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# Video-Assisted Thoracic Accesses Easing Anterior Vertebral Body Tethering for Idiopathic Adolescent Scoliosis

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## Abstract

This is a very new and very effective video-assisted transthoracic approach easing anterior vertebral body tethering for patients with adolescent idiopathic scoliosis. Herein all of the technical steps are described in detail. The results for the study group are discussed thoroughly in the light of literature in the field.

**Keywords: Adolescent idiopathic scoliosis; Anterior vertebral tethering; Novel access; Thoracoscopic approach; Fusionless correction**

## Introduction

Video-Assisted Thoracic Surgery (VATS) tethering allows for shorter transthoracic incisions and thus, potentially faster recovery, avoiding the morbidity associated with fusion.

For mild to moderate curves (20° to 40°) bracing is the current accepted general treatment modality [1-3], while being able to prevent progression of the curves to 50° [4]. Bracing was reported to be most successful in patients who have less growth potential and curves under 40° [5,6]. However, many studies reported about the low success rates of bracing [3], together with complications associated with bracing including progression of the curves [4,5,7]. There are only a few studies in the literature reporting the outcomes of anterior VBT performed thoracoscopically on a limited number of patients with short-term follow-up [8,9].

The ideal age range for tethering is between 11 and 18 years, and there should be no evidence of growth plate closure as continued growth after tethering allows for gradual curve correction. The Cobb angle is the angle of the most tilted vertebra from the apex (mid-point) of the curve. The indications for tethering are angles of 40° to 70° and a Risser stage of ≤ 2.

This novel thoracoscopic access technique provides anterior Vertebral Body Tethering (VBT) for Adolescent Idiopathic Scoliosis (AIS). Thoracic surgeons could provide orthopedic surgeon friendly and effective anterior access to the intrathoracic vertebral bodies. This new unique approach helps the anterior VBT process done effectively and fluently without consuming much time and almost with minimal complications. The whole process is described in detail throughout the manuscript.

## Methods

This novel approach is applied to 24 patients (18 males, 6 females) with adolescent idiopathic scoliosis who were 9-14 years of age.

After the detailed examination of patient, which side to be operated on is first decided. This is always the convex side of the curve.

Second step is to decide which spinal levels are about to be tethered decided as a result of the assessment of standing full body X-rays of the whole spine (Figure 1).

Third step; the patient is intubated using double-lumen Carlens intubation tubes by experienced anesthesiologists.

Fourth step; after double-lumen intubation the patient is positioned at lateral decubitis position (the convex side of the curve is placed facing upwards) with an axillary pad positioned under the armpit at the dependent side (Figure 2).

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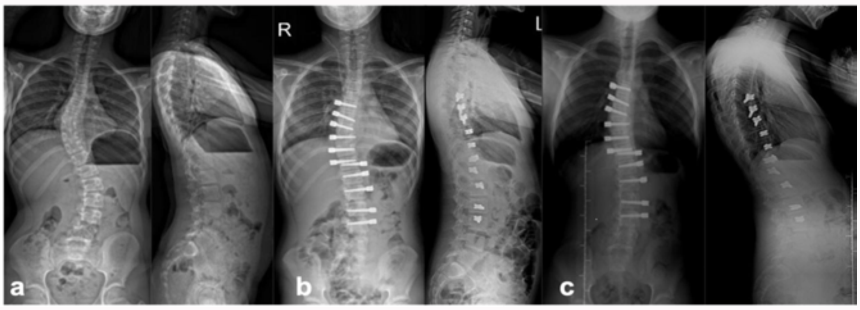


**Figure 1:** Standing full body X-Rays taken pre-operatively and on the last follow-up appointment of an 11 years old female patient with double curves after failed bracing. Double sided tethering was performed. (a) She presented to us with thoracic and lumbar curve magnitudes of 56° and 51° respectively. After double sided vertebral body tethering, the thoracic and lumbar curve magnitudes were reduced to 20° and 7° on the first erect X-rays (b) respectively, while at the end of the two-years follow-up, the thoracic and lumbar curve magnitudes were detected as 12° and 5° respectively (c).

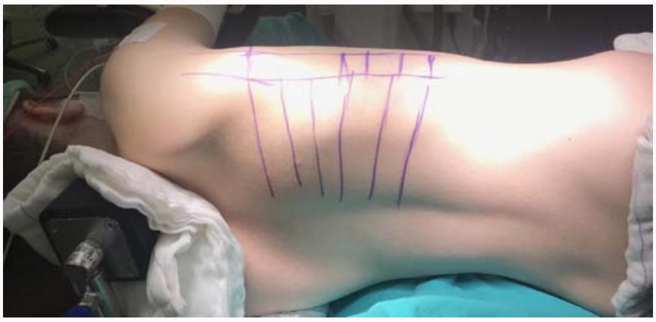

**Figure 2:** Lateral Decubitis Positioning.

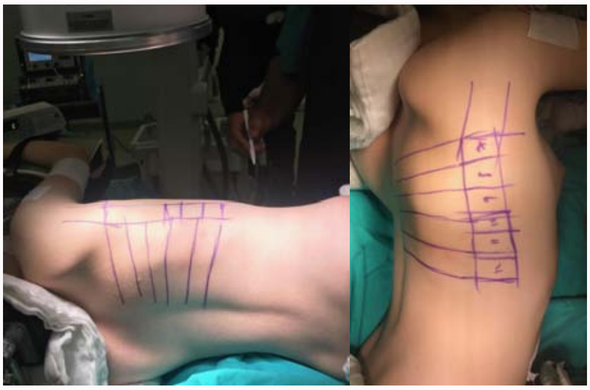

**Figure 3:** Skin marking of the vertebral projections under the fluoroscopic guidance.

Fifth step; (the most important step of this novel technique) The chief surgeon marks the related vertebrae on the lateral chest wall and the flank skin projecting the positions of the vertebrae (along anterior and posterior borders of the vertebral bodies and between pedicle at each level) and the discs under fluoroscopic guidance (Figure 3).

Sixth step; after marking is completed, the patient is draped and wrapped with sterile coverings after being scrubbed with sterile chlorhexidine solution.

Seventh step; It should be underlined that during the whole procedure the fluoroscopic guidance is very important. First, we place a port for a 30 degree optic before any incision is done (at the intersection of anterior axillary line and $7^{th}$ intercostal space). The camera trocar is inserted through the chest wall after requesting from the anesthesiologist to provide single lung ventilation by deflating the lung on the operated side.

Then, the mini thoracic and/or flank skin incision sites are marked additionally. We preferably use 1 mini skin incision (≤ 5 cm) for 3 or 4 vertebrae. The skin incision is placed obliquely exactly in the middle of the 3-4 vertebrae which are projectedly marked on the skin. The upper and the lower vertebrae are reached through separate trocars which are placed intercostally one or two levels up and down the uniportal mini thoracotomy incision (Figure 4).

Muscles paring incisions are preferred; the latissimus and the serratus muscles are divided along side their fibers. The intercostal space is opened using a cautery just over the related rib under direct vision with the endocamera. If needed a second oblique mini thoracic or flank incision is placed over the last 3-4 vertebrae projections to be screwed.

Eighth step; the screw placement process is started with the upper most vertebra. Initially, the entry point for a screw is detected

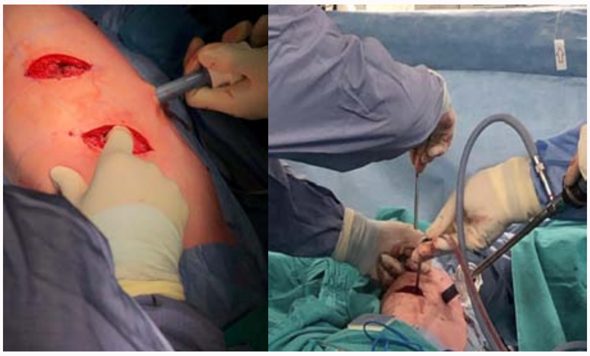

**Figure 4:** Thoracic incisions and the position of the 30° endocamera port.

very carefully using the real time fluoroscopic viewing laterally and anteroposteriorly. After the confirmation of the correct location and direction of the screw, it is placed very neatly by the experienced orthopedic spine surgeon. This procedure is repeated for the rest of the vertebrae that were about to be instrumented in a sequential fashion.

Ninth step; The tether was introduced through the most caudal 15 mm port and advanced proximally while being placed inside every screw head. The tether was advanced Trans diaphragmatically from caudal to cranial if lumbar levels were also tethered.

Tenth step; after completing the whole process, a chest tube was inserted through the thoracoscopic camera port, the hemithorax was irrigated with saline solution, and the lung was re-inflated under visualization with the endocamera. Then the mini thoracic access incisions are closed as usual.

All the thoracic vertebrae starting at T5 could be screwed through the mini thoracic incisions. The T12 and L1 vertebrae could be accessed transthoracically and using deep ecartation of the diaphragma by an L-shaped ecartoras well. L1 vertebra could be reached and a screw could be placed through the diaphragmatic muscle cruses without dissecting the diaphragm. At this stage we put a non-absorbable purse suture around the detected potential screw side in order to prevent a possible lymphatic leakage at this L1 vertebra level (we had 2 transient chylothorax due to a minor injury to the lumbar collateral lymphatic branch originating from the cysterna chyli which were managed conservatively).

## Results

### Demographic data

Twenty-four patients (18 females, 6 males) were enrolled in the present study. Patients had an average age of 11.4 (range 9-14) and average follow-up duration of 24.7 months (range 21-36). Patients had a mean Risser score of 0.45 (range 0-2) and Sanders digital hand score of 3.3 (range 2-4). Among the female patients, all were pre-menarche, except two patients whose menses started 1 and 3 months before the Vats - VBT operation.

The most proximal level was T5 and the most distal level was L3. Patients underwent an average of 8.1 vertebrae levels of tethering (range 6-10).

The mean duration of operation was 228 ± 71 min (range 185-268). Mean intra-operative Estimated Blood Loss (EBL) was calculated as 85 ± 52 ml (range 46-101).

Patients had an average pre-operative main thoracic curve magnitude of 48.2° (range 44° to 52.1°). On the final follow-up full body X-ray, patients were noted to have an average thoracic curve magnitude of 10.1° (range 7.7° to 11.2°) ($p<0.0001$).

The thoracic Cobb angles range from 44° to 55.1°. Lumbar angles range from 44.7° to 47.2°.

No of right side "thoracal" accesses are 20 whereas "thoracal" & "flank" accesses are in 3 patients.

No of left side "thoracal" access is only in 1 patient.

### Complications

No neurologic or infectious complications were detected during the entire follow-up duration. Also no hardware related complications (including under-/over correction, screw pull-out and failure, tether breakage) were noted. Two patients developed transient chylothorax immediately after surgery (postop 2$^{nd}$ day when started oral intake) and both managed conservatively. One patient had a total left lung atelectases which needed bronchoscopic aspiration and irrigation.

## Discussion

Adolescent idiopathic scoliosis presents in up to 5% of children younger than 18 years [10]. Bracing is utilized to correct curves less than 40° [5]. Fusion is an option for advanced curves but has associated morbidity and reduced mobility. Tethering leads to gradual curve correction by changing the shape of the vertebra while preserving spine mobility. The application of VATS leads to reduced pain; less blood loss and shorter length of hospital stay [11]. Spinal tethering was first reported by Crawford and Lenke [10,12], and 2-year results were reported in Samdani's series. They have reported good outcomes in a majority of patients experiencing curve correction with an associated reduction in the Cobb angle and minimal complications. Potential complications include either over deformity or under deformity correction, progression of scoliosis, gradual screw migration, cord rupture and nerve injury. Spinal fusion or redo tethering may be necessary in such cases.

There was a search to find an alternative treatment modality, that was able to correct the deformity and modulate growth, while protecting the adjacent segments and allowing spinal motion without causing the risk and problems of the older growth friendly techniques [3,9].

Crawford and Lenke presented their promising 5-year results of VBT for the first time in the literature on the index case with AIS and showed that this technique was providing progressive curve correction without any major complication and scarification of spinal motion along the tethered area [12].

To get long term results, we need progressive studies and more patients to be treated using VBT with VATS for AIS. In our pioneer study, we can conclude that there are a few complications related to this complex procedure as chylothorax (manageable by conservative approaches), atelectasis due to patient's reluctance to do breathing exercises, and pain. But, this novel complex synchronized approach seems very promising in the related field.

## Conclusion

The application of VATS to disorders of the thoracic spine is a new area for further development. Our joint practice with orthopedic surgeons will allow skills from both disciplines to be employed. Prospective, comparative and long-term studies are needed to have a better understanding regarding the prognosis of VBT done with VATS thoracoscopic accesses and the possible complications (including implant-related, infectious, pulmonary and neurological) and effects on biomechanics of tethered spinal segments.

The thoracic surgeons should take part in this a complex joint approach performing the minimal invasive VATS technique for VBT in patients with AIS in order to optimize and ease the technique, to increase the success rate, to decrease the complications and to increase the patients' satisfaction together with the higher cost effectivity.

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