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Review

Cantilever method for severe kyphotic deformity correction in spondylitis tuberculosis: A technical note and literature review

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A R T I C L E I N F O

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A B S T R A C T

Background: The kyphotic deformity is more than just a cosmetic disfigurement. It is potentially life-threatening and disturbs the quality of life by causing cardiopulmonary dysfunction, spinal imbalance, and other associated problems. Corrective surgery is challenging but it is needed to bring the spinal balance back thus halting the progressiveness of the deformity. The cantilever technique is a gold standard to correct the sagittal plane deformity.

Methods: This is a review article with some case illustrations from Author's experience.

Objective: We aim to review the cantilever technique for kyphotic correction in spondylitis tuberculosis patients.

Conclusion: The cantilever technique is the standard for sagittal plane deformity correction that can be applied for kyphotic deformity correction in spondylitis tuberculosis cases. Developing the safest techniques and instrumentation is crucial to achieving spinal balance with minimal risk of morbidities.

1. Introduction

Indonesia as an endemic country of tuberculosis has made great progress expanding the tuberculosis program over the last few years, but the case reduction has been slow, and the country still ranks third for the tb incidence globally. The World Health Organization (WHO) in 2018 estimates 316 per 100,000 Indonesian population suffer from the disease. In 2016, the case finding of extrapulmonary Tb (EPTB) in Indonesia is 29,785 new cases. [1]. The spinal manifestation of EPTB is around 5% of EPTB and 3% of all TB cases. However, the exact data of spinal manifestation in Indonesia has not been established yet. [2,3].

The evidence of neurological deficit is one of the indications for surgery in spondylitis TB infection. However, patients may also come with back pain or abnormal posture related to spinal imbalance as the result of severe kyphotic deformity even if the infection has subsided. The management of this residual deformity - like any other spinal deformity - is always challenging, especially in an excellent preoperative neurological state. Appropriate surgical approaches and techniques are issues to face in correcting deformity without adding any harmful damage to the patient. [4].

The cantilever technique is amongst the most commonly used technique to correct spinal deformity. We aim to review the cantilever technique in correcting deformities in spondylitis tuberculosis cases.

2. Surgical indications

Surgical indications in spondylitis TB are neurological deficit which has failed conservative therapy, large abscess, instability, posterior spinal lesion, intractable pain, complicated disease, or diagnosis uncertainty. [5]. Surgery is also indicated in severe deformity in any stage of the disease which can cause neurologic, cosmetic, and functional problems. Kyphosis of $>30^\circ$ in children and $\geq 60^\circ$ in adults are generally managed surgically, but overall sagittal balance and comorbidities should also be considered. [6]. Fig. 1 illustrated a spondylitis tuberculosis case that came to our center with back pain and abnormal kyphotic.

3. Deformity correction maneuvers by cantilever technique

Determination of the level of fusion, osteotomy type, hardware selection, and reduction technique is essential to achieve a desirable angle of correction. Generally, several techniques of reduction are known: rod de-rotation, vertebra-to-rod, and three-rod techniques, cantilever

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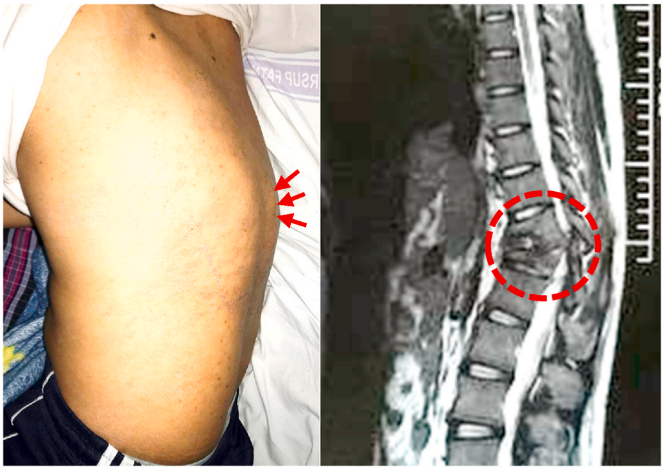

Fig. 1. Gibbus in thoracolumbar region of spondylitis tuberculosis patient. A. An abnormal kyphotic /gibbus (arrow) in thoracolumbar area which use to appear as a smooth gradation from thoracal kyphotic to lumbar lordosis; B. T2 weighted image of magnetic resonance imaging (MRI) showed bone destruction particularly in anterior column and abscess formation in T10–T12 vertebrae, note the narrowed canal on apex of kyphotic deformity.

technique, compression-distraction technique, and in situ rod bending technique. Kyphotic deformity which is basically a sagittal-plane deformity (rarely with rotational component) usually sufficient with the cantilever technique. [4].

The cantilever bending method is the most commonly used technique and a basic reduction technique for kyphotic correction since the discovery of the pedicle screw a couple decades ago. It offers reduction and reconstruction of the spine after destabilization by trauma, neoplasm, infection, and degenerative pathologies. The principle of this technique is achieving reduction by securing a pre-bend rod to pedicle screws proximal to apex of deformity following osteotomy procedure. The rod will act as a cantilever bending to correct the sagittal angulation (Fig. 2). [7].

A cantilever means any projecting structure (such as pedicle screw) that is fixed at one end but carries a load either along its length or at the opposite end. Pedicle screws or vertebral body screws can act as the cantilever in the spinal construct but must be able to withstand deformation under various physiological loads. Rod or plates that are applied vertically are used to transmit the load to another cantilever beam to the spinal column. [8].

There are three cantilever beam fixation types: fixed moment arm, non-fixed moment arm, and applied moment arm. Fixed and applied moment arm cantilever beam constructs provide rigid fixation. Whereas the non-fixed moment arm creates a dynamic or semi-rigid fixation. However, most constructs are applied in a hybrid fashion depends on the stress applied to the region. Surgeons can put moment arm (compression, distraction, or rotational forces) to the construct or leave it in neutral mode. In a neutral mode, the construct will face a great force during physiologic loading and may face failure unless an anterior support graft is applied. In the other hand, the applied moment arm cantilever construct offers the ability to alter spinal alignment, thus it is desirable for deformity correction. The application of moment arm through distraction, compression, or rotational forces to the screws which are attached to rods, offers the ability to correct spinal alignment. As an example, the application of compression to screws can reduce the posterior gap after debridement or osteotomy procedure. [8].

The decision on which cantilever construct is best to apply depends on the underlying spinal pathology. In spondylitis TB deformity with enough spinal components to resist axial loading, any cantilever techniques can be used for deformity correction. However, in the case which the stability has been severely disrupted, applied moment arm cantilever beam with additional anterior support with a graft can offer biomechanical and clinical advantages. [8].

4. Cantilever technique procedure

A standard posterior midline incision is made and extended to three or four vertebrae above and below the involved segment. The pedicles are exposed by subperiosteal dissection of the paraspinal muscles from the spinous processes to the tip of the transverse processes. Care must be taken to preserve posterior ligamentous structures.

Pedicle screws are placed bilaterally at the proximal and distal segments of the apex of deformity. Osteotomy is performed at the apex of deformity along with spinal decompression (laminectomy, facetectomy), if necessary. Usually, debridement and tissue culture/biopsy can be done following this step in the case of active infection.

Rods are bent into the desired curvature. Pre-bend rods are then inserted and connected sequentially to each pedicle screw. The spine begins to take the shape of the rods and comes into the desired sagittal and coronal alignment as the screws are tightened to the rods from proximal to distal. These proximally fixed rods will act as a cantilever that pulls underlying segments posteriorly as distal screws are tightened gradually (Fig. 3). [4,7].

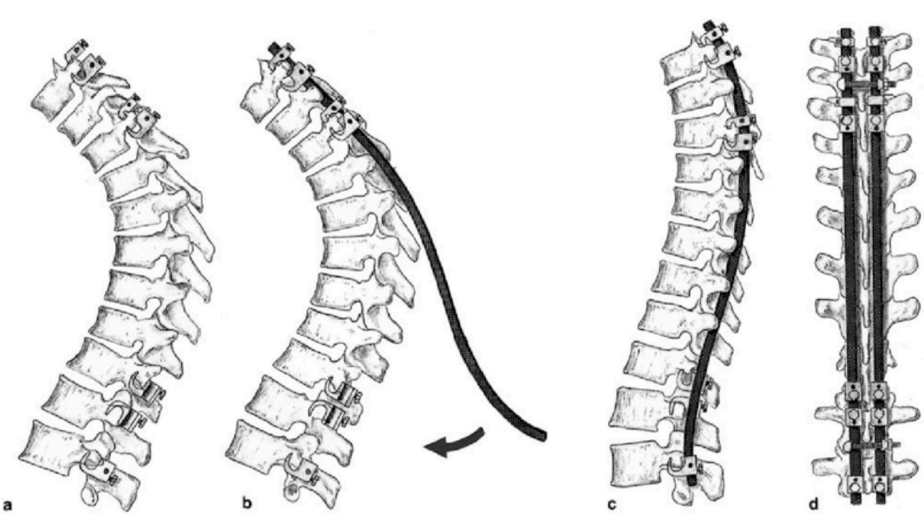

Fig. 2. The cantilever technique. A. Insert of pedicle screws in determined correction level; B. Lock the pre-bend rod to proximal pedicle screws; C. Cantilever bending to correct deformity, secure the pre-bend rod to the distal pedicle screws. [12,28].

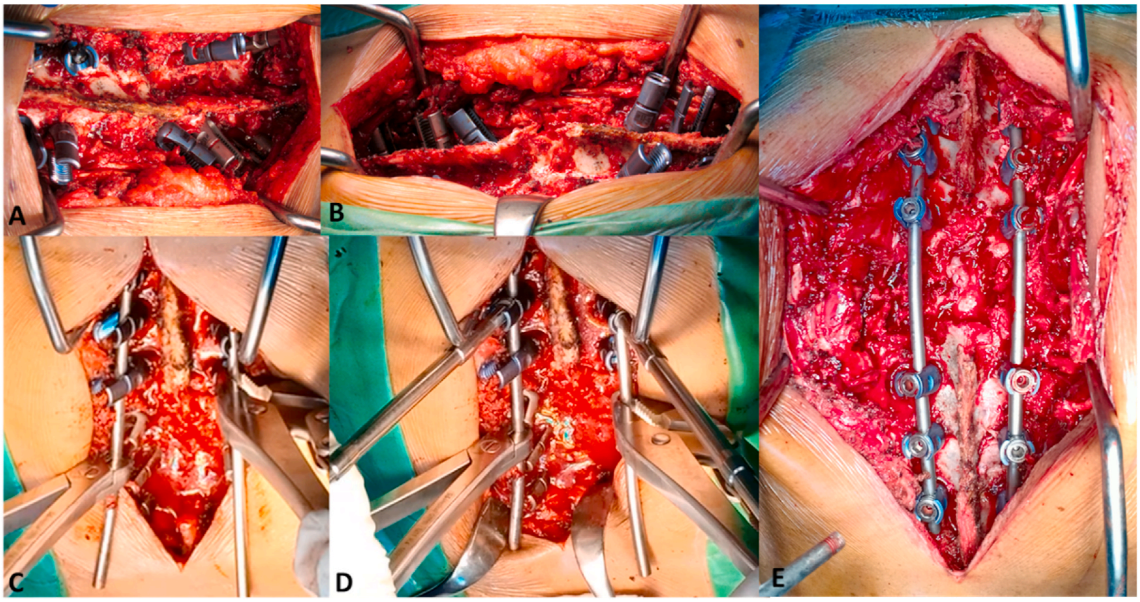

Fig. 3. The cantilever method for kyphotic deformity correction: A. Pedicle screw insertion in desired level of stabilization; B. Osteotomy at the apex of deformity; C. Insertion of pre-bend rods; D. Gradual screw tightening from proximal to distal, adjustments are made to achieve final correction. E. Final construct.

In severe curves, connecting the screws to the rods may be tricky. Reduction screws and persuaders can be utilized for these cases. These screws have an extra-long arm to facilitate the connection of rods to screws, which are then broken after the final screw tightening. Another important tip is making the spine into extension to aid the reduction by bending the operating table. Besides ease the reduction force, this maneuver prevents screw pull-out during the kyphotic correction. Finally, decortication is performed to the laminae and transverse process. Bone grafts are inserted to facilitate fusion. However, in case of a large bone defect or lack of mechanical stability, an additional strut graft can be inserted anteriorly to provide a stable load sharing construct (Fig. 4). This additional stability will prevent construct failure and offers biomechanical and clinical advantages. [4,7,8].

5. Outcomes

This technique took advantage of the biomechanical superiority of pedicle screws over other forms of spinal bone-implant interfaces as strong anchorages. It allows enough corrective force to be applied to overcome the rigidity of the deformity, thereby avoiding the need for anterior release [7]. Fig. 5 shows an intra-operative comparison of the kyphotic hump before and after correction. However, in cases with severe deformity, the incidence of screw cut out is quite high, particularly in the most proximal and distal segments.

Wang et al. [9] study compared surgical approaches in treating spondylitis tuberculosis in the aged population. The cantilever reduction method was used in both groups which gave a similar angle correction profile of 16.3 ± 2.0 vs 15.4 ± 5.0 (p: 0.068). J, Hu et al. [10] also used this technique for active thoracic and lumbar spinal tuberculosis in 20 children with kyphotic deformity. The correction rate in their study was 72.2% without any significant loss of correction on the latest follow-up. A report from Saleh, I. [11]. also used cantilever reduction techniques for severe kyphotic deformity correction in healed spinal tuberculosis patients. A significant reduction was achieved from 91.47° to 51.35° without any adverse event intraoperatively and postoperatively.

6. Complications

Drawback of this technique is the correction achieved solely determined by the manually pre-bend rod which consequently needs a high force to achieve the desired correction. On the other hand, the higher force of correction comes with a great risk of screw loosening and pull-out because implants always fail at the point of maximum stress application. In a long rigid (fixed moment arm cantilever beam) multi-segmented fixation, the most distal screws receive more loading than the proximal screws which is related to geometric and mechanical factors. However, these risks can be overcome by adding a wire-loop surrounding the lamina which will act as a fulcrum to reduce forces across the lever arm and distance screws. [4,8].

Moreover, acute and unmeasurable correction in this technique can cause iatrogenic nerve injury. Lonstein et al. [12] showed that in kyphotic correction particularly if the apex is rigid, only several areas except the apex are moved due to the maneuver. This leads to an extension of the cord anteriorly followed by mechanical compression and reduced blood flow. Edema will further reduce the blood supply that leads to nerve ischemic injury. [2].

To prevent nerve injury and avoid the risk of implant failure after kyphotic correction, a gradual correction with multiple osteotomy levels may be needed. However, the evidence of the measurable techniques and instrumentation is still limited. [12].

7. Conclusions

The kyphotic deformity is potentially disturbing the quality of life and survival and is not merely a cosmetic problem. The cantilever technique is a gold standard to correct sagittal plane deformity and also has proved as an effective and safe method in correcting kyphotic deformity in spondylitis tuberculosis cases. Developing the safest techniques and instrumentation are future directions that is crucial to achieving spinal balance with minimal risk of morbidities.

Provenance and peer review

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No patient or author details are included in the figures.

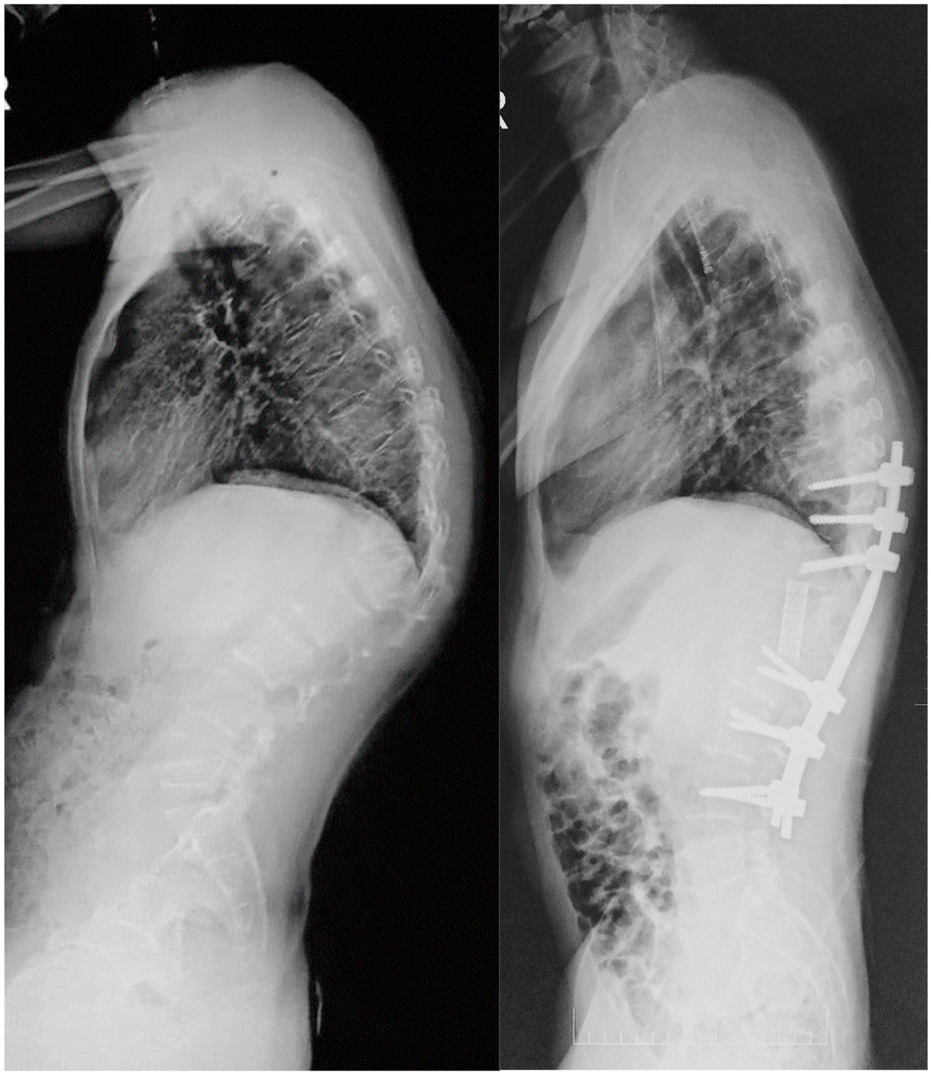

Fig. 4. Load bearing-to-load-sharing construct by the additional anterior placement of an interbody weight-bearing cage with bone graft and compression of the construct onto the anterior graft and remaining intrinsic weight-bearing spinal elements.

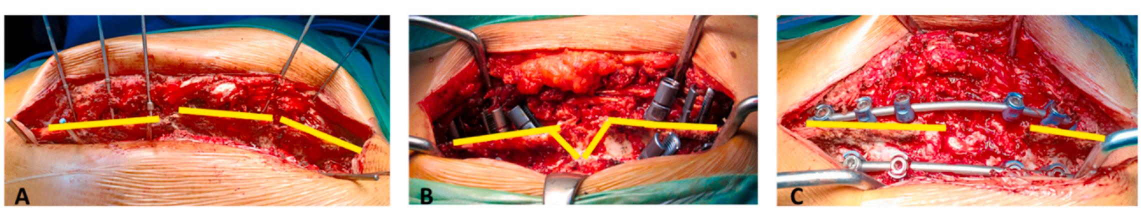

Fig. 5. Intraoperative comparison: A. Initial; B. After osteotomy; C. After reduction.

Ethical approval

None. Because this paper is a literature review and not considered as human research. Thus, it does not typically require IRB review and approval.

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Author contribution

All authors contributed to data analysis, drafting or revising the article, have agreed on the journal to which the article will be submitted, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

Consent

Written informed consent was not required for this review.

Registration of research studies

Not required.

Guarantor

Didik Librianto is the sole guarantor of this submitted article.

Declaration of competing interest

None declared.

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