**Titanium Mesh as a Titanium Bridge alternative for Isshiki Thyroplasty Type 2**

Sixteen (16) figures; One (1) table

**Abstract**

**Objectives:**

**General:** To demonstrate the utility of the conventional titanium cranimaxillofacial mesh as an alternative to standard titanium bridge for thyroplasty type II.

**Specific:**

To be able to assess the effectivity of using titanium mesh as an alternative to thyroplasty bridge for thyroplasty type II using the validated voice handicap index and PRAAT voice analysis software

**Study Design:** Instrumental Innovation

**Setting:** Tertiary Government hospital

**Participant:** Patient seen at the ENT-HNS outpatient department diagnosed with spasmodic dysphonia for Isshiki Thyroplasty type II.

**Results:** Post-operative evaluation of patient’s voice after using titanium mesh plates as titanium bridge for Isshiki thyroplasty type 2 can provide marked improvement on its voice acoustic parameters such as jitter, shimmer, harmonics to noise ratio and fundamental frequency . Thus marked improvement in his voice. The customized thyroplasty mesh was comparable to the standard Isshiki thyroplasty bridge.

**Conclusion:**

Titanium mesh is a good and effective alternative for thyroplasty titanium bridge. Customized thyroplasty bridge using titanium mesh are comparable to expensive thyroplasty titanium bridge used in Isshiki’s thyroplasty type II as evidenced by the validated Filipino voice handicap index and PRAAT voice analysis software. Titanium mesh can be a good alternative for type 2 thyroplasty in the absence of the standard titanium bridge.

**Keywords: spastic dysphonia, thyroplasty, titanium, surgical mesh**

Thyroplasty Type II is a standard procedure for patients with spasmodic dysphonia. Such requires the use of standard titanium bridge which is only available in Japan and is relatively expensive.

Management of spasmodic dysphonia is directed at the relief of vocal spasm. Patient may be managed medically and given botulinum toxin injections however it requires repeated injections after 3 to 4 months due to its temporary effect1. Another option for the management of Spasmodic Dysphonia is Surgery. Surgical management would offer a more immediate and more permanent result compared to medical and botox injection. Current surgical management for Spasmodic Dysphonia would include laryngeal nerve sectioning, thyroarytenoid myectomy and Isshiki Thyroplasty Type 22.

Among the surgical management options, Isshiki Thyroplasty Type 2 proved to be very effective for SD patients 3. It provides an immediate, more permanent improvement of the voice and is reversible3 This techinique is a surgical method innovated by Ishikki provides a long term relief of the symptoms of spasmodic dysphonia3. It’s principle is to release the tightness of the vocal cords during adduction by separating the the thyroid cartilage and creating a more relaxed anterior glottal gap4. The separated incised thyroid cartilage would be maintained using a surgical keel. In the past, several materials such as cartilage, rig graft, silicone have been used as a keel to maintain the interthyroidal cartilage space of the incised thyroid cartilage2. At present, a specially fabricated titanium bridge is being used to maintain the inter-thyroidal cartilage gap . However, the thyroplasty titanium bridge is currently available only in Japan and is relatively expensive2.

 Therefore, it is the aim of this paper to present an alternative thyroplasty bridge for Ishikki thyroplasty type II using locally available medically grade titanium mesh. With this, Phonosurgeons would be able to customize the thyroplasty bridge per patient’s need.

**CASE REPORT**

A 27 year old, male sought consult in our institution due to dysphonia characterized as shaky with involuntary phonatory breaks associated with sensation of strangulation and exhaustion after speaking long phrases. Patient consulted an ENT specialist wherein he was managed as a case of spasmodic dysphonia and underwent botolinum toxin injection which provided temporary relief of symptoms of spasmodic dysphonia. Due to persistence of dysphonia, patient sought consult in our institution and was advised to undergo Isshiki’s Thyroplasty Type 2 for spasmodic dysphonia.

**METHODOLOGY** (**Figure 1**. )

**Materials**

A. Craniomaxillofacial Titanium mesh

 B. Caliper

C. Titanium Bender

D. Thyroid Cartilage Spreader

E. Hand piece drill

F. Thyroid cartilage elevator

G.Tissue Hook Retractors

H.Voice Analysis Machine (PRAAT Software)

**Procedure**

1. **Pre-operative Evaluation**

 Patient was subjected to basic physical head and neck examination, laryngoscopy endoscopy, complete blood count and chest xray. Patient’s voice was evaluated using the Filipino Voice handicap index developed and validated by Umali and Hernandez et. al, in 2006 (**Figure 2**.) and PRAAT Voice analysis software (**Figure 3**. ).

 **B. Surgical Technique**

Surgery was performed in the operating room under local anesthesia. Patient was placed on a supine position with the neck extended **(Figure 4).** Several landmarks such as thyroid prominence, cricoid and anterior border of the sternocleidomastoid muscle were identified and marked. A 4 cm curvilinear at mid thyroid cartilage level was marked **(Figure 5 ).** Infiltration of local anesthesia was done. Sterile water, lidocaine and epinephrine was used as local anesthetic with the dilution of 10:10:0.1. Cross hatched markings were then placed on the lines of incision. Incision was then made up to the sub-platysmal level . Superior flap was developed up to the level of the hyoid followed by the development of the inferior flap up to the level of the cricoid cartilage (**Figure 6**). Anterior strap muscles were then exposed and dissected. Anterior Strap muscles were separated in the midline and were lateralized using tissue hook retractor. Thyroid cartilage was then exposed and dimensions were measured and recorded **(Figure 7 ).** A vertical midline incision on the thyroid cartilage was done using a surgical blade and a hand-piece motor with a fine tip drill **(Figure 8 ).** The thyroid cartilage was then separated with a thyroid cartilage spreader.

**Intra-Operative Voice Calibration**

 The ideal inter-thyroidal cartilage gap was determined based on the patient’s voice which was assessed subjectively and objectively intra-operatively. Subjective evaluation was done by asking the patient to phonate while the thyroid cartilage was being separated. Patient was asked to say the vowels “e” and “a” for 10 seconds and recite the numbers 1-10. The inter-thyroidal gap was noted on the best voice that the patient has produced. Regression of phonatory breaks were noted during patients phonation as well as the regression in the sensation of strangulation. Patient’s voice was also recorded intra-operatively and analyzed with PRAAT software. Based on the Intra-operative Voice Calibration. The ideal inter-thyroidal gap for this patient was at 3.5mm.

**Titanium Bridge Preparation**

A 2 x 4 titanium mesh plate measuring 30 x 14mm was used for this case. The titanium mesh was now carefuly folded using hand bender pliers to fit the required inter-thyroidal gap for the patient **(Figure 9 ).**

 **Titanium Bridge Placement**

The customized titanium bridge was then anchored to the thyroid cartilage using a 2-O nylon suture placed on the superior and inferior edge of the plates **(Figure 10 )**.

After final evaluation of patient’s voice the surgical site was closed layer by layer. Strap muscles were re-approximated and sutured. Subcutaneous layer was closed with Vicryl 3.O suture and the skin was closed with 3.O nylon suture **(Figure 11 )**. Sterile strip was then applied to incision site. Patient was returned to the room and regular diet was resumed. Patient was instructed to refrain from talking, whispering nor shouting for one week.

**Post-operative Voice Evaluation**

Immediately after surgery patient’s voice was evaluated using Voice Handicap Index and PRAAT Voice Analysis. Endoscopic evaluation of the patient’s vocal cords was also done. Patient was observed for 24 hours and was then discharged. He was instructed to come back after 5 days for the removal of suture and for a one week postoperative voice evaluation.

**RESULTS AND DISCUSSION**

The Isshiki Thyroplasty 2 provides an immediate, more permanent improvement of voice3. It is a simple procedure that aims to relieve the tightness of vocal cords during adduction by lateralizing the true vocal cords during separation of thyroid cartilage3.

In the past, silicone was utilized as a keel for thyroplasty type 2 procedures however, external muscular forces are strong making the final outcome unstable, hence the use of titanium bridge sutured directly to the cartilage was developed2. In addition, titanium has been used in other parts of the body wherein no reactive side effects are reported hence making titanium a safe implant material for thyroplasty type 2. In an Isshiki Thyroplasty Type 2 surgical technique two titanium bridges were placed one below and one above the level of anterior commissure to maintain the separation of thyroid cartilages2. Each titanium bridge was fixed to the cartilage with sutures of 4-0 nylon thread. This techniqe provides optimal glottal closure and can be adjusted and readjusted. There is also no damage to the physiologic function and it is reversible2. However, Isshiki Thyroplasty Titanium bridge (**Figure 12 )** is currently available only in Japan and is relatively expensive therefore locally available titanium mesh plates was used in this study. In our patient, a 2 x 4 titanium mesh plates measuring 30 x 14 mm was used. The titanium mesh was carefuly folded using hand bender pliers to fit the required inter-thyroidal gap for the patient. Nylon 3.O suture was used to secure the plates.

In Isshiki’s thyroplasty 2 technique, two titanium bridges were placed at the superior and inferior of the thyroid cartilage. However in this study, we only used one titanium bridge supporting the whole vertical length of the thyroid cartilage from superior and inferior .

**Voice Evaluation**

Assesment of voice was done pre, intra and post-operatively with the help of a licensed speech pathologist. Subjective voice assessment was done by using the validated Filipino Voice Handicap Index by *Umali and Hernandez* **(Figure 2)** while objective measurement was done using the PRAAT voice analysis software **(Figure 3).**

**A. Subjective Voice Evaluation**

The validated Filipino Voice Handicap Index is a self-administered 30-item questionnaire that determines the functional, physical and emotional impact of voice disorders (**Figure 2**). The physical subscale items included statements representing self-perceptions of laryngeal discomfort and voice output characteristics5,6. Functional subscale items described the impact of a person’s voice disorders on daily activities. Emotional subscale items consisted of statements representing patient’s affective response to voice disorders5,6. This tool has been used to assess effectiveness of voice rehabilitation, medical and surgical treatment5,6. The total assessment of handicap is measured by obtaining the mean of the scores on all 30 statements, which is the total VHI score. A score of 0-30 is a low score and indicates a minimal amount of handicap associated with the voice disorder5,6. A score of 31-60 indicates a moderate amount of handicap due to dysphonia. A score of 61-120 represents a significant and serious amount of handicap due to dysphonia5,6 .

For the subjective voice evaluation, our patient answered the VHI questionnaire pre-operatively and 24 hours post-operatively. The pre-operatively VHI score of our patient is 49 indicating a moderate amount of handicap due to dysphonia. 24-hours postoperatively, patient scored 15 indicating minimal amount of handicap due to dysphonia. Patient also noted that there was improvement from symptoms such as strangulation, difficulty of breathing and exhaustion from speaking long phrases.

1. **Objective Voice Evaluation**

PRAAT is a computer software created by Paul Boersma and David Weenink of the Institution of Phonetics Sciences of the University of Amsterdam7 (**Figure 3** ). This software is used for analysis of speech in phonetics. It evaluates voice acoustic parameters such as jitter, shimmer, harmonics to noise ratio and fundamental frequency7. Measurements of these parameters has been proven to be useful in describing the vocal characteristics. These parameters are very important in measuring the severity of a Spasmodic Dysphonia.

Jitter is defined as the parameter of frequecy variation from cycle to cycle while shimmer relates to amplitude variation of the sound wave7. It is affected by lack of control of vibration of the cords hence the voices of the patients with pathologies often have a higher percentage of jitter7. Literatures consider 0.5 to 1% jitter for sustained phonation as normal8. Results showed that the vocal jitters of patient improved from 9.34 % (**Figure 13)** to 0.553 % postoperatively (**Figure15**). This indicates that there is control of vibration of the vocal cords.

The shimmer changes with reduction of glottal resistance and mass lesions on the vocal cords and is correlated with the presence of breathiness9. It is considered pathological if the shimmer is less than 3% for adults and around 0.4 to 1% for children9. Vocal shimmer is within normal range preoperatively and postoperatively from 17.649% to 8.717 % (**Figure 13,15**).

Harmonic to noise ratio (HNR) is the assesment of the ratio between periodic components and non periodic component comprising a segment of voiced speech10. The first component arises from the vibration of the vocal cords and the second follows from the glottal noise expressed in dB10. This reflects efficiency of speech. A voice sound characterized by a high HNR is associated with sonorant and harmonic vocie. A low HNR denotes an asthenic voice and dysphonia8. A value less than 7 dB in HNR is considered pathological8. The patient’s HNR noted to increase from 2.063 dB preoperatively to 11.740 dB postoperatively which is indicative of a more sonorant and harmonic voice(**Figure 13,15**).

Pitch is defined as the number of times a sound wave is produced by the vocal cords and the number of cycles of opening and closing of the glottis8. The mean pitch of 386.49 Hz preoperatively (**Figure 13,14**) to 190.16 Hz postoperatively which is more ideal for males. This indicates less sensation of strangulation and tension during phonation (**15,16**).

Post-operative evaluation of patient’s voice proved that there was marked improvement on its voice acoustic parameters such as jitter, shimmer, harmonics to noise ratio and fundamental frequency . Subjectively, there was marked improvement the voice such as decreased voice breaks and voice effort.

**CONCLUSION**

In this research, we conclude that a customized titanium mesh may be used as an alternative to Isshiki thyroplasty type 2 titanium bridge to effectively treat patients with Spasmodic Dysphonia surgically. There was marked improvement on patient’s Voice Handicap Index and voice acoustic parameters such as jitter, shimmer, harmonics to noise ratio and fundamental frequency hence proving the effectivity of using titanium mesh as an alternative to thyroplasty bridge for thyroplasty type II.

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**References:**

1. Blitzer. Cummings Otolaryngology Head and Neck Surgery, 6th edition
2. Sanuki T, Yumoto E Long-term evaluation of Type 2 thyroplasty with titanium bridges for Adductor Spasmodic Dysphonia. Americal Otolaryngology-Head and Neck Surgery. 2017
3. Isshiki. Thyroplasty for adductor spasmodic dysphonia: further experiences. Laryngoscope. 1983; 93:1-8
4. Sanuki. Overall Evaluation of Effectiveness of Type II Thyroplasty for Adductor Spasmodic dysphonia. Laryngoscope*.* 2009
5. Hernadez, M, Lim, A., Llanes E.,Measurement of Handicap of Dysohonic patients using the Filipino Voice Handicap Index, Philippine Journal of Otolaryngology-Head and Neck Surgery, June 2010
6. Jacobson BH, Johnson A et al. The voice handicap index (VHI): development and validation. Am J Speech Lang Pathol. 1997; 6:66-70
7. Zwetsch et al., Digital signal processing in the differential diagnosis of benign larynx diseases, Porto Alegre, 2006
8. Teixeira, Vocal acoustic analysis-Jitter, Shimmer and HNR Parameters, Procedia Technology 9, 2013
9. Guimaraes, I. A Ciencia e Arte da Voz Humana. Escola Superior de Saude de Alcoitao, 2007
10. Murphy. Cepstrum-Based Estimation of the Harmonics to noise ratio for synthesized and Human Voice Signals. In nonlinear Analyses and algorithms for Speech Processing, Barcelona, LNAI 3817, Springer, 2005
11. Hyodo M. Nationwide survey of spasmodic dysphonia in Japan. Japan Journal of Logopedics and Phoniartrics. 2016
12. Schweinfurth JM, Billante M, Courey MS. Risk factors and demographics in patients with spasmodic dysphonia. Laryngoscope*.* 2002 Feb. 112(2):220-3

**Table 1. COMPARISON using Titanium Mesh versus Isshiki’s Titanium bridge**

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| --- | --- | --- |
|  | **TITANIUM MESH** | **ISSHIKI’S TITANIUM BRIDGE** |
| **Cost** | P 75,000 | P 160,000-170,000 |
| **Availability** | Available locally | Available only in Japan |
| **Surgical time** | 2 1/2 hours | 1 hour |
| **Hospital stay** | 1 day | 1 day |