

## Abstract

**Objectives:** The most devastating complication of cricotracheal resection (CTR) is anastomotic dehiscence. Post-operative management in our institution included the use of a modified Minerva cervical-thoracic orthosis (MMCTO). To date there has been no analysis of the risks and benefits of the brace's use following CTR. We aim to analyse this with our retrospective study.

**Study Design:** Retrospective review.

**Methods:** A search with the keywords "cricotracheal resection" and "laryngotracheal reconstruction" was performed in Electronic Medical Record Search Engine to identify the patients retrospectively. The statistical package for social sciences was used.

**Results:** There were 18 males and 13 females with a median age of 3.5 years. Almost 2/3 had release performed. Post-operatively, 20 had Grillo stitch and MMCTO for a mean of 7 days. Most (n=20) had no complications. The most common complications were agitation due to the discomfort of the brace, and skin irritation or break down. The single most devastating complication was a stroke.

**Conclusions:** Our novel modification of the brace is a useful adjunct in the post-operative management. However, it is important to be aware of these complications in order to prevent them.

## Introduction

- Subglottic stenosis (SGS) can lead to significant airway insufficiency.
- Surgical management include tracheostomy, endoscopic dilation, hot or cold incision, and open surgery with expansion (laryngotracheal reconstruction (LTR) with costal cartilage grafts), resection (cricotracheal resection (CTR) or tracheal resection (TR), or slide tracheoplasty.
- Excessive tension of the anastomosis following CTR and TR may cause anastomotic dehiscence. These surgeries are technically challenging, and are not first line treatments in pediatric patients.
- To ensure success of the surgery, a Grillo stitch is placed for one week to maintain neck flexion after the resection. However, the stitch does not prevent lateral movements of the neck, and it may irritate the skin, or rupture with neck extension.
- To prevent anastomotic dehiscence, various orthotic devices have been used to maintain neck flexion.
- Our modified Minerva cervical-thoracic orthosis (MMCTO) has been tailored to maintain middle and lower cervical spine flexion while keeping the upper cervical spine extended.
- Our retrospective study aims to analyze its use and complications following CTR and TR.

## Methods

- A search with the keywords "cricotracheal resection" and "laryngotracheal reconstruction" was performed in the Electronic Medical Record Search Engine (EMERSE).
- 66 patients fitting these criteria were identified since EMERSE was used in our institution from 1992 to 2016.
- 35 of these patients had either a Grillo Stitch or MMCTO in place following their operation.
- Patients' age at operation, gender, grade of stenosis, type of surgery, the use of Grillo stitch and MMCTO, length of time used, and complications associated with the MMCTO were gathered.
- The statistical package for social sciences (SPSS) was used for the descriptive analysis. Paired samples T test, chi squared and Fisher's exact tests were used with a p<0.05 considered significant.

## Results

- 28 patients were included in the study: We excluded two patients who had their procedure at an outside institution as there was insufficient information and were unlikely to have used our MMCTO, and another one who used the Aspen collar.
- The median age was 4 years (range: 2 months to 60 years), with 15 males and 13 females.

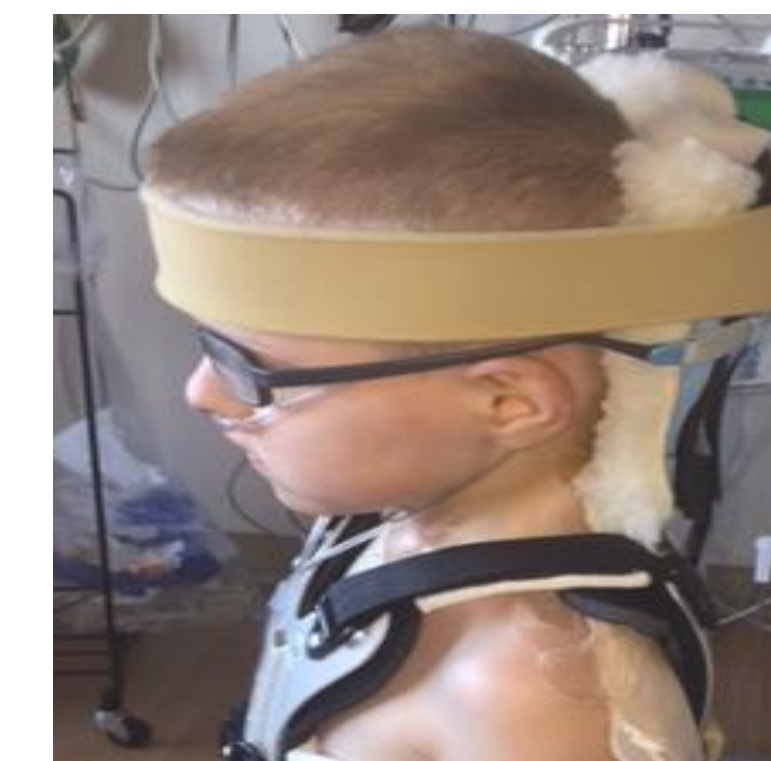
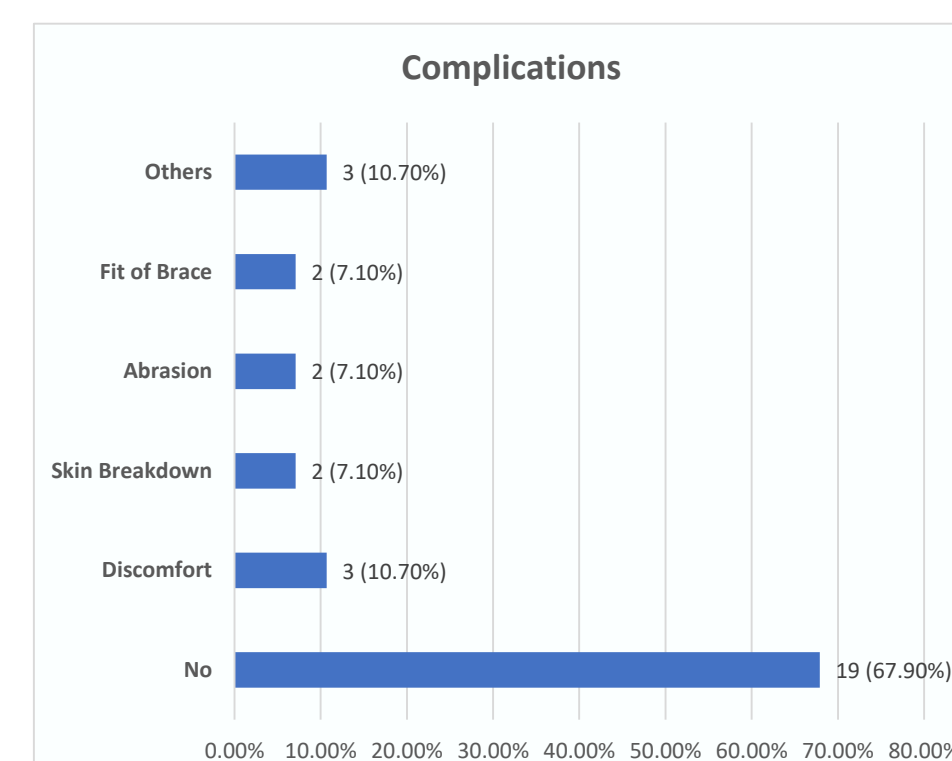
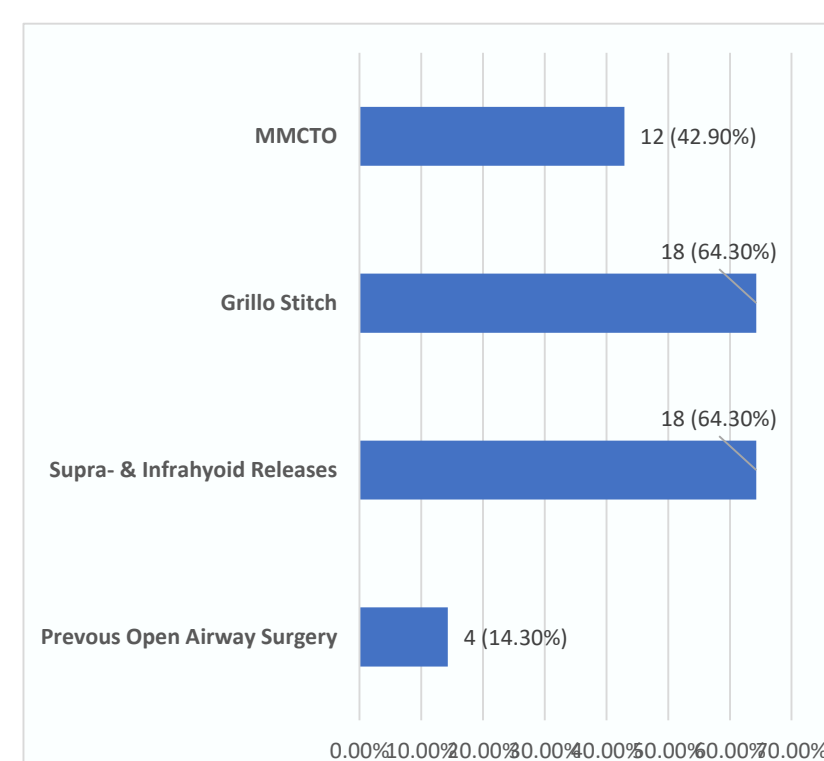
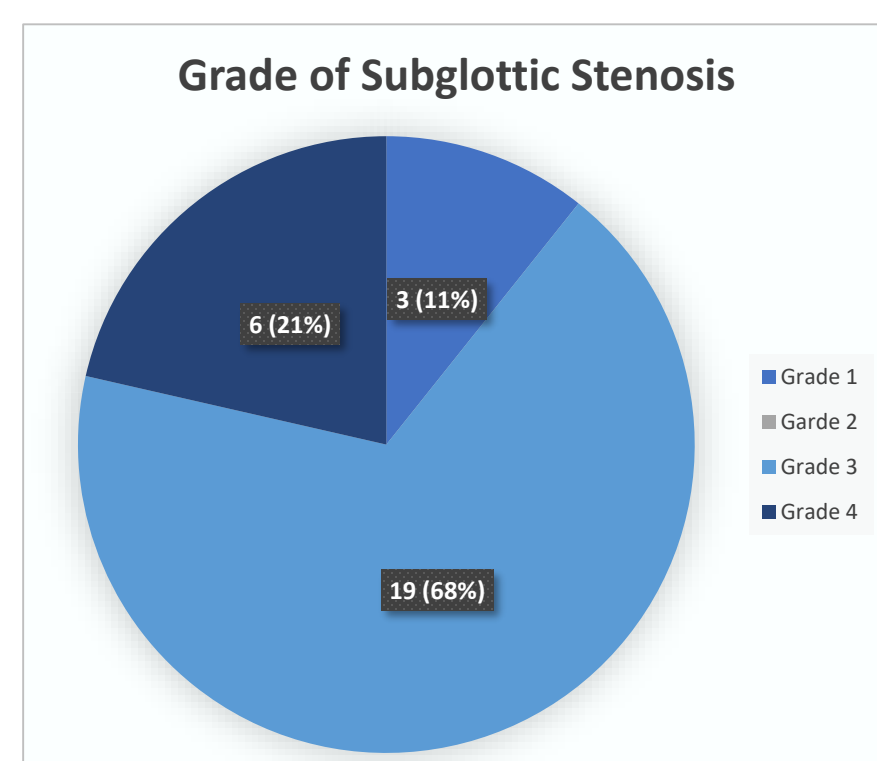


Figure 1: Padding placed behind the occipital portion of the MMCTO.

- The median time in situ for Grillo stitch is 7 days (range: 0-12 days), and MMCTO is 7 days (range: 0-16 days). 12 (42.9%) had both Grillo stitch and MMCTO in place.
- Younger age was significantly correlated with the presence of complications (t(27)=3.64, p=0.001). Gender was significantly correlated with the presence of complications (Fisher's p=0.016). There were 8 males with complications compared to one female. However, our sample size is small and this needs to be interpreted with caution. The presence of brace use (Fisher's p=0.003) and length of time the brace was used (t(27)=5.37, p=0.000) were also significantly correlated with the presence of complication, as was the length in time the stitch was present (t(27)=6.53, p=0.000). In addition, the grade of stenosis was also significantly correlated with the presence of complications (t(27)=-13.89, p=0.000).

## Conclusions

- The MMCTO maintains flexion of the cervical spine to reduce tension on the anastomosis following TR and CTR. It controls motion through the adjustable occipital support and headband strap, which prevent neck mobility and allow for custom fitting.
- Additionally, the modular components allow for the angle of cervical flexion and length of the orthosis to be changed. The open design permits examination of wounds and sutures, so that healthcare providers may assess the healing process.
- The rigidity of an orthosis against bony prominences can lead to pressure ulcers. Only one patient developed an occipital pressure sore (stage 1), which formed 9 days after the MMCTO was fitted. The superficial nature of the sore resulted in no complications.
- Pressure sore development was prevented by utilizing foam padding (figure 1) underneath the brace and the usage of soft straps, intensive monitoring and regular nursing assessment and care.
- As for agitation due to the discomfort of the brace, they took place after the initial period following extubation. It may be in part due to withdrawal of sedatives, or due to confusion following a prolonged period of sedation. It resolved within 4 days.
- Issues regarding the fit of the brace occurred in two patients. One patient's cranial strap was not fitted properly, resulting in "buckling" motions. A new MMCTO was then fitted three days later with a better fitting cranial band to discourage extension with the buckling motion. The second patient had his cranial strap bow down to his eyes, but this was promptly resolved. In another, skin abrasions appeared superficially on the right forehead and right chest, but both completely healed in two weeks.
- The rarest and most devastating complication of a stroke due to the neck flexion occurred in one of our patients.
- Cervical manipulation has been linked to occasional spinal ischemia. These ischemic events are often random, and difficult to predict. Our patient was noted to have no voluntary movements in addition to minimal respiratory efforts despite being weaned off sedation. It is uncertain if this occurred intra- or post-operatively as he was sedated the entire time. Whether the injury occurred solely as a result of the position in the orthosis is difficult to determine.
- Difficulty with pulmonary toileting occurred in only one patient. However, this was not directly due to the brace itself, but rather due to the sedation resulting in atelectasis and increased pulmonary secretions.
- Other orthoses were described to maintain cervical flexion post-operatively: the Halo orthosis, Aspen collar, Philadelphia brace, and Shiraz brace. Each of these reduced sagittal plane translation during flexion and extension, but the Minerva and Halo have been found to inhibit neck movements more efficiently.
- We prefer our modified Minerva design over the more invasive Halo brace as it allowed for a greater ease of adjustment while also circumventing issues associated with halo pins, such as loosening, infections, and cerebral spinal fluid leaks.
- The challenge in this series is that the patients are sedated, so they are unable to give feedback on pain or discomfort. It is crucial that the care team monitor the fit of the orthosis throughout the entire course of the wear, not just the initial fitting. Patients can shift in bed due to various procedures, pressure relief, etc.
- Proper positioning of the orthosis is crucial to ensure the contours of the plastic line up with the anatomical structures to avoid complications.

## Discussion

- The MMCTO may be used to control cervical position following CTR and TR to ensure that disruption of the post-operative anastomosis does not occur. In our series, most patients had no or minor complications and it is a preferred alternative to other orthoses. However, it is important to be aware of these complications in order to prevent them.

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