Effects of reduction and fixation of the screw-rod connection on pedicle screw anchorage: a biomechanical study

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Background

Pedicle screw loosening is one of the most frequent complications after instrumented posterior thoracolumbar fusion, with an incidence up to 15% in good bone quality [1] and up to 63% in osteoporotic bone [2]. Recent studies suggest that the majority of screws later identified as loosened were pulled out during reduction and tightening of the screw-rod connection [3,4]. These mechanically critical procedures can lead to biomechanical overload of the implant construct and surrounding tissues, which in turn is associated with an increased risk of revision surgery.

Purpose

The purpose of this study is to investigate the effects of reduction and fixation as well as the influence of additional distraction forces on pedicle screw anchorage during construct assembly and locking.

Human cadaver specimens with instrumentation between T5-S1: Upper: Neo pedicle screws with screw extender guides; Lower: Solera pedicle screws with rod in situ after reduction and tightening.

Methods

Biomechanical study, two human cadaver specimens, each with 13 segments (T5-S1), were fixed in direct side-by-side comparison using pedicle screw rod systems of different fixation philosophies (controlled fixation (CF): Neo Pedicle Screw System; standard fixation (SF): CD Horizon Solera).

The insertion torques were digitally recorded. After assembly and locking of the construct, the specimen was left a short period before the rod was removed and the screws were extracted. The extraction torques of the screws were digitally recorded. The effects of reduction and final fixation of the construct were evaluated by comparing the torque losses between insertion and extraction of both groups. In addition, the impact of distraction forces (100N) applied directly across the screw heads on pedicle screws in polyurethane foam blocks of certain densities was investigated. Statistical significance ($p < 0.05$) was determined using a Mann-Whitney test, and correlation analyses were performed using the Spearman method.

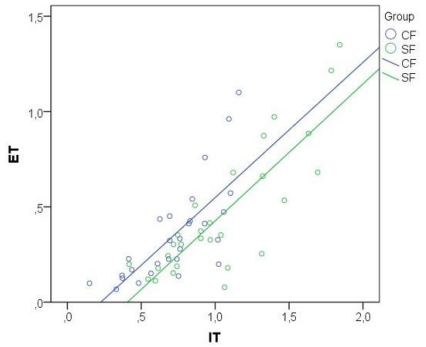

Figure 2. IT and ET correlate statistically significant with each other for both **CF** (r=0.792; p<0.001) and **SF** (r=0.783; p<0.001).

Measure	Group	N (valid)	Median Torque [Nm]	25% - 75% Torque Interval [Nm]	P
IT	CF	28	0.747	0.503 - 0.931	0.004
	SF	28	0.966	0.724 - 1.327	
ET	CF	28	0.301	0.156 - 0.447	0.272
	SF	28	0.344	0.191 - 0.675	
Delta	CF	28	0.393	0.233 - 0.507	<0.001
	SF	28	0.539	0.437 - 0.681	

Figure 1: Cadaver measurements by fixation philosophy group. Pedicle screw IT and ET after reduction and tightening of the screw-rod assembly for CF and SF.
IT, insertion torque; ET, extraction torque; Delta, IT – ET; CF, controlled fixation; SF, standard fixation; P, between group p-value (CF vs. SF using Sample Mann-Whitney U Test)

Results

With CF, the median torque loss of 0.393Nm was significantly lower than with SF (0.539Nm) ($p<0.001$). Despite higher insertion torques with SF (0.966 vs. 0.747Nm), extraction torques were similar (0.344 vs. 0.301Nm) (Fig.1). Insertion and extraction torques correlated statistically significant with each other (CF: r=0.792 and SF: r=0.783; $p<0.001$) (Fig. 2).

Torque losses were higher in both groups when additional distraction forces were applied directly across pedicle screw heads ($p \leq 0.041$).

Conclusions

Reduction and tightening of the rod-screw interface have a relevant impact on pedicle screw anchorage. The loss of biomechanical behavior and consequently the load transferred to the instrumentation and the surrounding tissue is lower if the instrument assembly is performed in a controlled manner. Controlled fixation technique means that lower forces are applied during reduction and tightening of the pedicle screw construct. As a result, the patient's individual anatomical and biomechanical balance is more respected. This has the potential to reduce pedicle screw loosening, construct failure, and reoperation rates, and improve clinical outcomes.

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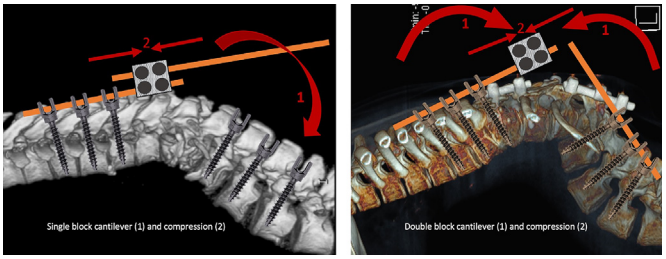
different rod cantilever techniques is effective for the reduction of thoracic pedicle subtraction osteotomy achieving satisfactory radiological and clinical outcome. The distribution of correctional forces across multiple screws avoids intraoperative mechanical complications and increases the power of simultaneous compression at the osteotomy site together with the adjacent levels



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EFFECTS OF REDUCTION AND FIXATION OF THE SCREW-ROD CONNECTION ON PEDICLE SCREW ANCHORAGE: A BIOMECHANICAL STUDY

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Background Pedicle screw loosening is one of the most frequent complications after instrumented posterior thoracolumbar fusion, with an incidence up to 15% in good bone quality [1] and up to 63% in osteoporotic bone [2]. Recent studies suggest that the majority of screws later identified as loosened were pulled out during reduction and tightening of the screw-rod connection [3,4]. These mechanically critical procedures can lead to biomechanical overload of the implant construct and surrounding tissues, which in turn is associated with an increased risk of revision surgery. Purpose The purpose of this study is to investigate the effects of reduction and fixation as well as the influence of additional distraction forces on pedicle screw anchorage during construct assembly and locking. Methods Biomechanical study, two human cadaver specimens, each with 13 segments (T5-S1), were fixed in direct side-by-side comparison using pedicle screw rod systems of different fixation philosophies (controlled fixation (CF): Neo Pedicle Screw System; standard fixation (SF): CD Horizon Solera). The insertion torques were digitally recorded. After assembly and locking of the construct, the specimen was left a short period before the rod was removed and the screws were extracted. The extraction torques of the screws were digitally recorded. The effects of reduction and final fixation of the construct were evaluated by comparing the torque losses between insertion and extraction of both groups. In addition, the impact of distraction forces (100N) applied directly across the screw heads on pedicle screws in polyurethane foam blocks of certain densities was investigated. Statistical significance ($p < 0.05$) was determined using a Mann-Whitney test, and correlation analyses were performed using the Spearman method. Results With CF, the median torque loss of 0.393Nm was significantly lower than with SF (0.539Nm) ($p<0.001$). Despite higher insertion torques with SF (0.966 vs. 0.747Nm), extraction torques were similar (0.344 vs. 0.301Nm) (Fig.1). Insertion and extraction torques correlated statistically significant with each other (CF: $r=0.792$ and SF: $r=0.783$; $p<0.001$). Torque losses were higher in both groups when additional distraction forces were applied directly across pedicle screw heads ($p \leq 0.041$). Conclusions Reduction and tightening of the rod-screw interface have a relevant impact on pedicle screw anchorage. The loss of biomechanical behavior and consequently the load transferred to the instrumentation and the surrounding tissue is lower if the instrument assembly is performed in a controlled manner. Controlled fixation technique means that lower forces are applied during reduction and tightening of the pedicle screw construct. As a result, the patient's individual anatomical and biomechanical balance is more respected. This has the potential to reduce pedicle screw loosening, construct failure, and reoperation rates, and improve clinical outcomes.

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Disclosures: Konstantinos Kafchitsas royalties;Company=Globus, Philipp Drees none; Philipp Kobbe consultant;Company=Stryker, David C. Noriega consultant;Company=Stryker, neo spine, Pierce D. Nunley grants/research support;Company=Styrker, Zimmer, NuVasive, Spineology, Centinel Spine, Providence Medical, 3Spine,consultant;Company=Stryker, Zimmer, Spineology, Camber Spine, Accelus, Centinel Spine, Intrinisic Therepeutics, Providence Medical, Neo Spine, NG Medical, Regeltec,stock/shareholder;Company=Spineology, Camber Spine, Regeltec,royalties;Company=-Stryker, Zimmer, Camber Spine, Accelus, Spineology, Hugues Pascal-Moussellard consultant;Company=neo, Robert K. Eastlack grants/research support;Company=Nuvasive, Seaspine, Medtronic, AO,consultant;Company=Nuvasive, Seaspine, SI Bone, Medtronic, Spinal Elements, Biederman Motech, Carevature,stock/shareholder;Company=Alphatec, Nuvasive, Seaspine, SI Bone, Spine Innovation,royalties;Company=Globus, SI Bone, Seaspine, Nuvasive, Aesculap

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CERVICAL DISC REPLACEMENT VERSUS MINIMALLY-INVASIVE POSTERIOR CERVICAL FORAMINOTOMY IN THE TREATMENT OF CERVICAL RADICULOPATHY

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Introduction: Adjacent segment degeneration is one such complication in anterior cervical discectomy and fusion (ACDF) that is often associated with the loss of a motion segment. Pseudarthrosis is another complication that spine surgeons aim to avoid. As a result, motion preservation techniques such as cervical disc replacement (CDR) and minimally- invasive posterior cervical foraminotomy (MI-PCF) have been used as an alternative to ACDF with the goal of decreasing fusion related complications.
Purpose: The purpose of this study is to compare the motion preserving techniques of CDR and MI-PCF in the treatment of single-level cervical radiculopathy.
Methods: A retrospective review was performed to identify all patients who underwent either single-level CDR or MI-PCF for single-level unilateral cervical radiculopathy due to lateral pathology from 2012-2017 with a minimum follow-up of 2-years. Patients with myelopathy were excluded. Improvement in functional outcome scores were compared between both cohorts. Revision rate, as well as average time to revision, were also compared. All complications were reviewed. Standard binomial and categorical comparative analysis were performed.
Results: 119 patients were included in the study with an average follow-up of 49.2 months. 57 patients underwent CDR and 62 patients underwent MI-PCF. Both cohorts experienced significant improvement in all functional outcome scores (NDI, VAS-arm, VAS-Neck). There was no significant difference between the revision rates of the CDR and MI- PCF cohorts (3.5% vs 6.4%, $p=0.68$). The average time to revision of the CDR cohort was 10.5 months, while the MI-PCF cohort was 12.4 months ($p=0.28$). The most common complication of CDR was subjective post-operative dysphagia, while the most common complication of MI-PCF was transient neuropraxia, all of which resolved by final follow-up.
Conclusion: The results from our study suggest similar clinical and functional outcomes between single level CDR and MI-PCF for the treatment of unilateral cervical radiculopathy without myelopathy. In the right patient, CDR and MI-PCF can be effective motion preserving alternatives to ACDF to avoid fusion related complications.