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Open versus Percutaneous Stabilization of Thoracolumbar Spine Fractures: A Short-Term Functional and Radiological Follow-up

Srovnání otevřené a perkutánní stabilizace thorakolumbálních zlomenin páteře: krátkodobé funkční a radiologické výsledky

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ABSTRACT

PURPOSE OF THE STUDY

A prospective cohort study evaluates the functional and radiological outcome of thoracolumbar spine fractures treated either with open or percutaneous dorsal instrumentation.

In recent years, several studies advocate percutaneous stabilization of spinal fractures in patients without neurological deficits. However, it is still debated whether percutaneous stabilization is superior to open dorsal instrumentation in spinal trauma.

MATERIAL AND METHODS

This study was performed between 2010 and 2012 at a Level 1 trauma center. Patients treated either with an open or a percutaneous dorsal instrumentation for traumatic fractures of the thoracolumbar spine (T11 to L2) were included. Fracture morphology, screw positioning and clinical parameters were analyzed. Standardized questionnaires (VAS-spine-score; Oswestry-disability-score; SF-36) and follow up radiographs were performed.

RESULTS

Overall 72 patients (29 percutaneous; 43 open) could be included. The surgical and the early postsurgical course were similar between both groups. Furthermore the operative approach had no influence on the functional and radiological outcome one year after surgery, but the questionnaires showed moderate impairments within both groups. Also both groups showed a significant loss of reduction after the first postoperative month ($p < 0.01$).

Within the open group a significantly higher amount of fracture reduction ($p < 0.01$) and a significantly reduced intraoperative radiation exposure was seen (open 105.9 sec.; percutaneous 143.1 sec; $p < 0.05$); whereas the percutaneous approach was associated with significantly reduced intraoperative blood loss (open 2.2 g/dl; percutaneous 1.2 g/dl; $p < 0.001$).

CONCLUSION

The functional and the radiological outcome of both groups was comparable one year after trauma. Minor advantages of the percutaneous system was less blood loss, whereas the open approach was associated with a significantly higher amount of initial reduction and significantly less intraoperative radiation exposure. Independent from the type of posterior fixation loss of reduction was already significant in the early postoperative course.

Key words: percutaneous instrumentation; thoracolumbar fracture; outcome; loss of reduction.

INTRODUCTION

In recent years, several studies advocate percutaneous stabilization of spinal fractures in patients without neurological deficits (1, 4, 7, 8, 10, 12, 16, 20, 27–29). However, it is still debated whether percutaneous stabilization is superior to open dorsal instrumentation in spinal trauma. Advocates of percutaneous dorsal stabilization emphasize that this technique is associated with less intraoperative blood loss, shorter operation time, reduced risk for infections, reduced postoperative pain, and shorter hospitalization (6, 7, 8, 16, 20, 27, 29). However, opponents point out that percutaneous instrumentation is associated with higher radiation exposure, less intraoperative reduction and increased loss of reduction in the course (7, 11, 12, 16, 17, 27). Accuracy of pedicle screw placement is reported to be comparable between percutaneous and open instrumentation (7, 9, 10, 16, 23, 28).

The aim of this study was to compare the functional and radiological outcome between patients with thoracolumbar spine fractures treated either with open or percutaneous dorsal instrumentation one year after trauma.

MATERIAL AND METHODS

Study design

This study was designed as a prospective single-centre (Level 1) cohort study. Patients treated either with open or percutaneous dorsal instrumentation for a traumatic fracture of the thoracolumbar spine (T11 to L2) between May 2010 and May 2012 were subjected to standardised questionnaires and radiographs within the routine clinical follow-up. Excluded were patients younger than 18 years of age and those with neurological deficits, or polytrauma. Furthermore, patients treated with vertebro-/kyphoplasty or cement-augmented pedicle screws were excluded.

Ethics

This study was performed in accordance with the ethical standards of the responsible Committee on human experimentation and with the Helsinki Declaration of 1975, as revised in 2000.

Surgical procedure

Overall patients were treated by four different trauma surgeons. According to the fracture type, intraoperative closed reduction was performed by patient positioning and manual maneuver. It was not related to fracture type or any other objective criteria. The open group was treated by a conventional medial dorsal approach with the Universal Spine System (USS 1; Synthes®). In the percutaneous group the Longitude System (Medtronic®) was used. The entry point to the pedicle was determined by fluoroscopy and a 1.5 cm skin incision was set for instrumentation. The rods were inserted cranially over additional incisions.

In all patients posterior fixation was performed using 4 transpedicular screws. In case of incomplete burst fracture monosegmental instrumentation was performed if possible. In all other cases bisegmental technic was applied.

Initially all patients were treated using a stand-alone posterior fixation. Within follow-up a CT-scan was perform to verify bone healing. In case of nonunion ventral fusion was performed in the course.

Endpoints

Demographic and clinical data

Demographic and clinical parameters were obtained from the medical record. All fractures were classified regarding the established AO Classification (18) and the McCormack load sharing classification (19). Recorded data included operation time and time of intraoperative fluoroscopy. Blood loss was determined as the difference between the pre- and postoperative Hb-value. Blood transfusions were determined on the individual charts. Postoperative complications and revisions were categorized and documented. The time of hospital stay was separated into time of standard care and intensive care stay.

Radiological outcomes

Screw positioning was classified according to Zdichavsky (30) in three types: optimal (Type A1), suboptimal (Type A2-B2) and need for revision (Type C1-C2). Similar to the multicenter study of Siebenga et al. (24) reduction and loss of reduction was measured by the regional sagittal angle (RSA) and the local sagittal angle (LSA) by two experienced trauma surgeons. This was done pre- and postoperatively and at five different follow up radiographs. For statistical analyses, all measured angles were compared to the intraoperative result. By this procedure the amount of reduction loss could be evaluated. In case of anterior fusion in the course, measurement of reduction loss was stopped at the time of this second procedure. Consequently falsifying influence of anterior fusion regarding the results of reduction loss in the course was eliminated.

Functional outcomes

After written consent was obtained, four different questionnaires (VAS Spine Score, a modified pain scale, the Oswestry disability index, and the SF-36) were distributed to patients by routine medical follow up or by mail to evaluate the pain level and the quality of live.

The VAS-spine-score focuses on the description of pain in different life situations. It comprises 18 questions which are scored on a 100-mm visual analogue scale. A minimum score of zero is equal to the worst result (severe disability), while a score of 100 reflects the best result (no disability) within the context of the question (15, 24).

The modified pain scale focuses on the course of pain. Subjective pain intensity should be classified from zero (best) to ten (worst) on a visual analogue scale at different times in the course of treatment.

The Oswestry disability index (ODI) is a functional, disease specific instrument for low back pain. It includes ten questions on limitations of daily living. Zero to five points per question are added and the doubled total score represents the deficits of the subjective health state within a range between 0 % (best health state) and 100 % (worst health state), (5, 25).

General health status was assessed by using the SF-36 questionnaire. It is particularly suitable because of its high reliability and the possibility of comparing results to a high number of representative populations. Mental and functional outcome are measured by 36 Questions within eight subscales of health. It is already translated and validated for the German population (2, 29).

Statistical analysis

The deidentified data were analyzed using SPSS (Version 20, 76 Chicago, IL, USA). Data are presented as absolute means and as mean percentage values. Continuous variables were compared using the Mann–Whitney U-test in case of not normal distributed data. The Chi-squared-test was used to compare the counts of categorical responses between two independent groups. Analysis of variance (ANOVA) was used to compare between means of more than two groups for data of a normal

distribution and homogeneity of variance. Fisher's exact test was used in the analysis of contingency tables. Statistical significance was defined as $p < 0.05$.

RESULTS

Between June 2010 and June 2012, 72 patients fulfilled the inclusion criteria. 43 patients were managed with open and 29 patients with percutaneous dorsal instrumentation. There was no significant difference in age (open 50.4 years; percutaneous 53.1 years; $p > 0.05$) and gender distribution (open n = 22 male, n = 21 female and percutaneous n = 13 male, n = 16 female; $p > 0.05$) between the groups (Table 1).

Predominantly the vertebral bodies T12 (n = 19) and L1 (n = 31) were involved with T11 (n = 4) and L2 (n = 18) less frequently fractured. There was also no significant difference in the distribution of the localization of fractured vertebra ($p < 0.05$), (Table 1).

The predominant fracture type was burst fracture (overall 69.4 %; Type A3.1: n = 29; Type A3.2: n = 3; Type A3.3: n = 18). There was no significant difference regarding the distribution of burst fractures between the groups (open 69.8 %; percutaneous 69 %; $p < 0.05$). The remaining fractures were classified as Type A1.3 (n = 12), as Type A2.3 (n = 7) and as Type B.1.2 (n = 3) using the AO (Magerl) Classification (Table 1).

Regarding the McCormack Load Sharing Classification, 21 patients achieved three or four points, 29 had five or six points and 22 patients had seven or more points. There was no significant difference between the groups (open 5.56 points; percutaneous 5.34 points; ($p < 0.05$)).

Time of operative procedure was comparable in both groups (open 110.1 min; percutaneous 114.3 min; $p < 0.05$). The time of intraoperative fluoroscopy was significantly longer in the percutaneous compared to the open group (open 105.9 sec.; percutaneous 143.1 sec.; $p < 0.05$).

The amount of intraoperative blood loss was significantly higher in the open compared to the percutaneous group ($p < 0.001$). On average we found hemoglobin to decrease by 2.2 g/dL in the open group and 1.2 g/dL in the percutaneous group. Furthermore, four patients received a blood transfusion in the course of hospital stay (open 3, percutaneous 1).

The length of hospital stay was almost equal in both groups (open 9.63 d; percutaneous 10.04 d; $p > 0.05$), and there was no significant difference in time of intensive care stay (open 0.28 d; percutaneous 0.22 d; $p > 0.05$).

Overall 29 patients (open 22 of 43; percutaneous 7 of 29; $p > 0.05$) received an anterior fusion within the follow up period. Anterior fusion was performed a mean 116 d after the first operation (open 109 d; percutaneous 137 d; $p > 0.05$). 19 patients were treated with vertebral body replacement (cage with or without additive plate fixation) and ten with tricortical bone graft (with or without additive plate fixation).

Complications

We observed no major complications such as neurological deficits or vascular injuries. Overall five revision surgeries were performed (open n = 4 (9.3 %); percutaneous n = 1 (3.4 %); $p > 0.05$): Implant failure with progressive loss of reduction requiring elongation of the instrumentation was observed in four cases (open n = 3; percutaneous n = 1). A total of nine screws fulfilled the radiological criteria for screw correction (Zdichavsky Type C), (Table 2); however, missing clinical correlation and reduced general health status resulted in correction of only two screws (one patient) following an open stabilization. There were no wound infections, seroma, postsurgical bleedings or other minor complications observed.

Table 2. Showing screw positioning regarding to Zdichavsky-classification

Accuracy of pedicle screw positioning	approach		Σ
	open	percutaneous	
Type A1 (optimal)	122	77	199
Type A2 (suboptimal)	12	7	19
Type B1 (suboptimal)	1	0	1
Type B2 (suboptimal)	1	3	4
Type C1 (need for revision)	2	0	2
Type C2 (need for revision)	6	1	7
Σ	144	88	232

Table 1. Demographic data and location of the fractures separated to the operative approach

		Open		Percutaneous		Significance between open and percutaneous group
		absolute	%	absolute	%	
Gender	female	21	48.8	16	55.2	n.s.
	male	22	51.2	13	44.8	
Age	av. in years	50.4		53.1		n.s.
Fractured vertebra	T 11	2	4.7	2	6.9	n.s.
	T12	12	27.9	7	24.1	
	L 1	19	44.2	12	41.4	
	L2	10	23.3	8	27.6	

Radiological outcomes

Screw placement accuracy could be evaluated for 232 screws. 85.8 % (n = 199) of all screws were placed in optimal positions, 10.3 % (n = 24) were placed suboptimally, and 3.9 % (n = 9) fulfilled radiological revision requirements (Table 2). There was no significant difference between the accuracy of pedicle screw placement in the open and percutaneous groups.

The sagittal deformity was preoperatively higher in the open group (LSA initial: open 3.07° vs. percutaneous 0.04°; $p < 0.05$; RSA initial: open 7.76° vs. percutaneous 5.67°; $p > 0.05$).

Consequently, the amount of initial reduction was significantly higher in the open group (LSA improvement: open 9.12° vs. percutaneous 5.07°; $p < 0.01$; RSA improvement: open 10.95° vs. percutaneous 5.85°; $p < 0.01$), (Figs 1 and 2).

Within follow up patients of both groups presented with continuous loss of reduction ($p < 0.05$ after one week: LSA-loss for both systems 3.1°, RSA-loss open 5.31°, percutaneous 3.55°; $p < 0.01$ after one month: LSA-loss open 7.66° vs. percutaneous 7.67° RSA-loss open 6.32° vs. percutaneous 5.63°), without significant differences between the groups. At the final follow up, the open group had a RSA and LSA of -1.31° and -0.14° respectively, while the percutaneous group had a RSA and LSA of -4.43° and -1.94°, compared to the preoperative measured angles (Figs 1 and 2).

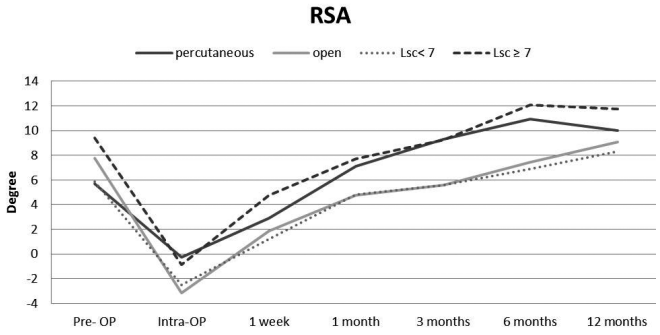

Fig. 1. Illustration of the regional sagittal angle (RSA) within a one year follow-up.

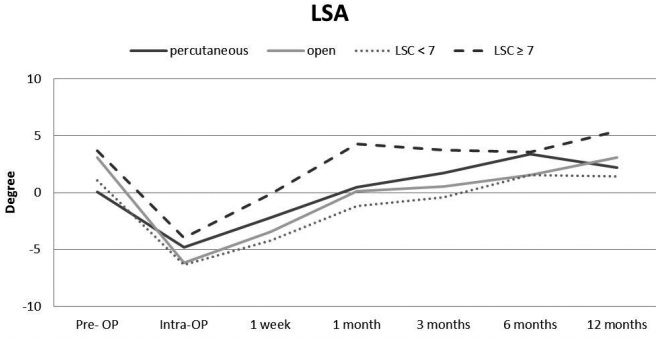

Fig. 2. Illustration of the local sagittal angle (LSA) within a one year follow-up.

The loss of reduction was most pronounced within the first three months after the operation (LSA and RSD: > 70 % in both groups). Consequently the further loss of reduction after three months presented itself in a much slower fashion.

Considering the severity of injury, there was a higher loss of reduction in the early course in the more complex fractures. The LSA already showed a loss of 4° after one week in complex fractures (LSC ≥ 7) compared to 2.68° in simple fractures (LSC < 7) despite the fact that the initial amount of reduction was almost similar (7.43° LSC ≥ 7 vs. 7.63° LSC < 7), (Figs 1 and 2). The regional deformity measured by the RSA showed similar results (LSC ≥ 7: loss 6.1° vs. LSC < 7: 4.1°; initial reduction LSC ≥ 7: 9.9° and LSC < 7: 8.49°).

Clinical outcomes

Overall 67% (48/72) of patients did participate on follow up.

To evaluate the intensity and the course of pain the VAS-Spine-Score (Ø378 d) and a modified pain score (Ø 355 d) were assessed. The VAS-Spine-Score showed no significant difference between the open (49.34/100) and the percutaneous (54.3/100) group ($p > 0.05$) (Table 3; Fig. 3). The modified pain score showed that both groups presented with significant pain relief within the first six month after the operation ($p < 0.001$), but there was no significant difference between the two groups at any time (Table 3; Fig. 4).

Clinical outcomes were assessed by the Oswestry disability questionnaire (Ø 355 d) and the SF-36-score (Ø 344 d). The ODI showed a trend of reduced disability for the percutaneous group (percutaneous 32.28 points (±21.2) vs. open 38.7(±24.1)); however this did not reach statistical significance. Both groups presented with moderate disabilities in daily life (Table 3; Fig. 5). Highest diverging values between both groups were found within the quality of sexual life (open 1.33; percutaneous 2.21; $p > 0.05$) and social life (open 1.57; percutaneous 2.33; $p > 0.05$), though both were without significance.

The SF-36-questionnaire revealed no significant differences between the open and the percutaneous groups. Both groups showed notable deficits compared to the age-matched SF-36 reference population; however with comparable results to a SF-36 back pain reference group (n = 243), (2), (Fig. 6). Patients from both groups described their own health as mildly worse than before the trauma (open 3.07; percutaneous 3.55; $p > 0.05$). Physical and mental component summary scales (PCS and MCS) were analyzed in these patients populations based on the qualities of operative treatment, fracture location, gender, age and fracture type (LSC), (Table 3). Interestingly, patients with fractures classified as less severe stated that their initial pain was significantly higher than patients with more complex fractures (9.2 LSC < 7 vs. 6.8 LSC < 7; $p < 0.05$); however, this was not detectable at later time points (4.5 LSC < 7 vs. 5.0 LSC < 7; $p > 0.05$).

*Table 3. Complete follow up analysis regarding operation type, fracture localisation, gender, age and fracture type (LSC), * = p < 0.05*

	Pain score early	**Pain score** at follow up	**VAS-spine**	**ODI**	**SF-36** mental	**SF-36** physical
Percutaneous	mean 8.7 SD ± 1.4	mean 4.5 SD ± 2.9	mean 54.3 SD ± 20.8	mean 38.7 SD ± 24.1	mean 42.8 SD± 12.5	mean 34.1 SD± 11.2
	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Conventional	mean 7.8 SD ± 3.1	mean 4.9 SD ± 2.1	mean 49.3 SD ± 26.6	mean 32.3 SD ± 21.2	mean 45.1 SD± 11.2	mean 33.9 SD± 10.4
LWK 1,2	mean 8.9 SD ± 1.2	mean 4.5 SD ± 2.7	mean 54.5 SD ± 26.1	mean 38.8 SD ± 22.8	mean 42.5 SD ± 10.4	mean 32.9 SD ± 10.8
	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
BWK 11,12	mean 7.1 SD ± 3.6	mean 5.1 SD ± 2.1	mean 45.8 SD ± 20.4	mean 26.9 SD ± 19.6	mean 47.0 SD ± 13.5	mean 36.0 SD ± 10.4
Mail	mean 8.7 SD ± 1.4	mean 5.7 SD ± 2.4	mean 49.1 SD ± 25.3	mean 35.7 SD ± 22.5	mean 43.0 SD ± 12.9	mean 33.0 SD ± 9.6
	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Femail	mean 7.9 SD ± 3.0	mean 3.9 SD ± 2.3	mean 53.3 SD ± 23.7	mean 32.6 SD ± 21.4	mean 45.1 SD ± 10.6	mean 34.8 SD ± 11.5
≤ 55 years	mean 8.9 SD ± 0.9	mean 4.5 SD ± 2.5	mean 52.7 SD ± 24.5	mean 33.0 SD ± 22.7	mean 43.9 SD ± 10.8	mean 34.6 SD ± 10.9
	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
> 55 years	mean 7.8 SD ± 3.2	mean 4.9 SD ± 2.6	mean 50.0 SD ± 24.6	mean 36.1 SD ± 22.1	mean 44.4 SD ± 12.8	mean 33.3 SD ± 10.5
LSC < 7	mean 9.2 SD ± 0.7	mean 4.5 SD ± 2.5	mean 51.3 SD ± 25	mean 36.4 SD ± 22.8	mean 43.4 SD ± 12.3	mean 33.9 SD ± 9.9
	p= 0.031*	n.s.	n.s.	n.s.	n.s.	n.s.
LSC ≥ 7	mean 6.8 SD ± 3.5	mean 5.0 SD ± 2.5	mean 51.28 SD ± 23.6	mean 31.7 SD ± 21.6	mean 45.3 SD ± 9.9	mean 34.3 SD ± 11.5

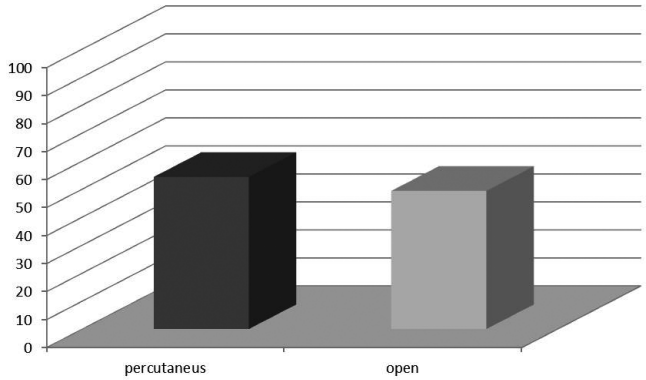

Fig. 3. Illustration of the VAS-spine-score results one year after trauma.

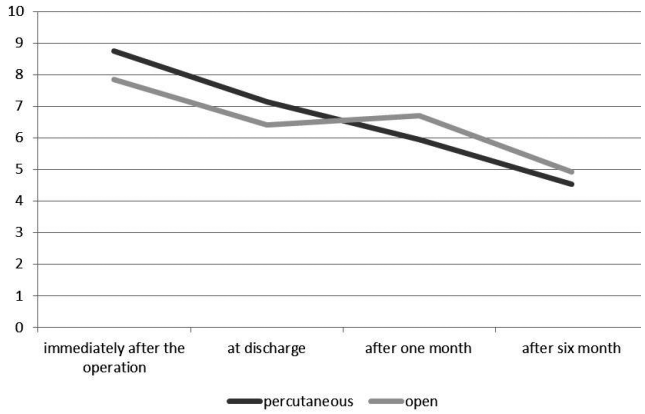

Fig. 4. Illustration of the course of pain up to 6 month post-operatively.

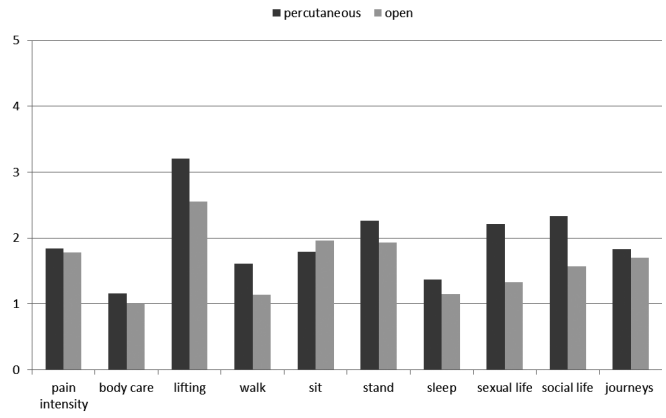

Fig. 5. Illustration of the Oswestry disability results.

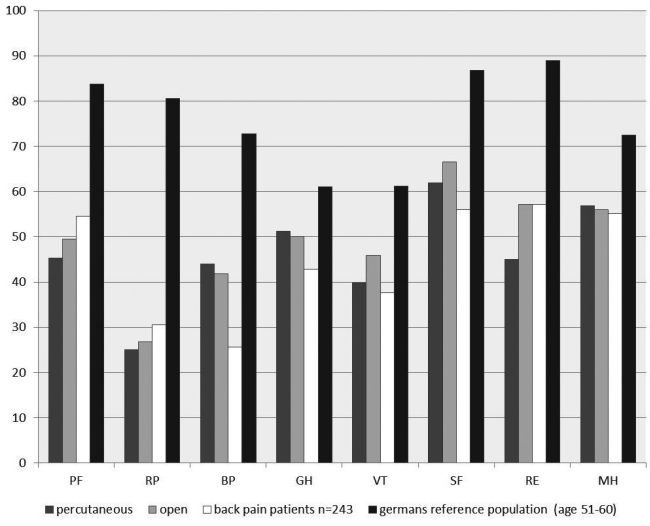

Fig. 6. Illustration of the SF-36 item results.

DISCUSSION

The focus of this study was to compare the functional and radiological outcome of patients treated either with open or percutaneous posterior stabilization for traumatic fractures of the thoracolumbar spine.

Our main findings are:

1. The surgical and the early postsurgical course as defined by length of operation, postoperative pain, length of hospital stay and complications were not influenced by the operative approach.
2. The operative approach had no influence on the functional and radiological outcome one year after surgery.
3. Both open and percutaneous groups showed a significant loss of reduction within the early postoperative period with a trend of higher reduction loss for patients treated with the percutaneous system.
4. Advantages of the open approach were a significantly higher amount of intraoperative fracture reduction and a significantly lower time of intraoperative fluoroscopy.
5. The advantage of the percutaneous approach was significantly reduced intraoperative blood loss.

Minimally invasive spine surgery in spinal trauma is on the rise. However, it is still debated whether percutaneous dorsal stabilization is superior to the classic open approach. Our data show that there is no major difference between the percutaneous and open approach in the surgical and the early postsurgical course.

We found no essential difference in the length of operative procedure between the open and the percutaneous group (open 110.1 min vs. percutaneous 114.3 min). Grass et al. (7) described a mean 15 minutes less operation time in the percutaneous group compared to the open group (85 min vs. 100 min). Jiang et al. (11) reported an approximate 10 minute reduction in surgical duration with the percutaneous approach (open 89.8 min vs. percutaneous 79.7 min). Krueger et al. (16) reported a median operative time of 61 minutes for the percutaneous technique. Others found higher operation times like Wang et al. (open 161 min vs. percutaneous 97.1 min).

At the time of discharge, a measurable pain relief was declared by patients of both groups (open: postoperative 7.84, at discharge 6.41; percutaneous postoperative 8.74 at discharge 7.14). Moreover the pain decreased continuously and showed significant improvement after 6 months with almost similar statements by patients of both groups at any time. This findings are in line with those of Kim et al. (12) who reported considerably reduced pain 21 months after the operation.

We found no significant differences in the length of hospital stay between the open (9.63 d) and the percutaneous groups (10.04 d). Both Kim et al. (12), as well as Jiang et al. (11), reported an approximate one day reduction of the length of hospital stay for percutaneous treated patients (Kim et al.: open 9.2 d vs. percutaneous 8 d; Jiang et al.: open 10.8 d vs. percutaneous 9.7 d). Interestingly, the range of length of hospital stay for percutaneous instrumentation varies in the literature from 5 to 11 days (Krueger et al. (16); Ni et al. (20)).

Overall, the complication rate between the open and the percutaneous approach showed no difference in our study. Major complications such as nerve or spinal cord injuries or injuries to the great blood vessels were not observed. Theoretically, minimal invasive procedures should be associated with lower rates of infection due to less soft tissue trauma and exposure. We observed no wound infections in either group. This is in line with reported low rates of wound infections for dorsal percutaneous instrumentations of Ni et al. and Kim et al. (12, 20).

We could not observe a difference in the accuracy of pedicle screw positioning between the open and percutaneous group, which is corroborated by several published studies (7, 9, 10, 13, 16, 23, 28). In our study 232 screws were analyzed, and optimal screw positioning was found in 199 screws (85.8%). This corresponds with the findings of the meta-analyses by Tian (26), who summarized 7533 pedicle screws and found a placement accuracy between 85% and 91%, and by Shin (22), who showed that risk of pedicle screw mal-positioning is around 15% without navigation.

As was expected, within the VAS-Spine-Score, patients from both groups described least pain at rest (open 59.63/100; percutaneous 68.35/100). Furthermore, compared to the other subqualities, patients from both groups reported relatively little limitations in activities of daily life (open 62/100; percutaneous 68.5/100). On the other hand, the correlation between running activity and pain showed the worst results in both groups (open 39.47/100; percutaneous 28.64/100).

To date the VAS-Spine-Score is not reported in literature for percutaneous procedures. Therefore a direct comparison of results is not possible. Our study however showed no clear correlation between pain and radiological deformity. This observation has been found in former studies using the VAS-Spine-Score (24).

The ODI questionnaire showed moderate limitations with respect to all subqualities. Both groups mentioned their highest limitation in lifting activities. Fewer disabilities were stated within body care and sleep categories. These ODI results are worse than the results in the study by Charles et al. (4), (13.1 ± 13.2 after one year) who performed an early anterior fusion. However, comparing these studies is difficult because of different patient populations and operative approach. Jiang et al. (11) also found no significant differences for the ODI between patients treated either by paraspinal or percutaneous approach. However, in contrast to our study results, he found a sharp improvement at about 3 to 6 months postoperatively.

Within the SF-36 Score we found quite similar results between the open and the percutaneous group. Both cohorts showed their worst results within the subquality 'role physical,' which reflects the amount of physical limitations in the context of activities of daily life. Surprisingly, these results were worse than the results of the reference back pain group (2), (Fig. 6). Interestingly,

our patients, however, had obvious better results regarding the subquality of 'physical pain' compared to this back pain population. This suggests that pain was not the reason for the impairments of our patients.

To explain the relation between pain and physical deficits, we analyzed the mental and physical summery scale for operative approach, fracture localization, age, gender and the severity of injury. Within this analysis we could not detect any significant differences that would explain these events (Table 3). One explanation might be that patients felt still insecure within their activities of daily life due to the carefully management of their injury immediately postoperatively. Summarizing we found relevant impairrments compared to Germans age matched SF-36 reverence group (2). Our results showed that patients still suffer under mental and physical deficits one year after trauma (open: mental 45.1, physical 33.9; percutaneous: mental 42.8, physical 34.1). In contrast Wild et al. (29) found the physical component summary scale in his patients to be 47.97 points for the open group and 49.81 points for the percutaneous group. Those results show a relevant improvement five years after implant removal despite the fact that he also described a relevant loss of reduction within both groups.

Our findings showed a significant higher amount of intraoperative reduction for the open compared to the percutaneous system (LSA improvement: open 9.12° vs. percutaneous 5.07°; RSA improvement: open 10.95° vs. percutaneous 5.85°). However, this data has to be interpreted with caution, because patient distribution was not randomized and the open group showed preoperatively a higher kyphotic deformity (LSA initial: open 3.07° vs. percutaneous 0.04°; RSA initial: open 7.76° vs. percutaneous 5.67°). In contrast, Wild et al. and Wang et al. found no significant differences in kyphotic deformity correction between an open and a percutaneous approach.

Newer studies show that there is no clear relation between the clinical outcome and a progressive change of local spinal deformity for short- and midterm outcomes (3, 14, 24, 29), but there is no data illustrating long term results. Loss of reduction is a common problem in standalone posterior stabilization (4, 14, 20, 21, 29). The largest study handling this topic included 372 patients and demonstrated that treatment with a single posterior stabilization is associated with a loss of more than 80 % of the initial reduction with respect to the LSA and even more than 100 % with respect to the RSA (14). This loss of reduction is also described in other studies (4, 20, 21). We observed a significant loss of reduction within the first week (LSA-loss for both systems 3.1°; RSA-loss open 5.31°, percutaneous 3.55°), especially in fracture types with a high grade of instability (LSC ≥ 7). Therefore, we extrapolate that in case anterior fusion is indicated, it should be performed as early as possible to support the posteriorly achieved reduction. Several studies have shown that the main loss of reduction occurs within the first year (4, 14). In our study we could show that the loss of reduction mainly occurred within the first 3 months, after which the speed of progression gradually decreased and even reached a plateau, in which hardly any further loss of reduction occurred. Although the open approach allowed a significantly higher amount of intraoperative reduction (RSA 10.95° and LSA 9.12°), it was also associated with a higher amount of reduction loss (RSA 12.26°; LSA 9.26°). However, net reduction (initial reduction minus reduction loss) was better in the open as compared to the percutaneous group (RSA -1.31° vs. -4.43°; LSA -0.14° vs. –1.94).

Higher intraoperative radiation time is reported for percutaneous dorsal stabilization (7, 12, 16, 27, 29). In the literature this time is reported between 88 seconds (7) and 342 seconds (29). In our study the time of intraoperative radiation exposure was significantly higher in the percutaneous as compared to the open group (percutaneous 143.1 sec.; open 105.9 sec.). These findings underline that appropriate percutaneous pedicle screw positioning is associated with increased intraoperative radiation.

Kim et al. (12) described reduced blood loss in the percutaneous group of approximately 500 ml; Wild et al. (29) went further to differentiate between intra- and postoperative blood loss and found for both parameters significantly lower results in the percutaneous group. These studies support our data, which shows that the intraoperative hemoglobin drop of patients treated with the percutaneous system was significantly lower compared to the open group.

This study is limited by several constraints. Our patients' population was not randomized. This caused group size inhomogeneity and differences in preoperative kyphotic deformity. Furthermore, 29 patients received an anterior instrumentation during follow up with a higher percentage in the open group. Nonetheless, our study provides reliable data to the early postoperative course with homogeneous demographic data and comparable fracture characteristics between both groups. Up-to-date there is no study comparing the open versus the percutaneous dorsal instrumentation in such continuous and short intervals for clinical and radiological data within the 1 year follow-up (12, 29).

CONCLUSION

Minor advantages of the percutaneous system were less blood loss, whereas the open approach was associated with a significantly higher amount of initial reduction and significantly less intraoperative radiation exposure. Independent from the type of posterior fixation both groups showed already a significant loss of reduction in the early postoperative course. Therefore, if anterior fusion is part of the treatment concept, it should be performed early to avoid secondary loss of reduction. Our study showed that there is no difference in the functional and radiological outcome between patients treated either with an open or a percutaneous approach one year after trauma.

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Authors certify that there is no conflict of interest.

References

1. AGRAWAL, A., MIZUNO, J., KATO, Y., INOUE, T., SANO, H.: Minimally invasive pedicle screw placement in a case of L4 fracture: case report with review of literature. Asian J Neurosurg 5: 64–69, 2010.
2. BULLINGER, M., KIRCHBERGER, I.: SF-36 Fragebogen zum Gesundheitszustand. Handanweisung. Göttingen, Hogrefe Verlag 1998.
3. BUTLER, J. S., WALSH, A., O'BYRNE, J.: Functional outcome of burst fractures of the first lumbar vertebra managed surgically and conservatively. Int. Orthop., 29: 51–54, 2005.
4. CHARLES, Y. P., WALTER, A., SCHULLER, S., ALDAKHEEL, D., STEIB, J. P.: Thoracolumbar fracture reduction by percutaneous in situ contouring. Eur Spine J., 11: 2214–2221, 2012.
5. FAIRBANK, J. C., PYNSENT, P. B.: The Oswestry disability index. Spine (Phila Pa 1976), 25: 2940-2952, 2000.
6. FOLEY, K. T., GUPTA, S. K.: Percutaneous pedicle screw fixation of the lumbar spine: preliminary clinical results. J. Neurosurg., 97: 7–12, 2002.
7. GRASS, R., BIEWENER, A., DICKOPF, A., RAMMELT, S., HEINECK, J., ZWIPP, H.: [Percutaneous dorsal versus open instrumentation for fractures of the thoracolumbar border. A comparative, prospective study]. Unfallchirurg, 109: 297-305, 2006.
8. GUHRING, T., RAIBLE, C., MATSCHKE, S.: [Percutaneous stabilization of thoracolumbar fractures : Techniques of fracture reduction and spinal cord decompression.]. Unfallchirurg, 116: 749–754, 2012.
9. HEINTEL, T. M., BERGLEHNER, A., MEFFERT, R.: Accuracy of percutaneous pedicle screws for thoracic and lumbar spine fractures: a prospective trial. Eur. Spine J., 22: 495–502, 2013.
10. HUBBE, U., KOGIAS, E., VOUGIOUKAS, V. I.: Image guided percutaneous trans-pedicular screw fixation of the thoracic spine. A clinical evaluation. Acta Neurochir. (Wien), 151: 545–549, 2009.
11. JIANG, X. Z., TIAN, W., LIU, B., LI, Q., ZHANG, G. L., HU, L., LI, Z., HE, D.: Comparison of a paraspinal approach with a percutaneous approach in the treatment of thoracolumbar burst fractures with posterior ligamentous complex injury: a prospective randomized controlled trial. J. Int. Med. Res., 40: 1343–1356, 2012.
12. KIM, D. Y., LEE, S. H., CHUNG, S. K., LEE, H. Y.: Comparison of multifidus muscle atrophy and trunk extension muscle strength: percutaneous versus open pedicle screw fixation. Spine (Phila Pa 1976), 30: 123–129, 2005.
13. KIM, M. C., CHUNG, H. T., CHO, J. L., KIM, D. J., CHUNG, N. S.: Factors affecting the accurate placement of percutaneous pedicle screws during minimally invasive transforaminal lumbar interbody fusion. Eur. Spine J., 20: 1635–1643, 2011.
14. KNOP, C., BLAUTH, M., BUHREN, V., ARAND, M., EGBERS, H. J., HAX, P. M., NOTHWANG, J., OESTERN, H. J., PIZANIS, A., ROTH, R., WECKBACH, A., WENTZENSEN, A.: [Surgical treatment of injuries of the thoracolumbar transitio-3: Follow-up examination. Results of a prospective multi-center study by the "Spinal" Study Group of the German Society of Trauma Surgery]. Unfallchirurg, 104: 583–600, 2001.
15. KNOP, C., OESER, M., BASTIAN, L., LANGE, U., ZDICHAVSKY, M., BLAUTH, M.: [Development and validation of the Visual Analogue Scale (VAS) Spine Score]. Unfallchirurg, 104: 488–497, 2001.
16. KRUGER, A., RAMMLER, K., ZIRING, E., ZETTL, R., RUCHHOLTZ, S., FRANGEN, T. M.: Percutaneous minimally invasive instrumentation for traumatic thoracic and lumbar fractures: a prospective analysis. Acta Orthop. Belg., 78: 376–381, 2012.
17. LEHMANN, W., USHMAEV, A., RUECKER, A., NUECHTERN, J., GROSSTERLINDEN, L., BEGEMANN, P. G., BAEUMER, T., RUEGER, J. M., BRIEM, D.: Comparison of open versus percutaneous pedicle screw insertion in a sheep model. Eur. Spine J., 17: 857–863, 2008.
18. MAGERL, F., AEBI, M., GERTZBEIN, S. D., HARMS, J., NAZARIAN, S.: A comprehensive classification of thoracic and lumbar injuries. Eur. Spine J., 3: 184–201, 1994.
19. McCORMACK, T., KARAIKOVIC, E., GAINES, R. W.: The load sharing classification of spine fractures. Spine (Phila Pa 1976), 19: 1741–1744, 1994.
20. NI, W. F., HUANG, Y. X., CHI, Y. L., XU, H. Z., LIN, Y., WANG, X. Y., HUANG, Q. S., MAO, F. M.: Percutaneous pedicle screw fixation for neurologic intact thoracolumbar burst fractures. J. Spinal Disord. Tech., 23: 530–537, 2010.
21. PALMISANI, M., GASBARRINI, A., BRODANO, G. B., DE IURE, F., CAPPUCCIO, M., BORIANI, L., AMENDOLA, L., BORIANI, S.: Minimally invasive percutaneous fixation in the treatment of thoracic and lumbar spine fractures. Eur. Spine J., 18 (Suppl. 1): 71–74, 2009.
22. SHIN, B. J., JAMES, A. R., NJOKU, I. U., HARTL, R.: Pedicle screw navigation: a systematic review and meta-analysis of perforation risk for computer-navigated versus freehand insertion. J. Neurosurg. Spine, 17: 113–122, 2012.
23. SCHIZAS, C., MICHEL, J., KOSMOPOULOS, V., THEUMANN, N.: Computer tomography assessment of pedicle screw insertion in percutaneous posterior transpedicular stabilization. Eur. Spine J., 16: 613-617, 2007.
24. SIEBENGA, J., LEFERINK, V. J., SEGERS, M. J., ELZINGA, M. J., BAKKER, F. C., HAARMAN, H. J., ROMMENS, P. M., TEN DUIS, H. J., PATKA, P.: Treatment of traumatic thoracolumbar spine fractures: a multicenter prospective randomized study of operative versus nonsurgical treatment. Spine (Phila Pa 1976), 31: 2881–2890, 2006.
25. STADHOUDER, A., BUSKENS, E., DE KLERK, L. W., VERHAAR, J. A., DHERT, W. A., VERBOUT, A. J., VACCARO, A. R., ONER, F. C.: Traumatic thoracic and lumbar spinal fractures: operative or nonoperative treatment: comparison of two treatment strategies by means of surgeon equipoise. Spine (Phila Pa 1976), 33: 1006–1017, 2008.
26. TIAN, N. F., XU, H. Z.: Image-guided pedicle screw insertion accuracy: a meta-analysis. Int. Orthop. 33: 895–903, 2009.
27. WANG, H. W., LI, C. Q., ZHOU, Y., ZHANG, Z. F., WANG, J., CHU, T. W.: Percutaneous pedicle screw fixation through the pedicle of fractured vertebra in the treatment of type A thoracolumbar fractures using Sextant system: an analysis of 38 cases. Chin. J. Traumatol., 13: 137–145, 2010.
28. WIESNER, L., KOTHE, R., SCHULITZ, K. P., RUTHER, W.: Clinical evaluation and computed tomography scan analysis of screw tracts after percutaneous insertion of pedicle screws in the lumbar spine. Spine (Phila Pa 1976), 25: 615-621, 2000.
29. WILD, M. H., GLEES, M., PLIESCHNEGGER, C., WENDA, K.: Five-year follow-up examination after purely minimally invasive posterior stabilization of thoracolumbar fractures: a comparison of minimally invasive percutaneously and conventionally open treated patients. Arch. Orthop. Trauma Surg., 127: 335–343, 2007.
30. ZDICHAVSKY, M. BLAUTH, M., KNOP, C., GRAESSNER, M., HERRMANN, H. K., BASTIAN, L.: Accuracy of pedicle screw placement in thoracic spine fractures part I: Inter- and intraobserver reliability of the scoring system. Eur. J. Trauma, 30: 234–240, 2004.

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