Minimal Invasive Scoliosis Surgery (MISS): Current State of Art for Adolescent Idiopathic Scoliosis

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Abstract

In recent years, minimally invasive spine surgery techniques have grown increasingly popular with both patients and surgeons. MIS have become increasingly feasible, efficient, and popular for the treatment of a variety of spinal pathologies. Minimally invasive scoliosis surgery (MISS) is not a familiar concept among many spine surgeons, but it is a novel technique with demonstration of advantages of MISS over traditional open technique in the final outcomes and will be the future of adolescent idiopathic scoliosis (AIS) surgery.

Keywords: Minimal invasive spine surgery, Minimally invasive scoliosis surgery (MISS), Adolescent idiopathic scoliosis (AIS)

Introduction

Over the past few decades, minimally invasive surgery (MIS) has grown quickly and in many areas of surgical specialities have become the "standard of care". Simultaneously to this, there has been a push in spinal surgery to execute more targeted procedures with less collateral damage to the critical spine structures, decrease surgical risk and expedited recovery. These advancements are the result of the synergy created by a concurrent "explosion" of technological knowledge and expertise in improved surgical instrumentation and implants, modern digital and traditional optical systems with intraoperative imaging systems. Although minimally invasive spine surgery has become more trustworthy, reproducible, and safe; because of advanced supporting technology, there is still a steep learning curve. So, it is crucial to understand that MIS surgery need not be an all-or-nothing situation and is instead a progressive process of knowledge and skill acquisition.

Currently, the preferred first-line treatment for a variety of spine pathologies is minimally invasive spine (MIS) surgery. Numerous studies are currently being conducted on MIS applications in spine operations around the globe and revolutionizing the approach towards surgical techniques. Posterior spinal instrumentation and fusion (PSIF) is the gold standard of surgical treatment for adolescent idiopathic scoliosis (AIS). Open AIS correction has been associated with long surgical scar mark, muscular morbidities, more blood loss, long -term post-operative pain, longer hospital stay and poor cosmesis [1]. In an effort to address these drawbacks, minimally invasive scoliosis surgery (MISS) has been suggested with advantages of small skin incision with less soft tissue damage, less blood loss, early mobilization, shorter hospital stay, lower analgesic dependence and better cosmetic outcome [2]. Although MISS offers theoretical advantages, MISS can be more technically demanding with long learning curve, distorted anatomy of deformed spine, the lack of intra-operative proper visualization by image intensifiers which may restrict spine surgeons from utilizing this technique for AIS correction [3, 4]. MISS is emerging as a feasible tool in deformity correction.

Authors surgical technique

We introduced our own minimally invasive scoliosis surgery (MISS) after performing numerous open scoliosis correction procedures and gaining experience treating degenerative spinal diseases using MIS. The aim was to minimize the risk of post operative complications like incision site infection,

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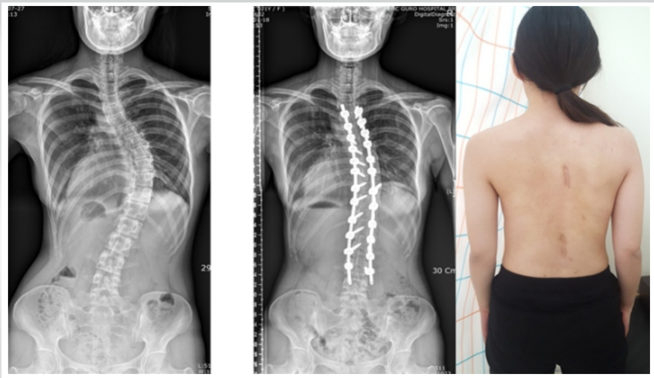

Figure 1: A18 years old female patient with pre-operative cobb's angle of 65 degrees. The surgery was performed through MISS and T3-L4 (14 levels) levels were fused through two incisions. note the cosmetically superior surgical scar.

hypertrophic scar, and rod dislodgement which was associated with existing MISS techniques.

After induction, the patient was placed in prone hyperextended position on operating table to increase the redundancy or movability of skin and soft tissues which led to better and easy retraction for pedicle screws and rods insertion. According to pre-determined upper and lower end of fusion level, precise level of skin incisions was marked under the guidance of image intensifier. Depending on the number of fusion levels, two or three midline incisions were made. Each skin incision has a size of around 3-3.5 cm and each such incision is supposed to cover six to seven thoracic segments and four to six lumbar segments.

After skin incision, at the level of fascia, author used different approaches for the thoracic and lumbar region as erector spine muscle splitting approach for the thoracic spine and the Wiltse (paraspinal approach) approach for lumbar spine. Through the same incision, thoracoplasty can be performed for deformed ribs and rib humps.

Following that, facet joints were exposed by inserting a tubular retractor system or right-angled retractors of various lengths and widths. Free hand technique was used to insert pedicle screws. After removing facet joint capsule with an insulated-tip electrocautery, the entry points of pedicle screw were marked at the lateral one-third of superior articular process (SAP) base.

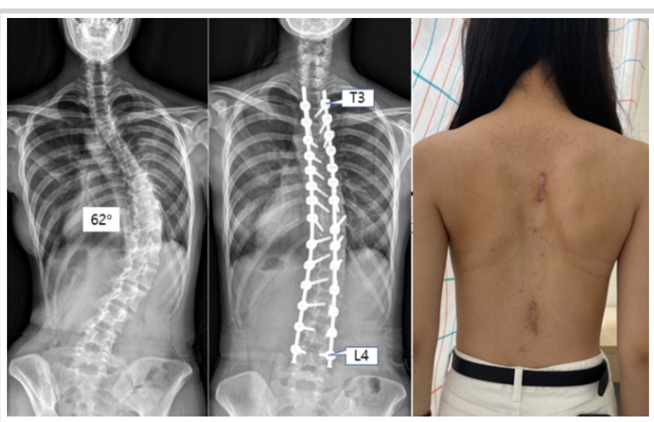

Figure 3: A 20 years old female patient with pre-operative cobb's angle of 62 degrees. The surgery was performed through MISS and T3-L4 (14 levels) levels were fused through two incisions. note the cosmetically superior surgical scar.

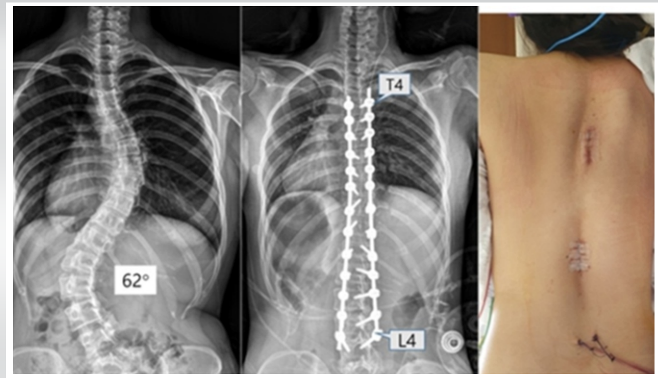

Figure 2: A 32 years old female patient with pre-operative cobb's angle of 62 degrees. The surgery was performed through MISS and T4-L4 (13 levels) levels were fused through two incisions. note the cosmetically superior surgical scar.

The initial pit on entry point was made with a motorized diamond burr or an entry awl, and a pedicle screw-trajectory was made with a curved Lenke probe perpendicular to the superior articular facet [5]. The integrity of pedicle walls was confirmed by a 2 mm curved ball-tip probe at each step. After the trajectory was made and confirmed, a guide wire was passed to ensure that the pedicle screws follow the same path. We used facet miller to ream all facet joints for fusion. After that we inserted cannulated poly-axial reduction screws over the guide wire and we used reduction screws at all fusion levels for easy rod assembly. We inserted chipped cancellous allografts to the fusion bed before insertion of screw to facilitate fusion. Similarly in the lumbar spine, we used junction of mamillary process, the inferior aspect of transverse process and the pars interarticularis for pedicle screw entry point. Pedicle screws were inserted at all fusion segment levels without skipping any vertebra level. Sometimes, addition percutaneous stab incision was required for the lower most vertebra level if original incision could not provide room for the screw trajectory. To minimize the length of additional stab incision, author used specific type of telescoping screws and later the same stab incision could be utilized for hemovac drain.

After all the screws were inserted, a 6.0 mm rod of the proper

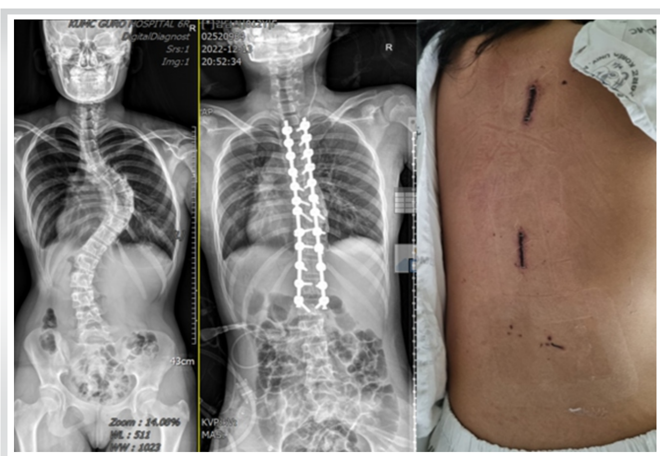

Figure 4: A 12 years old female patient with pre-operative cobb's angle of 78 degrees. The surgery was performed through MISS and T2-L1 (12 levels) levels were fused through two incisions.

length that was properly contoured to replicate the required sagittal plane thoracic kyphosis and lumbar lordosis was prepared. Pre-operative 3D CT scan was utilized to confirm the sagittal profile of spinal curvature. The rods were slightly overbent compared to the desired curve profile because we think that the straightening of the rod occurs during derotation maneuver. The contoured rod was inserted sub-fascially in a cephalus to caudal direction (convex side first) to prevent unwanted entry into the spinal canal. Rods were pushed into the screw heads and successively capped using a locking plier, long and thin Langenbeck retractors, and rod pushers (rod translation). A same process was carried out on the concave side. Simple rod derotation (RD) maneuver was carried out after rod translation, and linear markings on the center of rods served as a guide to the degree of rotation. Intra-operative anteroposterior and lateral radiographs were taken to confirm the position of the rod and degree of correction.

Salient features of MISS technique

- Prone positioning of patient in hyperextended operating table.
- Specially designed right angled retractors with various length and widths or use of tubular retractors.
- Use of free hand pedicle screw insertion technique with a guide wire and cannulated instruments system to maintain the pathway for the pedicle screws.
- Use of novel fusion technique with specially designed cannulated facet miller which encompass adequate grinding of facet joints and achieve satisfactory fusion.
- Pedicle screw fixation at all levels without skipping level.
- Use of poly-axial reduction screws at all fusion level for easy rod assembly.
- Multilevel thoracoplasty through same skin incision by undermining the skin.

Phillips FM et al. [6] proposed a definition of minimally invasive spine surgery (MIS) focusing on recognizing the common MIS surgery goals, objectives, and principles of MIS surgery as

"An MIS procedure is one that by virtue of the extent and means of surgical technique results in less collateral tissue damage, results in a measurable decrease in morbidity and more rapid functional recovery than traditional exposures, without differentiation in the intended surgical goal."

To attain the same objectives, minimally invasive surgery (MIS) of the spine should result in clinical, radiological, and functional outcomes that are equivalent to or superior to those of open and more extensive procedures. Despite its alleged benefits, there is currently limited publication available on the results of MIS in AIS patients.

Sarwahi et al. [7] published the study of 7 patients operated with MIS for idiopathic scoliosis with 2 years of follow-up data. In their technique, they used three midline (4 cm each) incisions. They reported a longer mean operating time (ORT) of 8.7 hours compared to open surgery and an encouraging mean curve correction rate of 81.7%. They reported complications such as dislodgement of rod, wound breakdown, late wound infection, and hypertrophied scars. They concluded that minimally invasive approach, although technically challenging, is a feasible option in patients with AIS.

Samdani et al. [8]published results of their retrospective study on posterior MIS technique for correction of AIS in 15 patients. Their surgical procedure differs slightly from the one previously described technique due to the use of a single midline skin incision rather than three separate incisions. Their results showed that an average preoperative major Cobb angle was 54° and post-operatively reduced to mean 18° with correction rate of 67%. The average blood loss in their series was 254 cc and ORT was on average 470 min. In terms of complications, one patient required revision after presenting with a pull-out of the proximal screws at 8 months after correction surgery.

Miyanji et al. [9] published comparative study between MIS and open posterior techniques in AIS patients. They reported that there was no significant difference between MIS and open surgery in terms of major Cobb angle correction (63% ±13 versus 68% ±8 respectively). The early postoperative findings of surgical outcomes were discussed in this study, and it was reported that MIS in AIS had advantages over traditional open PSIF in terms of less blood loss (277 ml ±105 versus 388 ml ±158) and shorter length of stay (LOS-4.63 days ±0.96 versus 6.19 days ±1.68) but ORT was significantly longer (444 min ±89 versus 350 min ±76).

Bodman et al. [10] published results of 70 consecutive patients of AIS operated with posterior MIS by a single surgeon. They reported that average preoperative major Cobb angle was 58.9°±12.6 and was significantly corrected to 17.7°±10.2 with mean correction rate of 69%±20. They concluded that MIS appears to offer sufficient correction in both planes and an acceptable rate of peri-operative complications for individuals with AIS. This method might be a good substitute for the conventional posterior technique, but more extensive research is required before it can be advised for usage on a regular basis.

Our studies regarding MISS for AIS showed satisfactory radiological outcomes, such as the correction rate of the Cobb angle, sagittal vertical axis (SVA), clavicle angle, and compared to preoperative values [11, 12, 13, 14, 15]. In comparative study between MIS and open correction surgery in AIS patients, mean pre-operative cobb's angles were 60.8° ± 9.4 and

62.1°±12.9 respectively with post-operative correction to 21.0°±5.8 and 17.6°±5.2 respectively. Correction rate of MIS surgery was 65%. In this study, minimally invasive scoliosis surgery was associated with significantly less blood loss than open surgery.

Adopting the MISS technique is challenging because correcting AIS requires multiple levels vertebral instrumentation and fusion, higher radiation exposure for both patient and surgeon, discomfort from small skin incisions, and numerous stab incisions required for inserting percutaneous pedicle screws, which leave unsightly scars [16]. Sarwahi et al. [7] employed a MIS surgical method for AIS correction that involved three midline incisions (2-inch each) and they inserted three to four pedicle screws per incision with leaving the intervening vertebrae between the incision sites. They used reduction screws alternately with extended wings and MIS screws with open connectors between levels. Similarly, de Bodman et al. [10] published their MIS technique with three midline incision and instrumenting three vertebrae at each incision and skipping the intervening two vertebrae level. But in our technique, we use two skin incisions, and each skin incision has a size of around 3-3.5 cm. we inserted pedicle screws with free hand technique like an open surgery in all vertebral level without skipping any screw to transfer the load equally on all the pedicle screws. Insertion of pedicle screws at all segments created a favourable environment for the fusion and decrease the risk of rod dislodgement. We used all poly-axial reduction screws for easy rod assembly under direct visualization. In our study, the primary distinction between MIS and open surgery was the length of surgical scar as MISS is associated with better cosmesis among the young female patients with AIS. We concluded that MISS might be a viable alternative to AIS since it offers similar deformity correction and fusion with several benefits, including less surgical morbidities and aesthetic improvements [11, 12, 13, 14, 15].

Conclusion

Similar to other MIS surgery in general, minimally invasive scoliosis surgery has a steep learning curve, and requires additional training, careful patient selection, and thorough understanding of the deformed spine anatomy. Conferences, didactic lectures, virtual reality training, cadaveric workshop training, and surgical observation are among remedies for these issues. There is a rising demand for minimally invasive scoliosis surgery as public awareness rises. This is especially true for conventionally "big" operations like correcting AIS in young patients, which are known for their extended and immense post operative pain, high complication rates, and protracted recovery times. Patients are becoming more knowledgeable about it via the Internet. Additionally, as more patients who have undergone minimally invasive scoliosis surgery (MISS) become accessible to testify their friends, relatives, and neighbours; public awareness and requests for MISS technique will rise.

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Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his/her consent for his/her images and other clinical information to be reported in the Journal. The patient understands that his/her name and initials will not be published, and due efforts will be made to conceal his/her identity, but anonymity cannot be guaranteed.

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