

Surgical treatment of neurological scoliosis using hybrid construct (lumbar transpedicular screws plus thoracic sublaminar acrylic loops)

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Abstract In the nineties, most spinal surgeons supported the validity of segmental spine instrumentation, but this procedure has progressively been abandoned because difficult and with a high risk of neurological complications, in favor of the Cotrel-Dobousset (CD). The CD instrumentation is based on segmentation of curves, thus improving the angular correction and actuates sagittal profile. Sublaminar acrylic loops (Universal Clamp) shows the same resistance to stress as steel or titanium alloy sublaminar wires. The simple procedure and the tensioning of the strips allows re-tensioning and progressive correction. The increased contact area, improves corrective forces, thus reducing the risk of laminar fractures. The aim of this study was to verify the validity of this spinal fixation implant in the surgical treatment of a consecutive series of patients affected by neurologic scoliosis. The authors treated surgically 84 patients affected by neurologic scoliosis with an average age of 14 years (range 10–17). Universal Clamps associated with Socore TM spinal assembly, transpedicular lumbar screws and thoracic hooks at the upper end of the curve were used. The etiology of disease was cerebral palsy in 81 cases, Friedreich ataxia in two cases and Aicardi syndrome in one case. The average preoperative angular value was $73^\circ \pm 16^\circ$. It was implanted a mean of seven Clamps for each procedure (range 5–9). The average percentage of correction was 72%. Mean operative time was 240 ± 30 min with mean blood loss of 1200 ± 400 ml. No intra-operative complications occurred. Mean follow-up was 36 months. At one-year follow-up the mean loss of

correction was $7^\circ \pm 2^\circ$ with no re-intervention required. This is the first report on treatment of neurological scoliosis with this hybrid construct (lumbar screws, thoracic acrylic clamps, thoracic hooks at the upper end of the curve). In this group of patients the Universal Clamps technique appeared safe and effective and its mechanical performance is comparable to all-level screws construct. Furthermore, the kyphotic component can be better managed in case of thoracic lordosis. The most important aspect of this technique is a short operative time and low vascular and neurologic risks combined with a satisfying stability in the short-postoperative period. Nevertheless, it is important to value results on a long-term follow-up to analyze correction loss, pseudoarthrosis, and mechanical failure of the strips.

Keywords Neurological scoliosis · Cerebral palsy · Universal Clamp · Coronal correction · Sagittal balance · Operative time

Introduction

Neurological scoliosis develops at a younger age than idiopathic type. A large portion of neurological curves is progressive. Unlike idiopathic types, neurological scoliosis may continue to progress beyond skeletal maturity, particularly in tetraplegic patients. Most of the neurological curves also include the sacrum and pelvic obliquity. Patients with neurological scoliosis may have pelvic obliquity from other sources, such as hip joint and other lower extremity contractures, and this could affect the lumbar spine. The deformity progression can interfere with trunk stability. These patients are often unresponsive to brace management. In these patients spinal surgery is associated with increased bleeding, less satisfactory bone

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stock, longer fusions, and the need for fusion to the pelvis. Furthermore, those features negatively affect operative time. The rate of surgical complications is higher than in idiopathic corrective procedures (approximately 30%) [1, 2]. The success of treatment depends on the maintenance a spine balanced in the coronal and sagittal planes over a level pelvis. Several studies have shown improved curve correction with screw-only and hybrid constructs as compared to hook constructs, reporting a not significant trend toward better correction of the main thoracic curve in all-screw versus hybrid hook-screw instrumentation [3]. Moreover potential advantages of pedicle screw fixation must be balanced against its risks. Among the potential complications of thoracic pedicle screws are neurologic lesions, vascular injuries, pleural tears, and increased radiation exposure during screw placement. Considering that hybrid constructs are associated with a low risk of complications and a good sagittal correction, the authors combined lumbar transpedicular screws and thoracic Universal Clamps (UC) in neurological scoliosis treatment. The UC technique was first described by Mazda et al. [4]. UC combines stability of pedicle screws, straightforwardness, potential correction of Luque wiring, increased surface of bone contact, allowing a greater reduction in forces. Moreover, it is possible to perform a retensioning and a progressive correction because of the simplicity of the implant and tensioning of the strips. The increased contact area improves corrective forces and reduces laminar fracture risk. Mazda et al. [4] demonstrated the efficacy and safety of UC posteromedial translation technique to correct adolescent idiopathic scoliosis. The aim of this study is to assess the validity of the hybrid construct in a prospective series of patients affected by neurological scoliosis.

Materials and methods

Between January 2006 and December 2008 the authors treated 84 patients (27 M, 57 F) affected by neurological scoliosis. Data were prospectively collected in all patients. Mean age was 14 years (range 10–17). The etiology was cerebral palsy in 81 cases, Friedreich's ataxia in 2 cases and Aicardi syndrome in 1 case. The average Cobb angle was $73^\circ \pm 16^\circ$. All patients were treated by posterior access to stabilize each affected level, combining screws (Socore TM spinal assembly), UC and hooks in a hybrid construct. In order to reduce intraoperative blood loss the authors used Caprolisin® (aminocaproic acid), 100 mg/kg in 15 min of anesthesia induction, then 10 mg/kg in the remaining time of the intervention. The Universal Clamp is made of three components: a woven polyester band (Dacron), a titanium alloy (or stainless steel) clamp, and a locking screw (titanium alloy or stainless steel).

The authors tried to achieve nearly 100% of implant density on the correcting rod [5]. In three patients presented high rate and rigid thoracic deformity a second posterior surgery was scheduled 15 days after in order to strengthen the effect obtained by concave ribs section by adding UC.

In all cases with pelvic obliquity greater than 20% skull traction was performed by sling and pelvic traction to control obliquity were used. Pelvic instrumentation was performed by iliosacral screw fixation according to Miladi et al. [6] or iliac fixation as described in literature [7]. The authors used two rods in the concave side of the curve and one or two in the convex side in all cases. Iliosacral screws were directly linked to a long-rod, or a short-rod was used according to Moe construct (Fig. 1). The correction was then performed by distraction and contraction maneuvers applied between the long- and short-rods, preceded by translation maneuvers. A square construct was created by applying 2 or 3 transverse connectors (DTT) and then sequential tensioning of the Clamps was performed.

Perioperative (30-day) results were evaluated in terms of technical success (deformity correction), operative time and blood loss. Deformity correction was further evaluated at clinic and radiographic controls performed at 1, 3, 6 months and 1 year thereafter.

Results

The average percentage of correction was 72% (mean postoperative Cobb: $21^\circ \pm 7^\circ$). Mean operative time was 240 ± 30 min with mean blood loss of 1200 ± 400 ml. It was used a mean of 6 transpedicular screws (range 4–11), 7 UC (range 5–9), and 5 hooks (range 4–6). Pelvic instrumentation was performed by iliosacral screw fixation or iliac fixation, with a pelvic obliquity correction ranging from 65 to 100%. Particularly, in those cases with a pelvic obliquity lesser than 15° a fusion up to L5 was performed, in those with a pelvic obliquity between 16° and 25° a monolateral iliac fixation was made, and in those with a pelvic obliquity greater than 25° a bilateral iliac fixation was performed. In the construct the implant density was about 90% on the correcting rod and about 50% on the stabilizing rod (Fig. 2). Mean radioscopy time was 6 ± 1.5 s. No intraoperative complications occurred. Perioperative (30-day) major complication was pneumothorax in five cases, minor complications were pleural effusion in three cases and intestinal disorders in six patients (overall complication rate 16.6%). No procedure-related death occurred. In the postoperative period a brace was used for 3–5 months. Mean follow-up time was 36 months (range 20–57) after brace removal. No early or late infection has been recorded. All patients underwent 1 and 2-year

Fig. 1 Cerebral palsy scoliosis (pre-operative Cobb angle: 85°) corrected to 15° by the hybrid construct (18° at 2 years follow-up, 80% correction). Bending test shows the extreme rigidity of the curve. Pelvic obliquity was completely corrected by an iliac screw placement

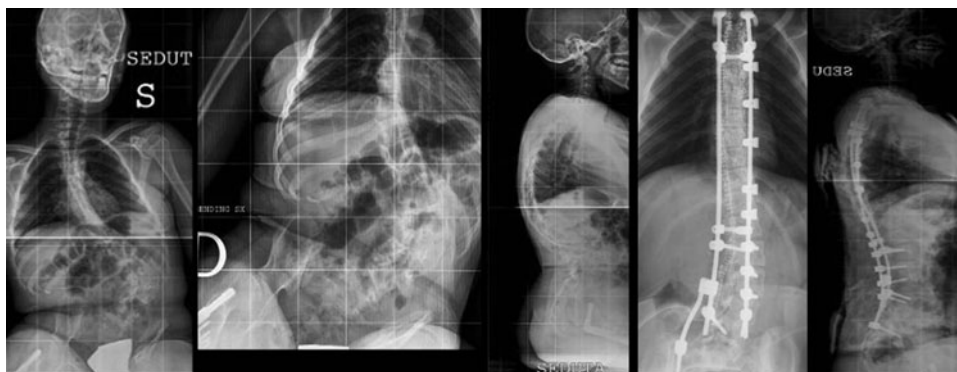
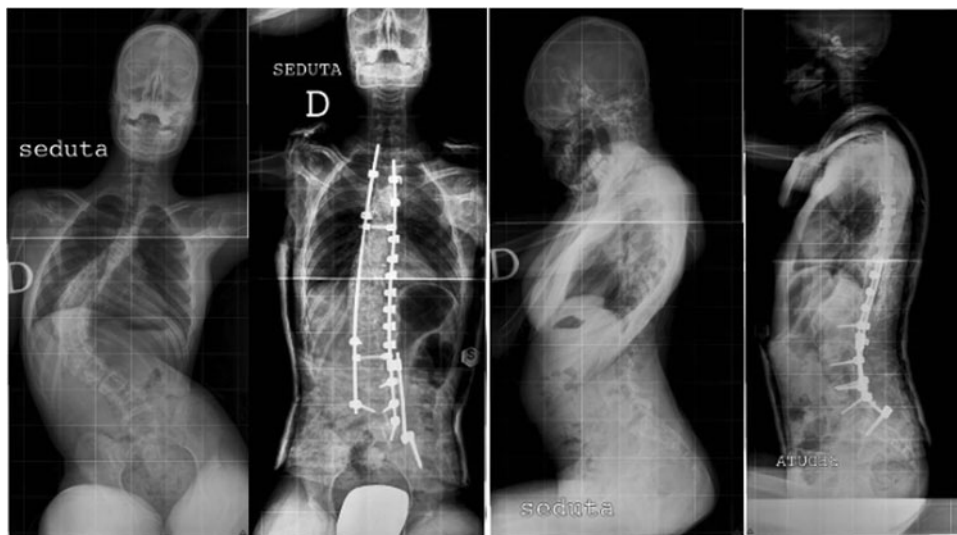


Fig. 2 Cerebral palsy scoliosis: implant density was 85% on the correcting rod and nearly 30% on the stabilizing rod. Post-operative frontal and sagittal profiles showing the optimal deformity resolution



follow-up examinations. The mean loss of correction in the coronal plane was $7^\circ \pm 2^\circ$ with no pelvic misplacement or iliac screw stress shielding at 1-year follow-up. No further loss of correction was observed in the subsequent assessments. No anterior surgery or re-intervention was required. Results are summarized in Table 1.

Discussion

Neurological scoliosis is characterized by long curves, pelvic obliquity, and loss of trunk stability, resulting in difficulty to maintain a sitting position on the wheelchair. Spinal surgery in these patients is associated with increased bleeding, longer fusions, and the necessity for fusion to the pelvis, that negatively affects operative time. Blood loss increases progressively with increasing number of vertebral levels treated. The hybrid construct (lumbar transpedicular screws, thoracic Universal Clamps, pedicle-transverse hooks at the upper end of the curve) provides a good correction of the deformity and reduces operative time, radiation exposure, and blood loss when compared to all-screws constructs.

Table 1 Peri-operative (30-day) and 1-year follow-up results in a consecutive series of 84 patients treated for neurological scoliosis

Total number of patients	84
Male (%)	27 (32.1)
Female (%)	57 (67.9)
Mean age (range)	14 (10–17)
Pre-operative Cobb angle (mean \pm SD)	$73^\circ \pm 16^\circ$
Post-operative Cobb angle (mean \pm SD)	$21^\circ \pm 7^\circ$
% of correction (mean \pm SD)	72 ± 7
Operative time (minutes; mean \pm SD)	240 ± 30
Blood loss (ml; mean \pm SD)	1200 ± 400
Radioscopy time (seconds; mean \pm SD)	6 ± 1.5
Peri-operative complications	16.6%
1 year F-UP loss of correction (mean \pm SD)	$7^\circ \pm 2^\circ$

Modi et al. [1] reported satisfactory coronal and sagittal correction with posterior-only pedicle screw fixation with a low complication rate in cerebral palsy patients. Kim et al. [3] reported that all-screw constructs provided significantly better curve correction than all-hook constructs and improved pulmonary function values in idiopathic patients.

Moreover, lumbar pedicle screws have been found to offer greater lumbar curve correction and better maintenance of correction than hooks constructs [8]. Hamill et al. [9] reported a better correction, translation, and horizontalization of the lumbar spine in patients with idiopathic scoliosis treated by pedicle screws compared with those treated by all-hook systems. In the instrumentation the authors used a mean of 4 convex-side and 2 concave-side lumbar transpedicular polyaxial screws, obtaining a good correction of the curve with no complication.

Lowenstein et al. [10] observed a non-significant trend toward better correction of the main thoracic curve in all-screw versus hybrid hook-screw instrumentation. Upendra et al. [11] recently reported a 10% pedicle screw misplacement rate in scoliosis patients using an outcome-based classification. Watanabe et al. [12] in a retrospective comparative study on treatment of scoliotic curves (mainly neuromuscular) greater than 100°, reported that all sublamina wires, hooks, anterior vertebral screws, and pedicle screws constructs were able to achieve and maintain acceptable correction safely without permanent neurologic deficit and demonstrated acceptable implant failure rate. At thoracic level it was mainly used UC on the concave side and one or two UC on the convex side. UC produced a posteromedial translation of the spine toward the rods providing a good rotational correction. In three patients a second posterior surgery was scheduled 15 days after in order to strengthen the effect obtained by concave ribs section by adding several UC, thus treating a rigid thoracic deformity.

In the experience this technique achieved a mean reduction of 72% in the frontal plane. Vora et al. [13] reported that pedicle screw constructs further lordosed the thoracic spine. In all patients the deformity reduction technique used with the UC provided an increase of thoracic kyphosis progressively translating the spine toward the rods linked with rigid transverse connectors in the sagittal plane. Neither slippage of one band inside the clamp nor lamina breakage was found.

Clements et al. [5] recently demonstrated the correlation of scoliosis curve correction with number and type of fixation anchors. They defined the number of fixation anchors placed per available anchors sites as “implant density”. Implant density on the correcting rod had a higher correlation with structural curve correction than with the stabilizing rod. A review of the series showed that the implant density was about 90% on the correcting rod and about 50% on the stabilizing rod.

The learning curve period is usually shorter if the surgeon has experienced the segmental spine instrumentation procedure [14] and the posterior segmental instrumentation [15]. In the experience the learning curve operative time, calculated on the first ten cases, resulted only 30 min

longer than the usual procedure. The overall operative time and radiation exposure time are reduced compared to surgical procedures in which all levels-screws are used.

Kasimian et al. [16] have shown that the use of an antifibrinolytic (Aprotinin) resulted in decreased blood loss and decreased rate of transfusions in children with neuromuscular scoliosis undergoing extensive spinal fusion. In the experience it was intraoperatively used Caprolisin® (aminocaproic acid) with mean blood loss of 1200 ± 400 ml. All patients received a mean of three homologous blood transfusions in the perioperative time. No adverse drug reaction occurred.

Conclusion

This is the first report on treatment of neurological scoliosis using this kind of hybrid construct (lumbar transpedicular screws, thoracic Universal Clamps, pedicle-transverse hooks at the upper end of the curve). This construct appears safe and effective in neurological scoliosis treatment, providing a good correction of the deformity and reducing operative time, radiation exposure time, and blood loss compared to all-screws constructs. The amount of coronal correction is excellent and the control of sagittal profile seems better than with all-screws assembly. Sublamina acrylic loops (Universal Clamp) have the same stress resistance as steel or titanium alloy sublamina wires, providing a better capacity of managing the kyphotic component in case of thoracic lordosis.

The ideal surgical corrective procedure for scoliosis should provide excellent coronal correction, optimal sagittal correction, no time-consuming procedure, less X-rays exposure, and less blood transfusions. Universal Clamps plus lumbar transpedicular screws can be considered a S.E.R.LE. surgery: Safe (no dural leakage or neurological complication), Effective (mean coronal correction of 72%), Reliable (short learning curve), and Less Expensive (cheaper than all-screw constructs in some Countries). All the results show that the authors must take into account this procedure if the authors plan a neurological scoliosis treatment.

Conflict of interest None.

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