Tips for Successful Microvascular Abdominal Flap Breast Reconstruction Utilizing the “Total Rib Preservation” Technique for Internal Mammary Vessel Exposure

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Introduction: The internal mammary vessels (IMVs) are increasingly the recipients for free flap breast reconstruction (FFBR). Access traditionally entails removing a segment of the third costal cartilage. Despite excellent exposure, some authors have reported localized tenderness as well as a thoracic contour deformity. We introduced the “total rib preservation” technique for IMV exposure after specific request by a patient, and have used it for all subsequent reconstructions.

Methods: All patients who underwent FFBR with rib preservation by a single surgeon in the year beginning June 2008 were studied prospectively. Intraoperative measurements of the inter-rib space available for microvascular anastomosis were taken. Operative details and flap outcomes were compared with a cohort of earlier patients who underwent rib sacrifice.

Results: Over a 12-month period, 42 FFBRs in 37 patients (36 DIEPs, 5 muscle-sparing TRAMs, and 1 SIEA flap) were performed by a single operator. All flap transfers were successful. In the first 4 patients, the interspace between the third and fourth ribs was used; but for all subsequent patients the second and third rib interspace was used. The average distance between adjacent ribs was 21.3 mm (range, 9–28 mm) and the vessel preparation time decreased from an average of 93 to 49 minutes (first and last 5 cases). There was no significant difference in mean ischemia time between the rib preservation and the rib sacrifice groups (104.4 vs. 103.6 minutes).

Conclusions: The total rib preservation method of IMV exposure is a viable, reproducible, and reliable option for microvascular breast reconstruction. It does not increase warm ischemia, which suggests time taken for anastomosis is not affected by rib preservation. There is a learning curve and care has to be taken to avoid possible pitfalls. We recommend the use of a higher rib interspace than originally described because of the greater vessel calibre, superior vessel exposure, and therefore, easier anastomosis.

Key Words: rib-preservation, internal mammary vessels, microvascular breast reconstruction, costal cartilage, recipient site morbidity, prospective assessment

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Under loupe magnification, resection of the intercostal muscles (with or without perichondrium) is started in the inferolateral corner and advanced medially. The muscle excision to the sternal edge is performed slowly looking for the vessels (identified by perivascular fat) and carefully ligating vessel branches. Using the operating microscope, the internal mammary artery and vein are then separated from the underlying pleura and from each other. Papaverine and warm saline-soaked swabs are then applied to encourage vasodilatation. The artery and the vein are clipped individually and then divided underneath the third rib. Microvascular anastomoses are then performed in the standard fashion.

All the anastomoses were performed end-to-end with 9/0 nylon; continuous for the vein and interrupted for the artery, except for 1 case in which a venous coupler was used. This was on loan, but subsequent funding for this was not approved at our institution.

**Statistical Analysis**

Significance was determined using the following statistical tests: χ² test, 2-tailed unpaired t test, Mann-Whitney U test, Pearson correlation (Microsoft Excel and Interactive Statistical Calculation Pages (available at: http://statpages.org/), P < 0.05.

**RESULTS**

Over the 12-month period (June 2008–June 2009), 37 patients underwent 42 abdominal FFBRs by the senior author (C.M.M.), using the total rib-preservation technique to access the IMVs. Their mean age was 51 years (range, 34–64). The first 4 patients had perichondrectomy of the third and fourth ribs and the next 33 patients (38 reconstructions) underwent IMV exposure via the second and third rib interspace because of better access. Five bilateral reconstructions each had bilateral rib preservation. The timing of the reconstructions was immediate in 24 patients (29 flaps) and delayed in 13 patients (13 flaps). The flaps used were 36 DIEPs, 5 muscle-sparing II TRAMs, and 1 SIEA flap.

The time taken for vessel dissection was 63 ± 23 minutes (mean ± standard deviation) (Table 1). For the sake of consist-

**TABLE 1. Comparison of Operative Details and Outcomes in Patients Undergoing Abdominal Free Flap Breast Reconstruction With and Without Rib Preservation**

<table>
<thead>
<tr>
<th></th>
<th>Rib Preservation</th>
<th>Standard Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. patients (flaps)</td>
<td>37 (42)</td>
<td>24 (30)</td>
</tr>
<tr>
<td>Mean age (range)</td>
<td>51 (29–64)</td>
<td>46 (21–62)</td>
</tr>
<tr>
<td>Mean BMI (mean ± SD)</td>
<td>29.3 ± 6.7</td>
<td>28.3 ± 5.4</td>
</tr>
<tr>
<td>Immediate:delayed</td>
<td>29:13</td>
<td>25:5</td>
</tr>
<tr>
<td>IMV Dissection time (mean, range)</td>
<td>63 (25–106)</td>
<td>Not recorded</td>
</tr>
<tr>
<td>Warm ischaemia time (mean ± SD)</td>
<td>104.4 ± 13.9</td>
<td>103.6 ± 33.2</td>
</tr>
<tr>
<td>Flap success rate</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Flap partial necrosis</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Recipient site morbidity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Localised tenderness/pain</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Contour deformity</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Expanding haematoma</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

*An expanding haematoma on day 5 postoperatively following therapeutic heparinisation for a suspected stroke. This was the only re-exploration in the 2 year period. BMI indicates body mass index; SD, standard deviation; IMV, internal mammary vessels.

**FIGURE 1.** Rib interspace measured at the level of the internal mammary artery. Three measurements were taken by the operating surgeons and then an average calculated. This was to eliminate parallax error.
tency, we started timing when the plastic surgeon began to operate on the patient’s chest. This included time taken to excise the mastectomy scar and raise the skin flaps in delayed reconstructions, and also bringing in/setting up the microscope for final preparation of the vessels.

The mean time for the first 5 cases was 93 ± 19 minutes compared with 49 ± 12 minutes for the most recent 5 cases (t test, \( P = 0.004 \)). The mean distance between the 2 adjacent ribs was 21.6 mm (range, 9–28 mm). The second patient in the series had a very narrow interspace that was too tight for microvascular anastomoses so a small amount of cartilage was excised from the third rib to optimize access. This was not required in any of the subsequent cases.

The mean ischemia time was 104.4 ± 13.9 minutes (mean ± standard deviation) (range, 76–141 minutes) compared with 103.6 ± 33.2 minutes (range, 55–228 minutes) in the rib sacrifice group. This difference was not significant (Mann-Whitney \( U \) test, \( P = 0.69 \)).

It was significantly more common to use 1 vein in the rib-sparing patients compared with previously (Fig. 2). There was no statistical correlation between inter-rib distance and time taken for the vessel dissection or the warm ischemia time (Figs. 3, 4).

All flaps were successful, and there were no partial flap failures or fat necrosis (Table 1). There was a re-exploration for hematoma while 3 arterial anastomoses were revised on-table for occlusion or excessive leakage. All 3 revisions were easily accomplished without resorting to removal of the second rib. Additionally, a vein graft was employed (from the SIEV) in a patient in whom we felt the DIEP flap had borderline venous adequacy at the end of surgery.

None of the patients in the rib-preservation group have so far (maximum follow-up = 18 months) complained of pain at this site or noticed a contour deformity. No chest wall deformity has been obvious on examination or on postoperative photographs (Figs. 5, 6).

**DISCUSSION**

*Why Rib Preservation?*

We began using the rib-preserving technique to access the IMVs after a specific request by a patient, who was fearful of the prospect of losing part of a rib. Other authors have described complications of rib resection such as a chest wall contour deformity or increased postoperative pain as motivation for developing rib-sparing techniques. However, in our clinical experience, these problems were not previously perceived to be major issues.

This technique may be safer than harvesting a rib because the vessels may adhere to the back of the rib and be damaged when the costal cartilage is dissected free from the perichondrium. It is easy to teach because no specialized instruments are required (such as pig-tail rib dissectors).

**Technical Tips**

*Use the Second Intercostal Space*

After the first 4 cases, we switched to the space cranial to the third rib principally because the third to fourth interspace provided less access for anastomoses. In the second–third interspace, we found the diameter of both vessels to be larger and the veins usually united. Caudal to the third rib there were usually small veins prior to their confluence (though some may prefer this to allow venous anastomoses). These findings have also been independently observed.
reported by Chang’s group.⁴⁹ We therefore now use this space preferentially.

Keep the Muscle (± Perichondrial) Excision to Medial 2 to 3 cm

The extensive dissection originally described³² is unnecessary because the vessels are located within 3 cm of the sternum; the lateral vein lies within 24 mm of the lateral border of the sternum.³ Because there is no perivascular fat, lateral dissection endangers the pleura unnecessarily.

Transfix the Vein Caudally (if Possible)

Because the vein confluence may be under the third rib³,⁴⁷,⁵⁰ injudicious clip application may lead to bleeding in an inaccessible location. We therefore preferred to transfix the IM vein at the caudal end (ie, just underneath the third rib).

Judicious Resection of the Costal Cartilage to Optimize Exposure and Facilitate Anastomosis

If access is difficult the available space can be increased by resection of up to 1/2 of the circumference of the third costal cartilage using a bone rongeur.³²,⁴⁹ This still preserves the integrity of the rib and its contour. Although Sacks and Chang have reported using this in up to a third of their cases,⁴⁹ we have never had to do this when using the second ICS. It may be helpful when adopting this technique and is made easier by performing a partial perichondriectomy when excising the intercostal muscles.

Conversion to Rib Sacrifice

Although this has been suggested for postradiation cases or in cases of suboptimal access, we have not found this necessary.³² It is thought that the vessels underneath the ribs are somewhat “protected” from radiotherapy and therefore less friable. All our delayed reconstructions were postradiation; subjectively, we found no difference in terms of the quality of the vessels. This may be related to the different radiotherapy regimens in the United Kingdom and the United States.⁵¹

Keep the Intercostal Nerve Above the Vessels

Resist the temptation to transpose the vessels above the nerve as the vein may become kinked over the nerve. Preserve the nerve if possible (rather than dividing it) to retain some medial exposure.
Native breast skin sensation. Additionally, preservation of the intercostal nerve may prevent some of the chest wall discomfort described by some patients postoperatively.

**Loose Approximation of Pectoralis Muscle Split**

After successful anastomosis, loosely approximate the split pectoralis muscle. We have not found this to constrict our vascular pedicle. This maneuver may in fact give the vessels some support and prevent kinking in a similar manner to the use of autologous fat grafts recently described by Bar Meir et al.52

**Standard Anastomotic Suture Technique**

We have found that a double Acland clamp can be easily rotated in the space (during anastomosis of the front and back walls of the vessels) without undue tension, twisting, or damage of the vessels. We would encourage surgeons to use whatever suture method they feel most comfortable with. We successfully used a vein coupler in one case.39

**Use Long-Handled Microvascular Instruments**

A total of 210 mm length instruments (S&T, Neuhauen, Switzerland) facilitated the IMV dissection and anastomosis. Use of visibility background material (Fig. 7) not only provided contrast but also helped to elevate the vessels so that the anastomoses be done more superficially. This elevation is more important in patients with thick ribs in whom the vessels lie in a “deep” hole.

**Disadvantages of Total Rib Preservation for IMV Access**

1. It is undeniable that the space available with rib sparing access is less than if costal cartilage has been resected. The relatively tight space for microvascular anastomosis: is not insurmountable by experienced microvascular surgeons. As mentioned earlier, we found the use of long-handled microsurgical instruments and a visibility background helped mitigate against this.

2. There is a learning curve before becoming comfortable with this approach as illustrated by the decreasing dissection time with increased experience. This is however short; probably just a few cases for surgeons used to routinely performing anastomosis to the IMVs.

3. In the eventuality of a flap failure, it might be difficult to expose the IMVs any higher in the chest to anastomose another free flap. In that case, we would probably use the thoracodorsal vessels. However, in our unit’s experience, no patient with a flap failure has opted for a second reconstruction with a free flap; all have had pedicled latissimus dorsi flap reconstructions.

**Reducing Morbidity in FFBR**

Since breast reconstruction with TRAM flaps was described by Hartrampf in 1982,53 there has been a stepwise reduction in donor site morbidity. This has been achieved by progression from pedicled to free flaps, then to muscle-sparing and lastly perforator-based flaps.8,34–37,43,44 Similarly, progression from rib-resection to rib-sparing techniques represents the next step in reduction of free flap morbidity, this time at the recipient site, whether achieved in the manner we describe, with endoscopic/robotic techniques46 or by anastomosis to a perforator.34–37,39,43,44

We believe that anastomosis to the IMVs with total rib-preservation is more reliable than anastomosis to a perforator because the vessels are larger, have increased flow and are consistently present; whereas the internal mammary perforators are not always present, may be small or may have been damaged by diathermy. In our experience, the perforators go to spasm more often and the vein is more prone to clotting. Rib preservation in our hands was as reliable as but requires less invasive surgical dissection than rib sacrifice.

Additionally, subjectively, there seems to be a reduction in the pain reported by the patients.57 This is not surprising because the pain experienced postoperatively is thought to be related to rib resection58 or to damage to the intercostal nerves at the time of vessel harvest.27,59,60 We are currently evaluating the analgesia requirements in patients with rib-sacrifice versus those with rib-preservation breast reconstructions in an attempt to quantify any difference in postoperative pain.

It is difficult to evaluate the effect on the chest wall contour—which is related to many other factors such as how the flap inset is performed, whether the patient has had any postoperative radiotherapy, whether there is any fat necrosis and whether or not the reconstruction is immediate.

Although this is not a novel technique having been described by Parrett et al in March 2008 our successful adoption 2 months later shows that this technique can be successfully reproduced by independent surgeons and confirms that it is reliable and safe. Although we started using the technique after a rather unusual patient request, we have developed the technique further. We are able to highlight particular technical points to make the process easier for other microvascular surgeons interested in switching to rib-preservation. In particular, we present an important modification of the original technique, ie, the exclusive use of the second intercostal space (between the second and third costal cartilages) rather than the third interspace as originally described.

**CONCLUSION**

In this single-operator series, it has been confirmed that total rib-preservation is a safe alternative to rib-resection for IMV exposure. It is reliable and reproducible and led to successful FFBR without increasing ischemic time or complications (when compared with rib sacrifice). It subjectively minimized local recipient site pain. We recommend the use of this technique of rib-preservation to access the IMVs in the second ICS for FFBR.

**REFERENCES**


AUTHOR QUERIES

AUTHOR PLEASE ANSWER ALL QUERIES

AQ1—Please check whether the author name “Michele Di Candia” is appropriate as typeset.

AQ2—Please expand DIEP, TRAM, and SIEA at their first occurrences in the abstract as well as in text.

AQ3—Please expand SIEV.

AQ4—Please expand IM.

AQ5—Please expand ICS.

AQ6—Please note that references have been renumbered to ensure sequential order.

AQ7—Please cite Ref. 56 at an appropriate place in the text.

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