tracheostomy tube for a shorter period. The reconstruction is stable due to the fixation provided by the resorbable screws.

One of the main advantages of this device is that in can be use in children as well, due to it's resorbable properties. The polyglycolic acid is suitable in such cases, due to it's fast resorption. In such cases the normal growth process will not be affected thanks to the fast disparition of the device.

In adults or in cases of extensive trauma that requires more time to properly heal, we recommend the the use of polylactic acid, which has a prolonged time of resorption. In this way, the complex is maintained in a fixed position for a longer time, allowing the fractured fragments to become perfectly stable.

Conclusions

The management of laryngeal trauma remains a challenge for the ENT surgeon, and great improvement may be obtained due to the technological advancements. The resorbable device we propose shows promising results in selected cases, where the structures may be reconstructed per primam.

Repeated fiber optic exam are mandatory in order to evaluate the integrity and the movement of the vocal fold.

The main advantages include a good fixation of the fractured fragments in a shorter time then that required for suturing the fragments. Also, if the screws are properly placed under tension, no further displacement of the fragments can occur. The fact that all the materials are resorbable means that this method may be used for children as well, without affecting the normal growth of the segment. Also in adults, no second intervention for the extraction of the device will be needed. The device will degrade to water and CO_2, substances that are normally eliminated from the body with no side effects.

One of the disadvantages of this method may be the short time in which the device is malleable. Also, the surgeon will need a period time in order to adjust to the use of this device. However, the time of the reconstructive surgery will be significantly shortened.

The use of this device offers a viable option in the management of laryngeal trauma, more specifically when we are dealing with a damaged cricoid or thyroid cartilage. The reconstruction of the damaged area per primam, the shorter time in which the patient requires a tracheostomy, the decreased time of surgery and general anesthesia and the fast reintegration translate into a better quality of life for the patient in terms of good functional results. For all of these reasons we consider the use of the resorbable plate to be a good option, at least in selected cases, with the possibility of expanding the indication after further research.

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