Section A-Research paper

An Overview about Management of Scheuermann's kyphosis

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Abstract

Background: Initial management of the patient presenting with Scheuermann's kyphosis includes documentation and assessment of the degree of deformity and/or pain, as well as an overall picture of the negative impact of the deformity on the patient's life. The treatment of Scheuermann's disease is based on the severity of the deformity, location of the deformity, presence of pain, and age of the patient, including non operative and operative methods. Non-operative treatment is classically indicated during the growth period if thoracic kyphosis exceeds 40˚- 45˚only in patients with mobile kyphotic deformity and with a sufficient amount of growth remaining. Up to one year of remaining growth is usually what is accepted as adequate to start the non operative treatment. There is controversy about the indications for surgical treatment because of limited evidence on the natural history of the condition regarding to pain, level of function or disability, self-esteem and deterioration of the kyphosis for treated and untreated patients. As well as the natural history of the disease is benign in most cases

Keywords: Scheuermann's kyphosis

Introduction

Initial management of the patient presenting with Scheuermann's kyphosis includes documentation and assessment of the degree of deformity and/or pain, as well as an overall picture of the negative impact of the deformity on the patient's life. The treatment of Scheuermann's disease is based on the severity of the deformity, location of the deformity, presence of pain, and age of the patient, including non operative and operative methods. **(1)**

Non operative treatment:

Indications:

Non-operative treatment is classically indicated during the growth period if thoracic kyphosis exceeds 40˚- 45˚only in patients with mobile kyphotic deformity and with a sufficient amount of growth remaining. Up to one year of remaining growth is usually what is accepted as adequate to start the non operative treatment. **(2)**

Bracing and/or casting is known to become ineffective once the patient's Risser sign is 4 or 5. 35

Conservative treatment of Scheuermann's hyperkyphosis in the international literature is generally regarded as an effective approach , it includes **exercise**, **bracing** and **casting**.

Physiotherapy and bracing are the first line treatments for this condition. **(3)**

Operative treatment

Indications:

There is controversy about the indications for surgical treatment because of limited evidence on the natural history of the condition regarding to pain, level of function or disability, self-esteem and deterioration of the kyphosis for treated and untreated patients. As well as the natural history of the disease is benign in most cases.Rarely, neurologic deficits have been reported to be an indication for surgery, however, this is the only absolute indication for surgery either due to an increase in kyphosis, a disc protrusion or other intraspinal pathology with neurological compromise. **(4)**

Such complications, fortunately exceptional, would require neurologic decompression through an anterior thoracotomy or a posterolateral decompression. **(4)**

Apart from these exceptional neurologic complications there is no evidence based criteria for an indication of surgery. According to the literature, operative treatment should be considered in patients cosmetically presenting with large curves above 75˚, significant progressive pain that has not responded to conservative measures and/or respiratory problems due to severe kyphosis usually above 100˚.37 But, the problem with pain as an indication, is that pain is impossible to be measured objectively and the causal relation between pain and kyphosis is unclear. **(5)**

The goal of treatment:

Surgical intervention focuses on correction of kyphosis and prevention of deformity progression, but the primary goal is to relief the associated pain and to prevent neurological failure or progression of neurological deficit. **(6)**

Decision making:

Surgery for Scheuermann's kyphosis is not benign and has a significant risk of complications,therefore, the decision for undertaking operative treatment of Scheuermann's kyphosis is ultimately an individual one between the surgeon and the patient. Potential benefits of the treatment in relieving pain and improving physical appearance and self-esteem, and their related social implications are weighed against the potential complications of treatment.27

In other words, the severity of the symptoms and the patient's self-perception are more important in decision-making for surgery than the degree of kyphosis, and the surgeon should evaluate his ability to produce a predictable correction with few complications. Several questions must be answered prior to any surgical decision: what is the amount of correction should be aimed at? Which correction technique should be used? What are the levels to be included in the spine fusion? And does the curve need an anterior release or not? **(7)**

What is the amount of correction should be aimed at?

How much correction should be aimed, and is straighter better? The Scoliosis Research Society (SRS) has defined normal thoracic kyphosis as between 20˚ and 40˚. Bernhart and Bridwell have stated that kyphosis up to 50˚ is perfectly normal. What is not known is the amount of thoracic kyphosis that an individual should have, depending on his pelvic incidence. **(7)**

It might seem preferable to try to correct the deformity to the normal range however, there is a risk of overcorrection, as the amount of correction will exceed the ability of the adjacent mobile spinal segments to realign. This might be evident in the cervicothoracic region, where a compensatory proximal junctional kyphosis may occur.Most current authors seem to favor normalizing thoracic kyphosis that is above 50˚, down into the 40–50˚ range, or limiting the correction to 50% of the original deformity in order to avoid postoperative imbalance and junctional kyphosis. **(7)**

The degree of hamstring tightness should be assessed and taken into consideration during planning. Therefore, straighter is not necessarily better in the operative treatment of Scheuermann's kyphosis.23

Preoperative evaluation:

Clinical assessment:

The preoperative workup will focus on the patient's pain and/or cosmetic concerns, trying to identify the motivation of the patient. Clinical examination will look for stiff hamstrings as well as any subtle neurological findings. The importance of tight hamstrings has recently been emphasized as a possible cause of sagittal decompensation after operation. Preoperative hamstring tightness predicts a limited lumbar and pelvic range of motion, i.e., a limited ability to adapt to curve correction. Therefore, patients with tight hamstrings have a significantly higher risk of postoperative sagittal imbalance **(8)**

It is also very important to evaluate for the presence of hip flexor muscle contractures on physical examination of the patient. Patients who have had to flex at the hips to correct long-standing loss of lordosis i.e., thoracolumber scheuermann's can develop flexor contractures that will not permit them to stand in good sagittal balance, even if adequate correction of the spinal curvature has been obtained. Applied stretching exercises and rehabilitative therapy are very important to obtain this final goal of good sagittal balance and can be sufficient to avoid further operations or more invasive corrective surgical techniques such as pedicle subtraction osteotomies. **(8)**

Radiographic assessment:

Radiographic assessment of the curve is the next most important step in planning for surgery. There are main components to this evaluation: curve magnitude, location, and flexibility. ***Curve magnitude*** is the most obvious parameter when assessing kyphotic deformities and sometimes the most clinically apparent. Except for the fact that there is often a positive linear correlation with increasing stiffness as curve magnitude increases, curve magnitude is probably the least important component of the deformity for determining surgical intervention. **(9)**

Curve location may carry with it some implications for surgery treatment. This is especially true when curves are located at transition segments of the spine as thoracolumbar junctions. Kyphotic deformities located at these transition zones may require crossing from the primary region of deformity into the adjacent functional zone. This may result in altered function and mobility and require application of different surgical techniques. **(9)**

The last and perhaps most important radiographic assessment to be made is that of spinal ***flexibility*** through the kyphotic region. The flexibility of the deformity will define the surgical techniques that are most appropriate for correction. Flexible curves such can be treated with cantilever correction maneuvers often without any osteotomy procedures. Rigid curves will require osteotomies to achieve correction. **(9)**

MRI before surgery is recommended to rule out any exceptional thoracic disc herniation, epidural cyst or possible spinal stenosis. The literature has shown such exceptional cases in various reports of neurologic complications in Scheuermann. The MRI will also assess the lumbar spine discs, as disc degeneration of the lumbar spine may explain, in some cases, the pain rather than the deformity itself. One will also look for a possible spondylolysis frequently observed in these patients. **(10)**

As the operation is essentially cosmetic, clinical photographs are mandatory. Pulmonary function tests are not necessary, as they are usually normal or even increased in the case of Scheuermann. **(7)**

SPO

SPO is a versatile technique that can be safely used to correct sagittal plane deformity and, to a certain extent, coronal plane deformity in both the thoracic and lumbar regions. In today's age of segmental spinal fixation, SPO has become a popular tool in the arsenal of surgical techniques used for spinal deformity correction that is offered to an ever-growing population of patients with recognized idiopathic, iatrogenic, and degenerative spinal pathology. **(11)**

History

In 1945, It was described a technique involving bone removal for surgical correction of deformity associated with ankylosing spondylitis. This technique, which has become known as the Smith–Petersen osteotomy (SPO), was initially applied using a single osteotomy, largely for the treatment of ankylosing spondylitis. The indications for SPO have gradually been expanded, however, to include the treatment of other types of kyphotic deformities, including iatrogenic fixed sagittal imbalance (flat-back syndrome), congenital spine deformities such as Scheuermann's kyphosis, and kyphosis associated with trauma. Smith–Petersen osteotomies have also been increasingly used in a polysegmental fashion and with asymmetric osteotomy techniques for coronal imbalance correction . **(11)**

Principle:

SPO is a posterior column wedge (chevron-type) osteotomy with opening of anterior column or an "extension" osteotomy of the spine **(6)**

in which the posterior column is shortened through resection of the posterior elements. Posterior compression is then used across the segments to achieve sagittal correction by closing the posterior column.As the osteotomy is closed, an axis of rotation (hinge point) is created at the posterior aspect of the disc space, thereby widening the front of the disc space. This widening of the anterior margin of the disc space is the reason that SPO has been called an extension osteotomy. The overall effect is to shorten the posterior column and to lengthen the anterior column, resulting in hyperextension at this level. Because the hinge is located at the posterior aspect of the disc space, the length of the middle column is either unaffected or shortened only slightly. **(11)**

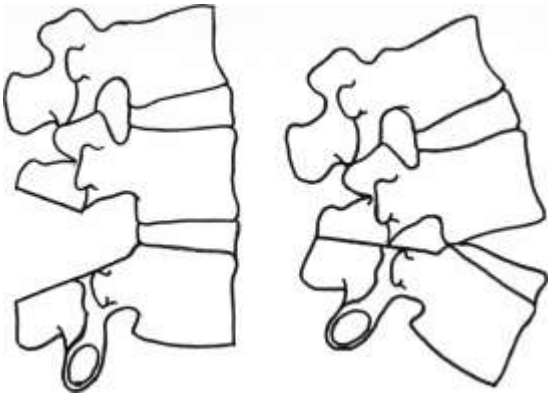

Figure 1: Smith-Petersen osteotomies shorten the posterior column and lengthen the anterior column. **(9)**

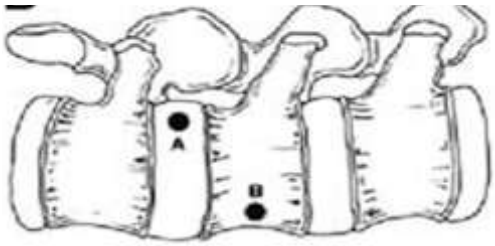

Figure 2: (point A) the fulcrum point of SPO closure, in the middle column of the spine in contrast (point B) the fulcrum point of PSO, in the anterior aspect. **(11)**

The posterior elements which resected:

The facet joints on both sides of a spinal level are removed, including the superior articulating facet of the lower vertebra and the inferior articulating facet of the upper vertebra, as well as the inferior portion of the lamina of the rostral vertebra. The inferior aspect of the spinous process of the upper vertebra is also removed, followed by removal of the underlying ligamentum flavum. The lower lamina is decorticated for arthrodesis, but it practically remains intact, as do the pedicles. **(11)**

Many are confused by the terminology and consider this a Chevron osteotomy. But other consider the SPO to be a radical posterior column resection followed by an anterior osteoclasis to achieve approximately 30° of correction at 1 level as in an ankylosing spondylitis patient. **(12)**

The amount of correction that can be achieved with an SPO:

The amount of correction that can be achieved with an SPO is 10 degrees with a maximum of approximately 15° per level. **(6)**

One may expect, as a general rule, 1 degree of correction for every 1 mm of bone resected posteriorly. **(11)**

If SPO is performed on an ankylosing spondylitis patient, a higher degree of correction can be achieved, up to 30-40˚, however, some authers consider this is theoretical and about 3˚ to 7˚ per level is more commonly achieved. **(13)**

Factors determining the amount of correction achieved with SPO:

The width of each SPO is to be calculated keeping in mind the specific anatomic situation of the patient.

1- Disc mobility:

Because the Smith–Petersen technique relies on widening of the anterior portion of the disc space to achieve correction, it requires a mobile disc space up front. A greater degree of correction will be possible at a motion segment with a very mobile disc versus at a level with a severely degenerated and sclerotic disc space presenting osteophyte. It cannot be performed at a level that is fixed anteriorly, as in the case of a thick bridging osteophyte. Careful study of preoperative x-rays is necessary to determine whether such an osteophyte is present. In the case of a fine bony bridge, some have used the technique of closed osteoclasis to release the anterior connection, followed by SPO. If there is a thick, solid bony bridge, it will be ineffective without anterior release. **(12)**

2-disc height:

Also, more correction can be expected at levels with greater disc height. The taller the disc, the more effective is the osteotomy, because this technique requires posterior osteotomy closure and simultaneous anterior opening. **(13)**

3-the integrity of the anterior longitudinal ligament:

In general, with anterior column structures intact, the SPO can achieve 10° of lordosis per level. However, if the integrity of the anterior column is disrupted, substantially more anterior column lengthening and subsequently sagittal correction can be achieved. Law achieved 25° to 45° of correction with a single SPO with rupture of anterior longitudinal ligament in patients with ankylosing spondylitis. **(14)**

4-resection of the posterior elements:

It is generally agreed, that SPO is a less aggressive form of extension osteotomy. However, the more aggressive resection of posterior elements, the more degrees of correction achieved. The radical resection of the posterior elements and subsequent anterior osteoclasis have been used to achieve greater than 30 degrees of correction at a single level. **(11)**

5-size of motion segment:

The size of motion segment determines the width i.e., it is useless to make a 2- cm osteotomy at a segment capable of permitting the closure of only a 1-cm osteotomy. **(11)**

The level at which SPO is performed:

SPO is rarely performed at one level and usually performed at 2 or more levels. **(12)**

They are usually performed at the apical segments of the deformity, Smith-Petersen osteotomy is typically performed in the thoracic spine, and even the lumbar spine, to achieve the desired correction. **(12)**

Indication of SPO:

The SPO is used for cases in whom a relatively small amount of correction is required. This procedure was performed for cases in which the correction should be performed to an angle of approximately 10-20˚ for each level. It was also performed in cases in which the apex of the deformity is located at the thoracic spine. Along, rounded, smooth kyphosis is often an ideal candidate for multiple SPOs. Scheuermann's kyphosis or kyphosis with a previous fusion and malunion as well as patients with a degenerative imbalance in the sagittal plane can be treated with SPO. **(15)**

Scheuermann's kyphosis, is more amenable to multiple SPOs, in part because it's a long rounded kyphosis owing to its multisegmental nature and in part because the pathology is in the thoracic spine. **(12)**

Combined SPO at the thoracic spine and PSO at the lumbar spine can be performed in cases in whom the deformity was extended severely from the thoracic spine to the lumbar spines . In addition, SPO can be used effectively in ankylosing spondylitis patients with localized kyphosis from pseudarthrosis (Andersen's lesion). **(15)**

SPO modification

In 1945, It was reported the first spinal osteotomy. It was termed a Smith-Petersen osteotomy, which has been performed by many authors. It was devised their spinal operation as a one-stage procedure that could be repeated at more than one level if necessary. **(16)**

Ponte osteotomy:

Also, as a modification of this technique, there are procedures, such as Ponte procedure or polysegmental osteotomy described by Alberto Ponte in 1987. 50

The Ponte osteotomy (PO) was described as a multilevel thoracic procedure to treat flexible thoracic kyphosis. It is executed by undertaking an aggressive resection of the unfused facet joints, lamina, intraspinous ligaments, and ligamentum flavum at each level. Since the "osteotomy" is applied to the unfused spine, it could be argued that it is not an osteotomy in the true sense of the term. However, since it does require significant and specific osseous resection to be effective, the fused *versus* unfused status of the spinal segment is probably irrelevant. The PO resection can be narrow, amounting to an aggressive facetectomy or as radical as a complete resection of the posterior elements from pedicle to pedicle at each level. **(17)**

Others consider Smith-Petersen and the Ponte osteotomy are similar but have certain differences that make them unique in both their application and their execution. The difference between the PO and the SPO is that using PO technique, resulting in an overall "closing wedge" effect. This differs from the SPO's anterior column "opening wedge" and posterior column "closing wedge" effect. In addition, the anterior column remains supported by its undisturbed physiologic structures (discs, ligaments), leaving a stable spine after posterior column reconstruction. Additional anterior column procedures are unnecessary. Ponte osteotomy may only provide a few degrees of correction per level so, multiple osteotomies will be required to achieve significant correction. **(9)**

Surgical technique

The osteotomy was developed to correct thoracic hyperkyphosis by a substantial shortening of the posterior column. This was obtained by first creating and then closing wide posterior intersegmental gaps. The high destabilizing power of the osteotomy determined its successful application in scoliosis in the years to follow. A posterior midline approach and subperiosteal exposure is performed in the usual fashion, encompassing the deformity. The subperiosteal exposure should include one vertebra above and one below the fusion levels previously determined. The ligamentous structures connecting the cranial and caudal end vertebrae to be instrumented with the adjacent segments should be protected and spared. Spinous processes are resected at their base to allow better visualization of the bony parts to be removed.

An angled double-action rongeur and/or a Kerrison is used to perform the bony resections. Complete facetectomies and wide inferior and superior laminectomies are performed at every intersegmental level of the entire fusion area, obtaining gaps of 5 to 8 mm, depending on the magnitude of the deformity and the size of the patient. A generous resection of facet joints and laminae, in severe deformities as far as the pedicles, is an essential step of the osteotomy and the technique. By not doing so, bony remnants will act as hinges during the phase of compression and alter the

mechanics of correction. The ligamentum flavum is removed entirely at all levels. The gaps extend uniformly over the entire width of the posterior spine. A straight nerve root retractor of 4-5 mm width, held vertically and horizontally, is used to assess that the resections are completed thoroughly in width and in depth. The borders of the bony resections should be even, paying attention to remove any residual bony spikes. This will later permit the closure of the gaps at thoracic levels. At apical levels of severe and stiff deformities, the osteotomy should extend from pedicle to pedicle .

A marked segmental flexibility in all three planes, primarily in extension, has been established over the entire curve and will be used for the correction. Manual pressure on the apical vertebrae of a kyphosis can already induce a momentary ‘‘spring-loaded’’ reduction. **(17)**

Figure 3: Illustration of Ponte osteotomy. **(17)**

Outcome

In general, results of surgery on Scheuermann’s kyphosis can be analyzed according to the two major indications for which the surgery was carried out; pain and cosmetic deformity. **(7)**

Pain:

As far as pain is concerned, all series report an improvement in the amount of back pain, ranging 66-90%. Hosmans showed a marked improvement in the Oswestry Disability Score, from an average of 23 preoperatively down to 6.6 at follow-up. However, neck pain did not seem to improve after surgery. As far as satisfaction is concerned, most series report a very high satisfaction rate, up to 96%. **(7)**

Interestingly, There does not appear to be a strong association between deformity correction and pain relief. It was suggested that the degree of correction achieved correlates poorly with the degree of pain relief or residual back pain.

Cosmetic:

There is no cosmetic scale is available for assessment of Scheuermann’s kyphosis, and the SRS instrument on Scheuermann’s has not been published. As cosmetic correction of Scheuermann’s kyphosis should be assessed according to patient satisfaction and improvement of perceived self-image, as well as by

independent judgment of clinical photographs, before and after surgery, by non medical judges. However, literature definitively lacks such information. Therefore, judging cosmetic correction on plain X-rays represents an extrapolation of the cosmetic results. The correction rate given in the various surgical series shows a correction from an average 70–75˚ initial Cobb angle to 40–45˚ at last follow- up, i.e., a correction rate of 40–50%. **(18)**

So it's hope that the future results of Scheuermann corrective surgery will be based not only on the pure percentage of Cobb angle correction but also on outcome questionnaires such as the scoliosis SRS; the patient's sagittal balance; as well as the residual lumbar and cervical lordosis on either side of the fusion, because once a segment of the spine becomes fused, one should also take interest in the non-fused segment of the spine. **(7)**

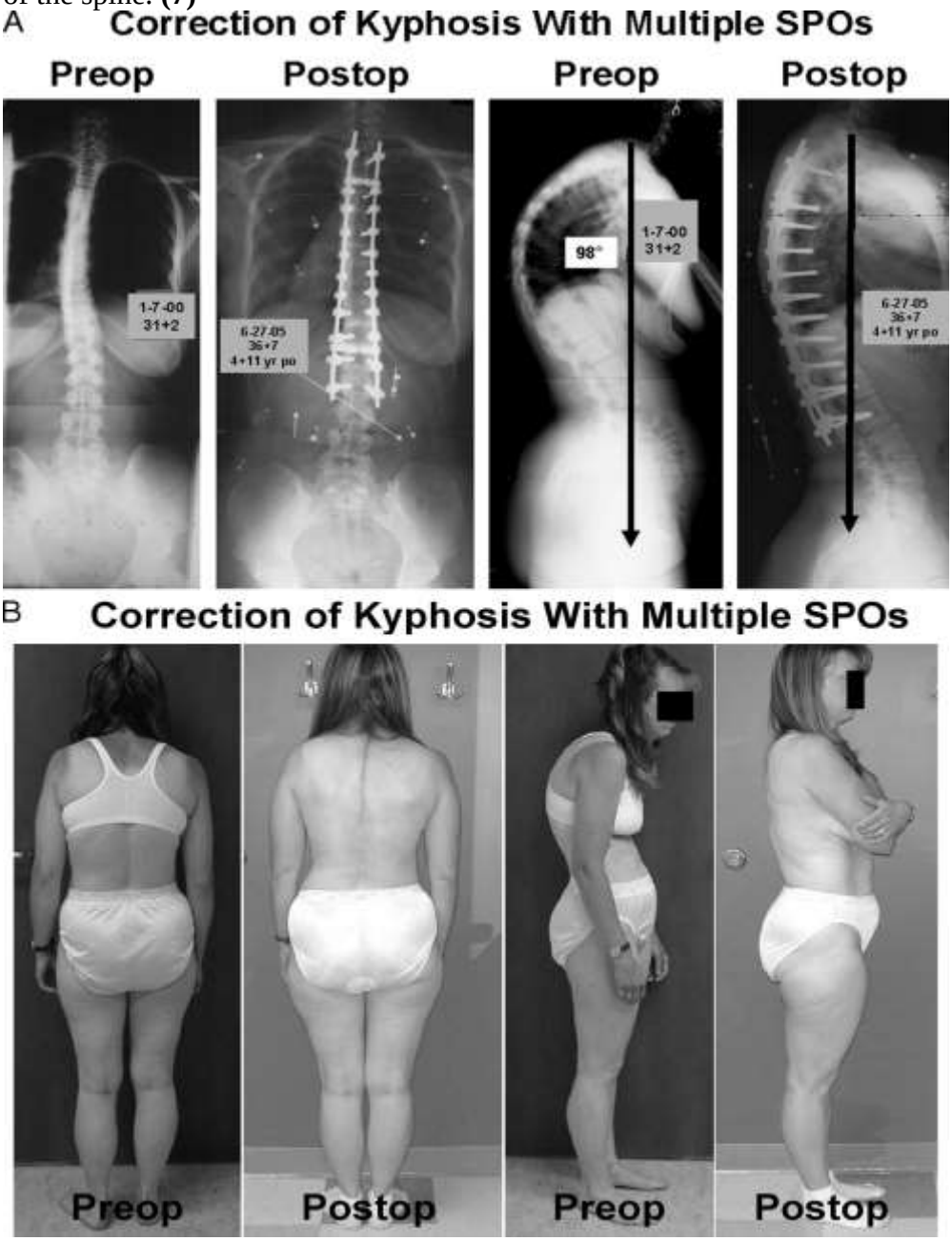

Figure 4: (**A**) Correction of kyphosis with multiple SPOs. Composite long cassette coronal and sagittal radiographs before and after treatment. A patient with Scheuermann's kyphosis with failed prior anterior and posterior surgery and 98° of kyphosis, which corrected to only 95° on supine hyperextension. This long

sweeping rounded fixed kyphosis in the thoracic spine was treated with multiple Smith-Petersen osteotomies to accomplish correction. (**B**) Correction of kyphosis with multiple SPOs.

The clinical appearance of the patient before and after surgical treatment with multiple Smith-Petersen osteotomies.

In a long-term study of patients who had undergone surgery 10 to 28 years previously, It was found that, despite different surgical treatments, most patients tended to achieve similar functional results, with no real correlation between back pain, occupation, or degree of kyphosis. Except patients with kyphotic curves >70° tended to have an inferior functional result. **(18)**

However Clinically, SPO offers some unique advantages. In comparison to the historic standard of anterior and posterior decompression and fusion for Scheuermann's kyphosis, Smith-Petersen osteotomies offer stable fixation and deformity correction with less blood loss, less operative time, and fewer complications. When compared to pedicle subtraction osteotomies, Smith-Petersen osteotomy can provide the same sagittal correction with significantly less blood loss. **(6)**

Lee et al. (19) compared 18 patients who had posterior correction using segmental pedicle-screw constructs and 12 of them had Smith- Petersen osteotomies with **Wood K B et al. (18)** who had undergone anteroposterior instrumented fusion using hybrid instrumentation at a minimum follow up of two years.

The groups were matched for age, pre-operative kyphosis and levels of posterior fusion. Surgical time and blood loss were significantly less in the posterior group. The mean pre-operative kyphosis was 84° in the posterior and 89° in the combined group. This was corrected to a mean of 38° in the posterior group with a mean loss of 2°, compared with a mean of 52° in the combined group with a mean loss of 6°. No complications occurred in the posterior group. In the anteroposterior group three patients developed a junctional deformity, one had permanent paraplegia and three a wound infection. In this study, posterior segmental pedicle-screw instrumentation with Smith- Petersen osteotomies achieved greater correction of the deformity,less mean residual kyphosis postoperatively, maintained more correction at final follow-up, had shorter surgical times, and experienced less blood loss and fewer complications compared with anteroposterior procedures with hybrid constructs. **(20)**

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