Analysis of Failures after Three Column Osteotomies of the Spine

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Disclosures:  N. Kavadi: None. R.A. Tallarico: 3B; Stryker. 5; Vertiflex. M. Sun: None. W.F. Lavelle: 2; Stryker. 5; Covidien, DePuy, A Johnson & Johnson Company, Medtronic, Vertebral Technologies, Inc..

Introduction: Fixed sagittal imbalance can be defined as a syndrome where the patient is unable to stand erect without flexing the knees and hips. Optimal sagittal balance can be achieved surgically with utilization of different types of osteotomies. Correction of fixed spinal imbalance in a sagittal and/or coronal plane frequently needs a tricolumnar wedge resection when the curve is rigid. Pedicle Subtraction Osteotomy (PSO) entails removal of a tricolumnar wedge when more significant correction and Vertebral Column Resection (VCR) involves complete resection of one or more vertebral segments for correction of moderate to severe spinal deformities. The complications typically associated with deformity correction surgery are pseudoarthrosis and implant failure located at the weak points along the construct. Increased rate of non-union at or adjacent to the level of three column osteotomy has been described in the literature. Another area highly prone to failure is the junctional segments of the spine. Recent techniques adopted by deformity surgeons have lowered the incidence of pseudoarthrosis at the lumbosacral junction.

The purpose of our study was to assess the comparative rates of pseudoarthrosis at the weaker points along lumbosacral junction and the level of osteotomy that has deficient posterior bone stock as a result of previous laminectomy. We estimated the overall incidence of implant failure in long fusions for spine deformity as well as comparatively analyzed failures at different points along the construct.

Methods: After IRB approval, twenty-six patients from 2008-2011 who had three column spinal osteotomies for correction of fixed spinal imbalance were included in this retrospective analysis. Radiographs were made prospectively and reviewed retrospectively. The study population consisted of 19 adult and 7 pediatric patients. Among the adult population, 12 were female and 7 male with a mean age of 61.3 years. The most common diagnostic category was flat back and/or sagittal imbalance for 16 of the patients. One patient presented with de novo scoliosis with predominant coronal imbalance. All seven children had surgical intervention for progressive congenital or early onset scoliosis. Postoperative follow-up ranged from 6-48 months (mean = 24 months). The procedures included were: PSO, VCR, hemivertebra excision (HE) and extracavitary corpectomy (EC). The patients were grouped according to procedure needed for correction. Standing anteroposterior (AP) and lateral radiographs were obtained preoperatively, postoperatively at 2 weeks and 3, 6, and 12 months and annually thereafter. Symptomatic implant failures were noted. Type of bone graft and graft substitutes and the type of metal and the diameter of the rod used for holding the correction were reviewed from the operative notes. Radiographic parameters studied included preoperative and postoperative segmental alignment in the lumbar and thoracic region as well as global spinal alignment, sagittal and coronal balance, lumbopelvic parameters namely sacral slope, pelvic tilt and pelvic incidence, presence or absence of interbody structural support and level and laterality of rod failure and time to implant failure. Implant failures were categorized into those occurring at or within one segment of the level of
an osteotomy and those remote from the osteotomy site. Incidence of proximal junctional kyphosis was also recorded.

**Results:** Eighteen patients underwent PSO, the predominant type of corrective osteotomy in the adult population. Fusion was extended to the pelvis to include the lumbosacral junction in seventeen adult patients while L5 was the last instrumented vertebra in two adult patients owing to the healthy L5-S1 disc with minimal signs of degeneration. Iliac bolts were inserted in sixteen of the adult patients to protect S1 screws in the relatively weak cancellous bone of the sacrum. Structural interbody graft was used in 8 patients with extension across lumbosacral junction. Transverse process hooks were used in 8 patients as proximal most points of fixation while pedicle screws were used in remaining 18 patients supported by sublaminar wires in one patient with severely osteoporotic bone. Titanium rods were used to achieve and maintain the correction in all adult patients. Two pediatric patients received a stainless steel rod. Twenty-five patients had bilateral pedicle screws as fixation anchors two levels above and below the level of osteotomy.

The level of the osteotomy was chosen based on a number of factors. Angular correction resulting from resection at one level was adequate for 22 patients while 2 patients needed more extensive osteotomy at two adjacent levels due to severe deformity while one patient needed unilateral decancellation of one adjacent segment in addition to the level of osteotomy to achieve coronal plane correction. One patient underwent bone-disc-bone type of osteotomy to achieve optimal balance. L2 was the most frequent level of osteotomy in 10 patients while 3 patients had osteotomy at L3 and L1 each. Osteotomy was located at L2 and L3 both in two patients who needed more significant correction. The level of resection was L4 in 2 patients and L5 in 2 patients while the thoracic location of osteotomy was at T8, T9, T10 and T12 in one patient each.

Seven of twenty six (27%) patients demonstrated breakage of the rod either unilateral or bilateral during the follow-up. Of the failures, one (4%) was at the lumbosacral junction and five (23%) occurred at the osteotomy level that had an accompanying same level previous laminectomy. A broken rod was noted at L2 level in three patients, L4 in two patients and L3 in one patient. Failure of both rods was evident in 5 patients while 2 patients demonstrated a unilateral broken rod. No failures were noted in patients with thoracic location of the wedge resection and pediatric patients. Implant failure was an incidental finding in 2 patients who were completely symptom free. Four patients (21%) with rod failure were symptomatic and chose to have revision surgery. Two of these patients demonstrated solid fusion at the previous non-union site at one year follow-up after revision surgery. The other 2 patients are less than one year from their surgery.

**Discussion:** Tricolumnar osteotomy by posterior approach is a valuable tool. Implant failures and pseudoarthrosis are common long term complications associated with long fusions. Our study had a 27% implant failure rate, with 86% located at the level of osteotomy, and 14% at junctional level. Rod failures were found approximately one year from surgery. 71% had increasing back pain or worsening sagittal balance, while the remaining failures were found incidentally on follow-up radiographs. The low rate of rod breakage at the lumbosacral junction site seen in our study may be related to adoption of structural interbody graft and stronger iliac screws.

A problem of pseudoarthrosis at one or multiple levels has been frequently reported in patients undergoing surgery for correction of spine deformity. Our study indicated a significantly higher rate (p=0.014) of implant failure at or adjacent to the level of tricolumnar osteotomy. This indirectly implies
higher rate of pseudoarthrosis at or adjacent to the level of osteotomy with pre-existing laminectomy, as compared to the junctional segments. This problem of non-union is likely a consequence of deficient posterior bone stock at the osteotomy site that has been rarely documented. It may also be related to the fact that the apex of a new curvature is at the osteotomy site that may subject this part to excessive stress. Therefore, a strategy needs to be developed to address this weak link in the fusion process. **Significance:** Better understanding and comparative analysis of this incidence and the mechanics of the failure will aid in surgical planning and application of suitable strategies.

*ORS 2015 Annual Meeting*

*Poster No: 1615*