Modification of the Nuss Procedure: The Single-incision Technique

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Summary: The Nuss procedure is a prevalent minimally invasive surgery for pectus excavatum. Although the Nuss procedure has the advantage of leaving less obtrusive scars, the standard technique requires at least 3 skin incisions to insert several instruments. We experienced 7 cases of the modified Nuss procedure using a single incision during a 7-year period. To facilitate passing of the bar, a traction guide was created according to our unique method. There was no need for a bar stabilizer, and no severe intraoperative complications occurred. All patients exhibited satisfactory short-term results; however, 1 patient suffered from bar rotation and required repeat surgery for fixation. Two patients underwent bar removal via the same single incision without any difficulties. (Plast Reconstr Surg Glob Open 2014;2:e256; doi: 10.1097/GOX.0000000000000225; Published online 21 October 2014.)

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ince first described by Nuss et al1 in 1998, various modifications have been described to improve its safety,2–4 and further modifications for cosmetic improvement are required.

The standard Nuss procedure uses at least 3 skin incisions to insert several instruments. Although efforts to decrease the number of incisions have been reported,5,6 there remains significant room for debate and improvement. We herein report our experience with a modified Nuss procedure using a single incision.

METHODS

Study Population

A retrospective analysis was performed in 7 patients treated with the single-incision Nuss procedure for pectus excavatum during a 7-year period (2005–2012).

Surgical Technique

The incision is 3 cm long along the anterior axillary line of the right lateral chest. A 5-mm 45-degree thoracoscope is used to provide clear visualization. The bar introducer and trocar port are inserted through the common skin incision at the same time. Due to the elasticity of the dermis, the introducer and thoracoscope are located distant enough so as to not interfere with each other. Dissection for bar placement on the right side of the chest is then performed under the pectoral muscles. To reach the retrosternal space, the introducer penetrates through the pleura from a point slightly medial to the highest point of the anterior chest wall. After crossing the mediastinum, the site of dissection is moved into the submuscular plane on the left side of the chest. Pleural penetration of the left side is also performed slightly medial to the highest point. After dissecting the submuscular layers, a guide is employed to facilitate the insertion of the pectus bar. There is a slit on the tip of the bar introducer; a needle stick with #0 silken thread is made directly through the overlying skin and muscle, and the needle is passed through the slit of introducer then passed back through the skin and muscle. Once the introducer is pulled out, the silken thread is placed in the dissected tunnel as a guide (Fig. 1). The silken

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thread is then fastened to the pectus bar. With an assistant tracking the other end of the silken thread, the bar is passed through the dissected tunnel smoothly and safely.

The pectus bar is prebent into a convex shape. Step-shaped bending allows the pectus bar to elevate the sternum directly due to its flat convexity while fitting the ribs with its hinge points. When the bar is flipped, it is firmly locked by the fulcrum effect at 3 points: the posterior sternum (*) and the 2 bilateral highest points (arrow) (Fig. 2). The right tip of the bar is fastened to the costal bone with polyester tape. No other devices, such as a bar stabilizer or sternal wire, are used.

RESULTS

None of 7 patients had extreme depression or eccentric asymmetry. The mean age of the patients was $16.4 \pm 7.31$ years, and the mean operative time was $78 \pm 20.7$ minutes. No severe intraoperative complications, such as cardiac injury or other bleeding events, occurred. Bar rotation occurred in 1 patient, who returned to surgery for repeat fixation of the pectus bar. The Haller’s index improved in 4 cases. Although the remaining 3 patients did not receive follow-up computed tomography, they demonstrated obvious improvements in their clinical appearance (Figs. 3 and 4). Patient satisfaction with the clinical results was excellent or good in all cases (Table 1).

DISCUSSION

The single-incision technique for the Nuss procedure provides cosmetic advantages. However, this method is also associated with several difficulties, including that involving bar passage, dissection of the opposite side, questions regarding the efficacy of unilateral bar fixation without a stabilizer, and subsequent bar removal.

Usually, bar passage is assisted by the introducer or umbilical tape via an incision on the opposite side. In the single-incision technique, the above-mentioned silken thread satisfactorily offers guidance.

Blunt dissection on the left side of the chest is one of the most crucial steps in this procedure. However, it requires a skilled technique to maneuver the introducer in the opposite side of the chest across the mediastinum. Narrow or incorrect layered dissection disturbs bar flipping. Defective bar flipping results in unbalanced momentum, thereby causing postoperative bar dislocation. The more severely depressed the sternum, the more difficult

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**Fig. 1.** The suture needle with silken thread passes through the slit of the introducer, invading the skin and muscle (A). Once the introducer is pulled out, the silken thread is placed in the dissected tunnel (B).

**Fig. 2.** The bar is bent into a stepwise convex shape (A). The bar is firmly locked by the fulcrum effect at 3 points: the posterior sternum (*) and the 2 bilateral highest points (arrow) (B).
the method of dissection. In severe cases, it may be necessary to supply supplementary work, such as sternal suspension.7

In our single-incision technique, it is impossible to perform bilateral fixation of the pectus bar. However, with an appropriate 3-point fulcrum effect, the bar is fixed on the chest wall by itself. We recognize that this fulcrum effect is the result of more than just a force in elevating the sternum. Although a bar stabilizer can be useful, we do not believe that it is essential.7 The one case of bar rotation observed in this series is considered to have been caused by a collapsed fulcrum effect due to inadequate dissection, rather than the lack of use of a stabilizer.

In the present study, only 2 patients have undergone bar removal; the other 5 patients continue to receive follow-up after bar placement. Bar removal was performed using the same single incision as a scar of the previous surgery. Concerning osteosis around the bar, all cases were so mild that there was no need for another incision to remove osseous tissue inhibiting removal of the pectus bar.

There is 1 limitation to this procedure. In this report, a single bar was placed in all cases, and we did not assess whether it is possible to place more than 1 bar through the single incision. We propose that it should be easy to insert a second or third bar within 2 intercostal spaces from the first bar, owing to firm retraction of the wound. However, additional fixation may be required, as it is uncertain whether multiple bars can induce an equal fulcrum effect.
CONCLUSION

In the present study, the single-incision Nuss procedure sufficiently corrected deformities of pectus excavatum without resulting in severe complications. The short-term results were either excellent or good.

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| Patient | Age | Sex | Haller’s Index | Preoperative | Postoperative | Clinical Result | No. Bars | Complications |
|---------|-----|-----|----------------|--------------|---------------|----------------|---------|---------------|
| 1       | 20  | Male| 3.36           | NCW          | Good          | 1              | Bar rotation |
| 2       | 14  | Male| 5.28           | 3.94         | Excellent     | 1              | None     |
| 3       | 9   | Female| 3.18          | 2.78         | Excellent     | 1              | None     |
| 4       | 15  | Female| 4.73           | 3.36         | Good          | 1              | None     |
| 5       | 32  | Male| 3.33           | NCW          | Good          | 1              | None     |
| 6       | 16  | Female| 4.53           | NCW          | Good          | 1              | Pleural effusion |
| 7       | 9   | Female| 3.27           | 3.01         | Excellent     | 1              | None     |

The clinical result was subjectively assessed by the patient. NCW, not complied with.