A safe and cosmetic method of removing the sternum by bone forceps for mediastinal dissection of recurrent thyroid cancer

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Abstract
Introduction
Thyroid cancer frequently recurs in the superior or anterior mediastinum. Midline sternotomy is usually performed in order to dissect recurrent mediastinal cancers, but there is a high risk of haemorrhage that can result from unintentionally cutting the brachiocephalic veins adhering to the sternum. A safe and minimally invasive method is thus required for the treatment of recurrent thyroid cancer in the mediastinum. The objective of this study was to evaluate a novel method of removing the sternum by bone forceps for mediastinal dissection to determine its safety, aesthetic outcome and duration of hospitalisation, as compared with conventional reversed T-shaped sternotomy.

Materials and methods
A collar skin incision was made followed by the removal of the sternum by bone forceps. As a result, soft tissues, including the sternothyroid muscle, behind the sternum were exposed and cut, allowing the surgeon a clear area in which to observe great vessels in the mediastinum. Mediastinal dissection could then be performed safely because of the clear view afforded when retracting the brachiocephalic veins. After dissection, many pieces of the sternum were grafted back to the sternum and were subsequently covered with vascularised muscle tissue. Twenty-one patients with recurrent thyroid carcinoma underwent this procedure between 2005 and 2010. The control group consisted of 12 patients treated by conventional methods between 2002 and 2004. The difference between the two groups was tested using Student’s t-test and Mann–Whitney test; p values <0.05 were considered to indicate significance.

Results and Discussion
The mean time for removal of the sternum was 11 min (9–15 min). After the sternum was removed, brachiocephalic veins could be clearly observed in the soft tissue. Mediastinal dissection could be performed safely because of the clear view provided, and it did not result in any complications. The mean blood loss for the new method group and that for the control group was 185 ml (35–530) and 278 ml (55–687), respectively. The mean surgical time for the new method group and the control group was 3 h 5 min and 3 h 58 min, respectively. The mean duration of hospitalisation for the new method group and the control group was 8.5 days (7–19) and 12.9 days (8–23), respectively. These three key areas of comparison were significantly different between the two groups. Patients were highly satisfied with the post-operative aesthetic results. This method is effective for the dissection of the central compartment rather than the lateral compartment.

Conclusion
This novel method of removing the sternum by bone forceps is more effective than the conventional method for mediastinal dissection of recurrent thyroid cancer in terms of safety, aesthetic outcome and duration of hospitalisation.

Introduction
Thyroid tumour frequently invades the superior or anterior mediastinum. In recurrent cases, large vessels closest behind the sternum frequently adhere to the sternum. Midline sternotomy is usually performed to dissect recurrent mediastinal cancers; however, the high risk of haemorrhage that can result from unintentionally cutting the brachiocephalic veins adhering to the sternum can cause great anxiety to the surgeon. These tumours occasionally occur in young female patients who may suffer severe scarring as a result of conventional midline sternotomy. Thus, a safe and minimally invasive method of operating is required for the treatment of recurrent thyroid cancer in the mediastinum.

Objective
To evaluate a novel method of removing the sternum by bone forceps for mediastinal dissection in terms of its safety, aesthetic outcomes and duration of hospitalisation, when compared with conventional midline sternotomy.

Materials and methods
A collar skin incision was made and the anterior thorax flap was elevated. It was followed by the removal of the sternum, without vertical skin incision, using three types of bone forceps for orthopedics (Mizuho, Japan). As a result, soft tissues, including the sternothyroid muscle, located behind the sternum were exposed and cut, allowing the surgeon a clear view of the great vessels in the mediastinum (Figure 1). Mediastinal...
Materials and methods (Cont.)

Figure 1: Method of removing the sternum. Pre-operative CT shows anterior mediastinum lymph nodes metastasis (arrow) (a). After a collar skin incision along the previous horizontal scar was made, the anterior thorax flap was elevated from the sternum. The area removed from the sternum was 29 mm in width and 31 mm in length (b).

dissection could then be performed safely because of the clear view afforded when retracting the brachiocephalic veins. After dissection, many pieces of the sternal bone were successfully grafted back to the sternum and were subsequently covered with vascularised muscle tissue (Figure 2a).

Twenty-one patients with recurrent thyroid carcinoma underwent this procedure between 2005 and 2010. The control group consisted of 12 patients with recurrence treated by means of reversed T-shaped sternotomy (conventional method) between 2002 and 2004. The number of repeated surgeries in the new method group was two, three and four in twelve, six and three patients, respectively, and, in the control group, it was two and three in ten and two patients, respectively. There were no differences between the two groups in median age, gender, number of surgeries and duration of surgeries; only the median follow-up periods were different. In recurrent laryngeal reconstruction, recurrent laryngeal nerves (RLNs) were Anastomosed vagal nerves or ansa cervicalis. In tracheal reconstruction, periosteum or tendons of the sternocleidomastoid muscles were used in the two groups. All the surgeries were performed by the same head and neck surgeon. The differences between the two groups’ surgical time, length of hospitalisation and blood loss were tested using Student’s t-test and Mann–Whitney test; p values <0.05 were considered to indicate significance.

Results

The mean time for removal of the sternum was 11 min (9–15 min). After the sternum was removed, the brachiocephalic veins located in the soft tissue could be clearly observed. Mediastinal dissection could then be performed safely as the surgeon had a clear view, which consequently resulted in no complications. The mean blood loss for the new method group and the control group was 185 ml (35–530) and 278 ml (55–687), respectively. The blood loss of the control group mainly resulted from bleeding from bone marrow, the periosteum behind the sternum and large vessels. The mean surgical time for the new method group and the control group was 3 h 5 min and 3 h 58 min, respectively. The mean duration of hospitalisation for the new method group and the control group was 8.5 days (7–19)
and 12.9 days (8–23), respectively. These three key areas of comparison were significantly different between the two groups (Table 1). The patients were highly satisfied with the post-operative aesthetic outcomes (Figure 2b).

The mean area removed from the sternum was 30 mm (27–35) in width and 34 mm (30–37) in length. The area of the sternum or clavicle that needed to be removed was determined based on the extent of tumour invasion. This substantial operating window enabled the surgeon to observe metastatic tumours more directly and manoeuvre surgical instruments more easily (Figure 2). This method was effective for the dissection of the central compartment rather than the lateral compartment.

Once a year, fluorodeoxyglucose positron emission tomography (FDG-PET) is performed to check patients for recurrent or distant metastasis. The FDG-PET study allowed us to determine that many pieces of grafted bone were alive within the based sternal bone in all the patients who underwent this procedure (Figure 3). Currently, all the patients are alive with no evidence of disease and are able to consume food daily as they were able to before surgery.

**Discussion**

Many post-operative complications, such as post-operative pain, cosmetic results and period of hospital stay, were experienced and described by the patients.

**Table 1**

<table>
<thead>
<tr>
<th>Patient characteristics</th>
<th>New method</th>
<th>Conventional method</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median age</td>
<td>72 (28–86)</td>
<td>71 (32–83)</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>No. of recurrent thyroid cancer cases</td>
<td>21</td>
<td>12</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Gender M/F</td>
<td>12:9</td>
<td>7:6</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Median follow-up (M)</td>
<td>36</td>
<td>96</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Surgical method</td>
<td></td>
<td></td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>1. Mediastinal dissection</td>
<td>12</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>2. Mediastinal dissection, reconstruction of RLN</td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>3. Mediastinal dissection, reconstruction of trachea</td>
<td>5</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Surgical time</td>
<td>3 h and 5 min</td>
<td>3 h and 58 min</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Blood loss (ml)</td>
<td>185 (35–530)</td>
<td>278 (55–687)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>No. of surgeries</td>
<td>2/3/4 = 12/6/3</td>
<td>2/3/4 = 10/2/0</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Duration of hospitalisation (days)</td>
<td>8.5</td>
<td>12.9</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>No. of removed nodes</td>
<td>16.8 (4–28)</td>
<td>18.4 (4–32)</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>No. of positive nodes</td>
<td>4.98 (3–16)</td>
<td>5.58 (1–18)</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Area of sternum removed</td>
<td>width: 30 mm (27–35), length: 34 mm (30–37)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 3**: FDG-PET post-operative appearance after a year. The FDG-PET study showed that many pieces of the grafted bone in the sternum were alive.
Discussion (Cont.)

patients. In sternum complications, median sternotomy is the standard procedure for removing mediastinal tumours. In total median sternotomy, the sternum is divided from the manubrium in a procedure called the xiphoid process. However, this procedure results in an extensive and unattractive vertical surgical scar, which may lead to infection and can cause persistent pain. Limited sternotomy such as the reversed T-shaped sternotomy is less invasive and is carried out to resect upper anterior mediastinal tumours. The reversed T-shaped sternotomy provides a wider surgical space than the L-shaped sternotomy, but unifying the upper and lower sternum is difficult, especially if the transverse division is done through the intercostal space.

To limit the extent of the surgical scar on the anterior thorax skin, Bellows et al. reported the use of a low U-shaped skin incision combined with a J-shaped upper mini-sternotomy. In this procedure, the surgical scar was covered with cloths, and the cosmetic appearance was more attractive than the conventional vertical scar. However, the U-shaped skin scar in the anterior thorax skin was still far more obvious than the collar incision in the neck.

To reduce these complications, we devised a minimally invasive technique that combines a novel, cosmetically safe skin incision that allows for removing the sternum by bone forceps and consequently provides superior exposure of the upper or anterior mediastinum.

The most important merit of this technique is that it reduces surgical complications such as cutting brachiocephalic veins adhering to the sternum in recurrent cases (Figures 4 and 5). It also provides excellent access and therein facilitates the complete removal of the tumour and the avoidance of post-operative pain, while producing superior cosmetic results.

Another advantage of this method is that the sternum or clavicle is transected according to the extent of tumour invasion. This allows for safe mediastinal dissection because of the clear view and also prevents complications.

Reduced hospital stays and the avoidance of major morbidity suggest that this method is a safe and feasible surgical option in the treatment of upper or anterior tumours, including thyroid cancer.

Figure 4: Operative findings. Due to extensive scarring from three previous dissections, the neck and anterior thorax had ugly post-operative appearance (a and b). Brachiocephalic veins adhered to the sternum firmly (arrows) (c).

Figure 5: CT findings. CT shows that the large vessels closest behind the sternum adhered to the sternum in recurrent cases (arrow). This resulted in a lack of space behind the sternum.

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Discussion (Cont.)

Concerning the incidence of disease associated with recurrent thyroid cancer, Machens et al.⁶ reported that in patients with recurrent thyroid cancer, morbidity was increased due to extensive scarring from previous dissections, entailing a substantial risk notably for the RLNs. It is important to point out that residual tumours, located in close proximity, may encroach on the trachea and RLNs, thereby causing significant morbidity with a substantial decrease in the quality of life. Unfortunately, no results of repeated mediastinal lymph-node dissection after previous sternotomy have appeared in the literature to date.

To reduce the morbidity that can result from median sternotomy, transcervical blind mediastinal dissection is also performed to treat thyroid cancer invading the upper mediastinum. However, the transcervical mediastinal dissection offers little exposure of the area and, therefore, entails the risk of the operation not being as comprehensive as required.⁶ Furthermore, in recurrent cases, most pre-operative localising studies with computed tomography (CT) and magnetic resonance imaging fail to accurately detect residual tumours, as many of the lymph nodes involved are well below the detection limit.⁷,⁸ Niederle et al.⁶ recommended partial median sternotomy as a better approach oncologically than the transcervical approach.

Cosmetic problems associated with the resulting vertical surgical scar are often attributed to keloid formations on the vertical skin incision.⁹,¹⁰ To avoid an extensive vertical surgical scar, a submammary horizontal skin incision was developed by Bédard et al. as a cosmetic approach.¹¹ However, Tatebe et al.¹² reported that this submammary horizontal incision was not generally acceptable due to severe deretration. They developed the limited vertical skin incision for median sternotomy in young women and reported that the surgical scars were less noticeable and did not impede surgical manoeuvres. However, it is difficult to perform upper mediastinal dissection for thyroid cancer using this procedure due to the distance from the skin incision. We developed a skin flap elevation of anterior thorax after a collar incision and removed the sternum by bone forceps under clear exposure. Our novel method resulted in no vertical scar or deformity to the sternum. As a result of our new procedure, all patients were highly satisfied with the post-operative aesthetic outcomes.

Conclusion

This novel method of removing the sternum by bone forceps is more effective than the conventional methods for mediastinal dissection of recurrent thyroid cancer in terms of safety, aesthetic outcome and the duration of hospitalisation required.

Acknowledgements

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References