Clinical Study of Accelerated Rehabilitation Concept Combined with Tianji Robot-Assisted Surgery in Lumbar Degenerative Diseases

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ABSTRACT

Objective: To compare the effectiveness and safety of two surgical methods for lumbar degenerative diseases; the combination of the concept of accelerated rehabilitation with the assistance of Tianji Robotics and the concept of accelerated rehabilitation combined with manual pedicle screw placement assisted by conventional C-arm fluoroscopy. Methods: A retrospective analysis was performed on 70 patients who received the concept of accelerated rehabilitation combined with spinal surgery for lumbar degenerative diseases in Baise People's Hospital from January 2022 to January 2024. Among them, 35 patients in the robot group received accelerated rehabilitation concept combined with robot-assisted surgery; In the conventional C-arm group, 35 patients received the accelerated rehabilitation concept combined with manual pedicle screw placement assisted by conventional C-arm fluoroscopy. VAS score (preoperative/postoperative), ODI score (preoperative/postoperative), intraoperative bleeding volume, postoperative hospital stay, postoperative complications and the accuracy rate of screw placement were compared between the two groups. Result: There was no statistically significant difference in preoperative VAS scores between the robot group and the conventional C-arm group (6.45 ± 0.82 VS 6.63 ± 0.81, P = 0.6600). The postoperative VAS score of the robot group was better than that of the conventional C-arm group (1.69 ± 0.80 VS 2.45 ± 0.85, P = 0.0000*).

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There was no statistically significant difference in preoperative ODI scores between the robot group and the conventional C-arm group (32.11 ± 3.18 VS 31.66 ± 2.25, P = 0.4900). The postoperative ODI score of the robot group was better than that of the conventional C-arm group (22.68 ± 1.94 VS 24.57 ± 2.25, P = 0.0000*). The postoperative complications in the robot group were less than those in the conventional C-arm group (2.7778% VS 28.5724%, P = 0.0030*). The intraoperative bleeding in the robot group was lower than that in the conventional C-arm group (320.85 ± 276.28 VS 490.00 ± 395.34, P = 0.0420*). The postoperative hospital stay of the robot group was shorter than that of the conventional C-arm group (10.00 ± 9.32 VS 14.49 ± 7.55, P = 0.0300*). The screw placement inaccuracy score of the robot group was lower than that of the conventional C-arm group (0.17 ± 0.51 VS 1.45 ± 1.46, P = 0.0000*). Conclusion: The combination of the concept of accelerated rehabilitation and Tianji Orthopedic robot-assisted surgery is more effective and safer in posterior lumbar decompression and internal fixation surgery with a screw rod system, and is worthy of promotion and application.

1. INTRODUCTION

In recent years, with the widespread application of the concept of accelerated rehabilitation and orthopedic robots in various orthopedic surgical fields, perioperative patients' pain and anxiety have been alleviated, which not only reduces the incidence of postoperative complications, but also improves patient satisfaction [1]. The concept of accelerated rehabilitation (ERAS) is a multidisciplinary patient care model based on evidence-based protocols that aims to reduce surgical stress responses and thereby improve postoperative outcomes [2, 3]. The concept of Accelerated Rehabilitation (ERAS) has achieved good application results in multiple surgical fields, such as chest, cardiology, gynecology, and orthopedics, by optimizing patient pathways through multiple modes, reducing complications, improving patient medical experience, and shortening hospital stay [4]. Although the concept of accelerated rehabilitation has been widely applied in the field of orthopedics and has achieved certain therapeutic effects, a complete consensus has not yet been formed [5]. In the field of orthopaedics, the concept of ERAS was first introduced in hip and knee replacement, and subsequently successfully applied in other complex orthopaedic operations, such as shoulder replacement, hip and knee revision, femoral neck fracture, spine surgery, etc. [6]. The successful application of the concept of accelerated rehabilitation in lumbar fusion surgery provides a strong theoretical basis for the application of ERAS concept in other clinical orthopedic surgeries [7]. According to the results of relevant literature retrieval, at present, there are no reports on the comparative study of accelerated rehabilitation concept combined with Tianji robot-assisted surgery and accelerated rehabilitation concept combined with manual pedicle screw placement assisted by conventional C-arm fluoroscopy in the surgery for lumbar degenerative diseases in the literature published by domestic and foreign scholars, which is worthy of more in-depth and extensive research. This study aims to evaluate the effectiveness, accuracy, and safety of the combination of the concept of accelerated rehabilitation with Tianji robot assisted surgery and the concept of accelerated rehabilitation with conventional C-arm fluoroscopy assisted manual pedicle screw placement surgery in lumbar degenerative diseases from six aspects. The six evaluation indicators include preoperative VAS score/postoperative VAS score, preoperative ODI score/postoperative ODI score, intraoperative bleeding volume, postoperative hospital stay, postoperative complications, and accuracy of screw insertion. The research results are reported as follows.

2. MATERIALS AND METHODS

2.1. Research Subjects

Retrospective analysis of 70 patients with lumbar degenerative diseases who were hospitalized in the Spinal Surgery Department of Baise People's Hospital (Southwest Hospital Affiliated to Youjiang Ethnic

Medical College) from January 2022 to January 2024 and received accelerated rehabilitation combined with surgical treatment. Among them, there are 24 males and 46 females; Comparison of incidence rates between men and women, $X^2 = 13.8286$, P = 0.0002, female patients have a higher incidence than male patients; The distribution of surgical segments: 51 patients underwent single segment surgery, 17 patients underwent double segment surgery, 1 patient underwent three segment surgery, and 1 patient underwent four segment surgery; All enrolled cases in this study obtained informed consent from all patients and were approved by the Ethics Committee of Baise People's Hospital (Southwest Hospital Affiliated to Youjiang Ethnic Medical College) before implementation. All surgeries were performed under the guidance of the head of the spinal surgery department at the People's Hospital of Baise City (Southwest Hospital Affiliated to Youjiang Ethnic Medical College), and were performed by the same team of chief physicians.

2.2. Research Methods

2.2.1. ERAS Concept Combined with Surgical Methods (See Table 1)

Table 1. ERAS concept combined with surgical methods.

Perioperative period	Item	Robot group	Conventional C-arm group
Preoperative	Preoperative education	Inform patients of the hospital related precautions, measures, and procedures for ERAS.	Inform patients of the hospital related precautions, measures, and procedures for ERAS.
	Preoperative nutrition	Ask the nutrition doctors to assist in the adjustment.	Ask the nutrition doctors to assist in the adjustment.
	Jejunitas	Solid foods were prohibited 6 hours before surgery, and 200 ml of carbohydrates were orally administered 2 hours before induction of general anesthesia.	Solid foods were prohibited 6 hours before surgery, and 200 ml of carbohydrates were orally administered 2 hours before induction of general anesthesia.
	Preemptive analgesia	Flurbiprofen injection was given 1 day before surgery for preemptive analgesia.	Flurbiprofen injection was given 1 day before surgery for preemptive analgesia.
Intraoperative	Controlled hypotension	Intraoperative systolic blood pressure was controlled by 80 - 90 mmHg and diastolic blood pressure by 50 - 65 mmHg.	Intraoperative systolic blood pressure was controlled by 80 - 90 mmHg and diastolic blood pressure by 50 - 65 mmHg.
	Surgical method selection	Tianji Orthopedics robot-assisted minimally invasive surgery.	Open surgery under conventional C-arm positioning.
	Local anesthesia	When suturing the incision, 1% ropivacaine and flurbiprofen were subcutaneously injected.	When suturing the incision, 1% ropivacaine and flurbiprofen were subcutaneously injected.
Postoperative	Analgesia	Flurbiprofen injection was given intravenously within 3 days after surgery, and imrecoxib was taken orally within 3 days to 1 week after surgery.	Flurbiprofen injection was given intravenously within 3 days after surgery, and imrecoxib was taken orally within 3 days to 2 weeks after surgery.

Continued

	Take food	A small amount of water can be given if the patient is conscious after surgery.	A small amount of water can be given if the patient is conscious after surgery.
	Early mobilization	After returning to the ward after surgery, the lower limbs began to be passively moved, the waist brace was worn and the drainage tube was fixed in the trouser pocket on the 2nd to 3rd day after surgery, and the patient was instructed to sit up in bed and walk on the ground after not feeling dizzy, and the rehabilitation physician assisted in developing the activity plan. After removing the drainage tube according to the condition of the drainage fluid after surgery, it was usually 1 - 2 days, and the wound healing was good after observation for 1 day before discharge	After returning to the ward after surgery, the lower limbs began to be passively moved, the waist brace was worn and the drainage tube was fixed in the trouser pocket on the 3rd to 4th day after surgery, and the patient was instructed to sit up in bed and walk on the ground after not feeling dizzy, and the rehabilitation physician assisted in developing the activity plan. After removing the drainage tube according to the condition of the drainage fluid after surgery, it was usually 2 - 3 days, and the wound healing was good after observation for 2 - 3 days before discharge.

2.2.2. Surgical Methods of the Robot Group

According to the guidelines for the placement of thoracolumbar pedicle screws assisted by orthopedic surgical robots [8], patient was placed in a prone position and fixed on a robot specific carbon steel operating table; General anesthesia, disinfection, drape placement, and exposure of paraspinal muscles and soft tissues were performed in the same manner as regular spinal surgery; The tracer was fixed on the spinous process of 1 - 2 vertebral bodies at the surgical segment near the head side. The end device of the robotic arm of the Tianji orthopedic robot has 5 calibration devices displaying black shadow points, which should be placed as close as possible to the surgical site. Firstly, the C-arm was used during the operation to scan the three-dimensional image of the lumbar spine in the surgical area, which was then automatically recognized by the calibration device, and finally the registration between the robot arm and the human body was performed. The spinal surgeon first operates the main control panel of the Dimensity Orthopedic Robot to plan the screw placement trajectory, then operates the buttons on the control panel to control the robotic arm to run to the preset nail placement point, drill holes under real-time navigation monitoring, and place the guide needle along the pre-planned path. Similar to the conventional C-wall assisted placement of screws, the guide needle used for positioning is removed for decompression surgery, and the screws are placed after satisfactory decompression surgery. Finally, use C-wall fluoroscopy to confirm the accuracy of the screws, and if you are not satisfied with the accuracy of the screws that have already been placed, you can adjust and reposition them again until the accuracy requirements are met [9].

2.2.3. Conventional C-Arm Assisted Surgical Methods

The patient was placed in a prone position and fixed on an O-shaped chest and abdomen pad. After general anesthesia, C-shaped arm fluoroscopy was performed to determine the surgical incision site, and finally, the surgical towel was laid according to ordinary surgical disinfection. The spine surgeon should make an incision about 8 - 10 cm of skin at the midline of the patient's back. The skin of the patient was first cut, and then the superficial fascia, fat and deep fascia were respectively cut by electrocoagulation with plasma electrotome; After coagulation and hemostasis with electrotome, the paravertebral muscles on both sides of the spinal process were separated by large curved forceps or periosteal stripper; Finally, the isthmus and vertebral plate on the surgical field side were exposed and removed. Screw trajectories should follow bottom-up and inside-out paths. The nail placement point was located 1mm below the lower edge of the transverse process and adjacent to the midpoint of the upper articular process; Use a 1.5 mm diameter guide needle to thread the correct path along the adjacent area; Next, the probe was used to determine the integrity of the pedicle wall, followed by the insertion of a guide needle for positioning; Last, C-shaped arm perspective front and lateral position to determine the accuracy of guide needle positioning. Due to the difficulty in decompression caused by the insertion of screws, the guide needle was removed first, and bone wax was used to stop bleeding before proceeding with spinal canal decompression surgery and intervertebral fusion cage implantation. After satisfactory decompression, a 3.0 mm tap was used to expand the screw channel, followed by the use of a guide needle to detect the integrity of the pedicle wall, and then the screw was inserted to stabilize it in the vertebral body. Finally, use C-wall fluoroscopy to confirm the accuracy of the screws, and if you are not satisfied with the accuracy of the screws that have already been placed, you can adjust and reposition them again until the accuracy requirements are met. The imaging procedures for the two surgical methods are shown in the attached **Figure 1**.

2.3. Inclusion Criteria

Case inclusion criteria: 1) Patients diagnosed with degenerative diseases of the lumbar spine (lumbar spinal stenosis, lumbar disc herniation, lumbar spondylolisthesis); 2) Accepting the ERAS concept combined with the assistance of Tianji orthopedic robots for posterior lumbar decompression reduction and internal fixation surgery using a screw rod system; 3) Accepting the ERAS concept combined with conventional C-arm fluoroscopy assisted manual posterior lumbar decompression reduction and internal fixation surgery with a screw rod system; 4) No combination of basic diseases that affect the postoperative effect alone, such as serious coronary heart disease and cerebrovascular disease.

2.4. Exclusion Criteria

Case exclusion criteria: 1) Concomitant severe systemic diseases; 2) greater than or equal to 1 spinal surgery history; 3) History of combined severe osteoporosis, tumors, tuberculosis, infections, and other bone diseases; 4) Transfer of department or hospital for treatment due to serious complications after surgery.

2.5. Exit Criteria

Case dropout criteria: 1) During the trial, the subjects withdrew on their own; 2) Poor compliance of subjects affects the judgment of safety and effectiveness; 3) Subjects experience serious adverse events, complications, and special physiological changes; 4) Those who withdraw from the trial, are lost to follow-up, or die before the end of the treatment due to other reasons.

2.6. Precautions

After surgery, patients should be given absolute bed rest for 6 hours and receive a group of prophylactic anti infection treatment with cefazolin. If the intraoperative time exceeds 3 hours, an additional group of prophylactic anti infection treatment with cefazolin can be given; After operation, ECG monitoring, finger pulse oxygen examination and central oxygen inhalation for 6 hours were given; Symptomatic treatment such as anti-inflammatory analgesia, osteoporosis prevention, anti-thrombosis and nutritional nerve were given; After the removal of ECG monitoring, finger pulse oxygen examination and central oxygen inhalation, lumbar radiographs, CT three-dimensional imaging and MRI can be re-examined; The drainage tube was removed when the postoperative drainage volume was less than 50 ml; Get out of bed for a short time movements under the protection of a hard waist belt after extubation after surgery; Follow-up was performed at 1, 3, 6, 9, and 12 months after surgery and annually thereafter.

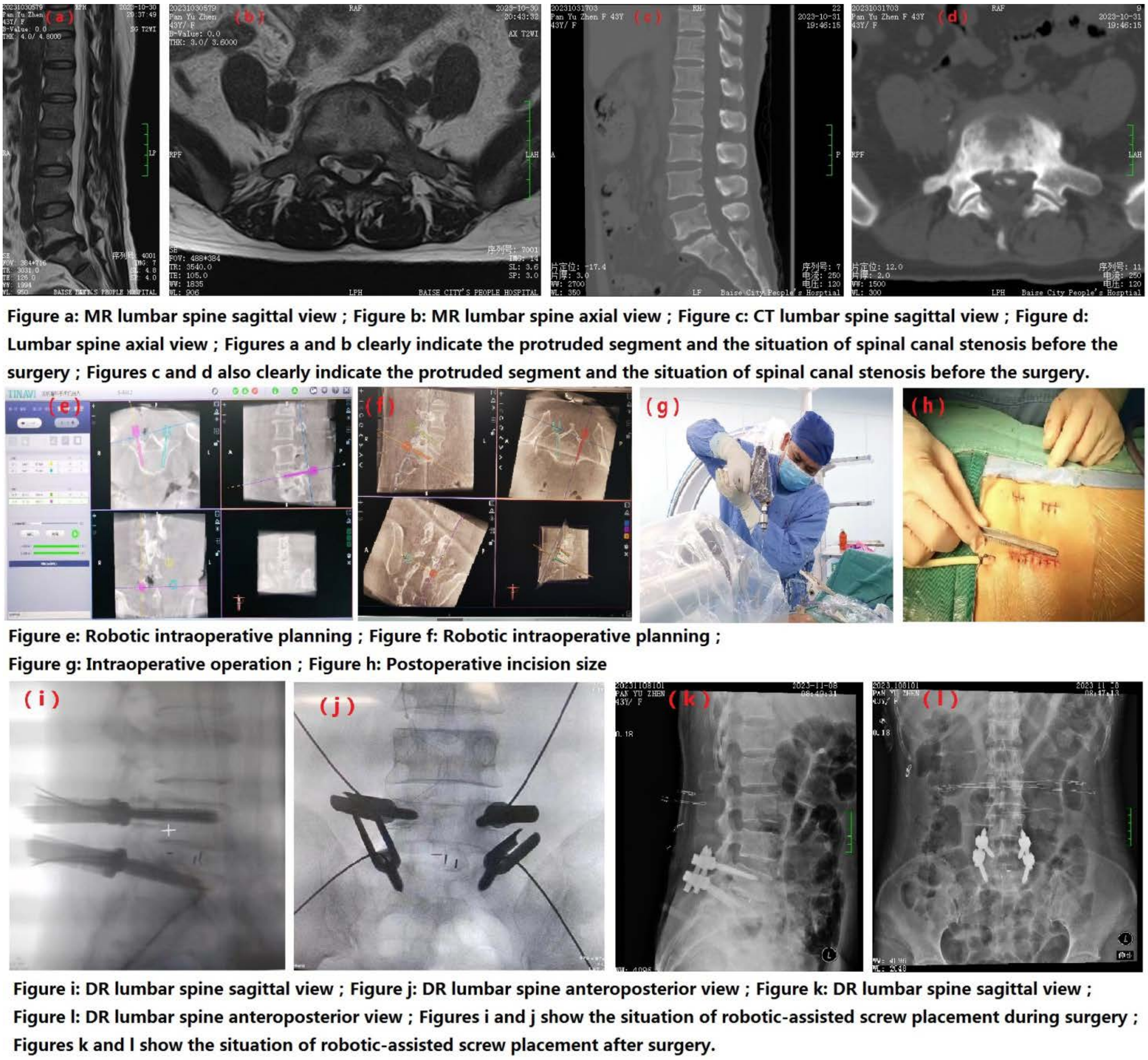

Figure 1. Two surgical methods.

2.7. Statistical Processing

Statistical software SPSS27.0 was used for statistical analysis of the data in this study. The measurement data were represented by mean ± standard deviation "x ± s" and T-test was performed. The counting data were represented by percentage (%) and χ^2 test was used. P < 0.05 was considered statistically significant.

3. RESULTS

3.1. Comparison of General Data of Patients

The study enrolled 70 patients with lumbar degenerative diseases who were hospitalized in the Spinal

Surgery Department of Baise People's Hospital (Southwest Hospital Affiliated to Youjiang Medical College for Nationalities) from January 2022 to January 2024 and received accelerated rehabilitation combined with surgical treatment. Among them, there were 10 males and 25 females in the robot group; 14 males and 21 females in the conventional C-arm group; The average age of the robot group is (56 ± 9.92) years old; The average age of the conventional C-arm group is (60 ± 6.67) years old; 26 patients in the robot group underwent single segment surgery, 7 patients underwent double segment surgery, 1 patient underwent three segment surgery, and 1 patient underwent four segment surgery; 25 patients underwent single segment surgery and 10 patients underwent double segment surgery in the conventional C-arm group; There was no statistically significant difference in preoperative general information such as gender, age, number of single segment surgeries, number of double segment surgeries, number of three segment surgeries, and number of four segment surgeries between the two groups of patients, with P > 0.05. Please refer to Table 2 for details.

Table 2. Comparison of general data and disease severity between robot and conventional C-arm groups.

Variable		Robot group **(n = 35)**	Conventional C-arm group **(n = 35)**	Statistical value (X^2/t)	P value
Gender	Male	10	14	1.1850	0.2760
	Female	25	21		
Age		56 ± 9.92	60 ± 6.67	1.8930	0.0630
Single segment	L1/2	0	0	0.3200	0.9560
	L2/3	1	1		
	L3/4	3	2		
	L4/5	17	18		
	L5/s1	5	4		
Double segment	L1/2 + L2/3	0	1	5.2480	0.3860
	L2/3 + L3/4	0	1		
	L3/4 + L4/5	6	8		
	L4/5 + L5/s1	1	0		
Three segment	L3/4 – L5/s1	1	0	—	—
Four segment	L2/3 – L5/s1	1	0	—	—
VAS score	Preoperative	6.54 ± 0.82	6.63 ± 0.81	0.4410	0.6600
	Postoperative	1.69 ± 0.80	2.45 ± 0.85	3.9100	0.0000*
ODI score	Preoperative	32.11 ± 3.18	31.66 ± 2.25	0.6950	0.4900
	Postoperative	22.68 ± 1.94	24.57 ± 2.25	3.7550	0.0000*

3.2. Comparison of Preoperative and Postoperative VAS Scores of Patients

There was no statistically significant difference in the preoperative VAS score between the robot group patients (6.54 ± 0.82) and the conventional C-arm group patients (6.63 ± 0.81), with P > 0.05; The postoperative VAS score of the robot group patients (1.69 ± 0.80) was compared with the postoperative VAS score of the conventional C-arm group patients (2.45 ± 0.85), and the difference was statistically significant, P <

0.05. Please refer to Table 2 for details.

3.3. Comparison of Preoperative and Postoperative ODI Scores of Patients

There was no statistically significant difference in the preoperative ODI score between the robot group patients (32.11 ± 3.18) and the conventional C-arm group patients (31.66 ± 2.25), with P > 0.05; The difference in postoperative ODI scores between the robot group patients (22.68 ± 1.94) and the conventional C-arm group patients (24.57 ± 2.25) was statistically significant, with P < 0.05. Please refer to Table 2 for details.

3.4. Comparison of Postoperative Complications in Patients

The incidence of postoperative complications in the robot group was lower than that in the conventional C-arm group; There was one postoperative complication in the robot group, with a complication rate of 2.7778%; And there were 10 postoperative complications in the conventional C-arm group, with a complication rate of 28.5724%; The difference in the incidence of complications between the two groups is statistically significant, P < 0.05. Please refer to Table 3 for details.

Table 3. Comparison of surgical quality indicators between robot and conventional C-arm groups.

Variable		Robot group (n = 35)	Conventional C-arm group (n = 35)	Statistic (X^2/t)	P value
Complication	No	34	25	8.737	0.0030*
	Yes	1	10		
Intraoperative bleeding volume		320.85 ± 276.28	490.00 ± 395.34	2.075	0.0420*
Postoperative hospitalization time		10.00 ± 9.32	14.49 ± 7.55	2.212	0.0300*
Inaccurate screw score		0.17 ± 0.51	1.45 ± 1.46	4.908	0.0000*

Note: A score of all A is 0, indicating that everything is accurate; B level is 1 point; C-level 2 points; D-level 3 points; The higher the score, the worse the quality, and the less accurate it is.

3.5. Comparison of Intraoperative Bleeding Volume among Patients

The intraoperative blood loss in the robot group was less than that in the conventional C-arm group, and the intraoperative blood loss in the robot group was (320.85 ± 276.28) ml; The intraoperative bleeding volume of patients in the conventional C-arm group was (490.00 ± 395.34) ml; The difference in intraoperative bleeding between the two groups was statistically significant, with P < 0.05. See Table 3 for details.

3.6. Comparison of Postoperative Hospital Stay of Patients

The postoperative hospital stay of the robot group was (10.00 ± 9.32) days, which was less than that of the conventional C-arm group. The length of hospital stay in the conventional C-arm group was (14.49 ± 7.55) days. The length of hospitalization between the two groups was statistically significant (P < 0.05). See Table 3 for details.

3.7. Comparison of Patients with Screw Inaccuracy Score

According to whether the screw is completely inserted into the vertebral pedicle, it can be divided into 5 grades: Grade A, the screw does not destroy the cortical layer of the vertebral pedicle; Grade B, cortical tear < 2 mm; Grade C, 2 mm ≤ cortical tear < 4 mm; Grade D, 4 mm ≤ cortical tear < 6 mm; Grade E, cortical tear ≥ 6 mm; Clinically, it can be considered that grade A is perfect nail placement, grade B is clinically acceptable, and grade C, D and E are significant deviations in nail placement [10]. The inaccurate score of screws in the robot group in this study was significantly lower than that in the conventional C-arm group, and the inaccurate score of screws was (0.17 ± 0.51) in the robot group; The inaccurate score of screws for conventional C-arm group was (1.45 ± 1.46) points; The difference in inaccurate scores between the two groups of screws is statistically significant, with $P < 0.05$. Please refer to **Table 3** for details.

4. DISCUSSION

In recent years, there has been a deep development in the use of accelerated rehabilitation concepts and treatment strategies in lumbar spine fusion surgery. Most early research has focused on perioperative management of the spine, incorporating single or multiple accelerated recovery indicators to confirm the application of accelerated rehabilitation concepts in lumbar spine surgery and explore their effectiveness and scientificity [11-13]. In the past decade, the ERAS protocol has held a prominent position in spinal surgery. Compared to traditional approaches, they have been proven to shorten hospitalization time, reduce hospitalization costs, and reduce the use of opioid drugs. Their applicability and repeatability in various spinal surgeries, including lumbar spine surgery, anterior cervical spine surgery, deformity correction surgery, and spinal tumor surgery, have again demonstrated their effectiveness [14]. It is important to note that different treatment centers may have different treatment outcomes. The current concept of accelerated rehabilitation mainly seeks to develop standardized management frameworks for specific patients, within which the patient's accelerated rehabilitation concept achieves personalized treatment plans [15, 16].

Currently, studies on robot-assisted spinal internal fixation and fusion surgery are quite popular; According to the findings of Wu Canglu *et al.* [17], robot-assisted percutaneous vertebroplasty for osteoporotic vertebral compression fractures in the middle and upper thoracic vertebrae is compared with the treatment of OVCF in the middle and upper thoracic vertebrae by manual PVP; It is concluded that Tianji orthopedic surgery robot-assisted PVP treatment not only has the same clinical effect, but also can optimize surgical indexes and reduce bone cement leakage. In addition, Tan Huangsheng *et al.* [18] also conducted relevant studies and found that pedicle screw placement with robot assistance had higher accuracy and less trauma than conventional C-arm assisted screw placement. Therefore, robot assisted percutaneous nail placement can further improve surgical safety and effectiveness compared to manual nail placement, thereby improving clinical efficacy. Since Tianji robot assisted spinal surgery is superior to conventional C-arm assisted open manual screw placement surgery in many aspects, does the comparison between the accelerated rehabilitation concept combined with Tianji robot assisted surgery and the accelerated rehabilitation concept combined with conventional C-arm fluoroscopy assisted manual cortical screw placement surgery in lumbar degenerative diseases also prove that the combination of accelerated rehabilitation concept and Tianji robot assisted surgery is more advantageous. From this perspective, this study intends to evaluate the effectiveness and safety of the Tianji orthopaedic robot in minimally invasive surgery for lumbar degenerative diseases, and carry out research on the accurate positioning of the Tianji orthopaedic robot, minimally invasive nail placement, pain reduction, intraoperative blood loss reduction, postoperative complications, postoperative hospital stay, spinal canal and disc decompression under minimally invasive channel, and fusion implant implantation. To establish a new method of minimally invasive lumbar internal fixation fusion with the assistance of Tianji Orthopedics robot, and to develop a new ERAS protocol and individual application in the surgery of lumbar degenerative diseases. For patients to improve the short-term and long-term effects of surgery, so that patients can return to work as soon as possible, obtain a wide range of clinical application value, as well as a wide range of social and economic benefits.

The results of this study showed that there was no statistically significant difference in various indicators of general information between the robot group and the conventional C-arm group, with $P > 0.05$; The postoperative pain relief in the robot group was significantly better than that in the conventional C-arm group, with a statistically significant difference ($P < 0.05$); The postoperative complications in the robot group were less than those in the conventional C-arm group, and the difference was statistically significant, $P < 0.05$; The intraoperative blood loss in the robot group was lower than that in the conventional C-arm group, and the difference was statistically significant, $P < 0.05$; The postoperative hospitalization time of the robot group was shorter than that of the conventional C-arm group, and the difference was statistically significant, $P < 0.05$; The accuracy of screw insertion in the robot group was significantly better than that in the conventional C-arm group, with a statistically significant difference of $P < 0.05$. This indicates that the combination of accelerated rehabilitation concept and Tianji robot assisted surgery has good clinical effects in lumbar degenerative diseases.

5. CONCLUSION

In summary, the comparison of surgical results of accelerated rehabilitation concept combined with Tianji robot assistance and accelerated rehabilitation concept combined with conventional C-arm fluoroscopy assisted with manual pedicle screw implantation for lumbar degenerative diseases showed that patients in the robot group had more obvious postoperative pain relief, less intraoperative blood loss, less postoperative complications and less hospital stay, and more accurate screw placement. It can be seen that the accelerated rehabilitation concept combined with Tianji robot-assisted surgery has the advantages of less trauma and accurate nail placement, which is conducive to postoperative rehabilitation of patients, reducing postoperative pain, shortening postoperative hospital stay and reducing postoperative complications. Therefore, the concept of accelerated rehabilitation combined with robot-assisted surgery of Tianji Orthopedics is more effective and safer in posterior lumbar decompression and internal fixation with the screw system, and is worthy of promotion and application.

6. LIMITATIONS OF THE STUDY

With the continuous development of Tianji robot technology in spinal surgery, and the continuous improvement and individualized application of the Accelerated Rehabilitation Concept (ERAS), there is still insufficient room for improvement and progress, and this study has broad clinical application prospects. The study in this paper is a retrospective small-sample medical record control study, and the conclusions of this study still need to be further verified by large-scale prospective studies.

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AUTHOR RANKING ORDER AND INTEREST RELATIONSHIP

Yang Weikang and Mai Yinwen analyzed and interpreted the data; Yang Weikang, Huang Yuanjian, Zeng Xianhai, Zhou Qianhou, and Lu Wanxia collected and organized data; Huang Chengkua and Su Guosheng designed and reviewed this study.

CONFLICTS OF INTEREST

There is no conflict of interest between the authors of this article.

REFERENCES

1. Huang, H.P., Mo, L.J., Li, T.Y., *et al.* (2020) The Application Effect of the Concept of Accelerated Rehabilitation Surgery in the Daytime Surgery Mode of Holmium Laser Lithotripsy under Ureteroscopy. *Guangxi Medicine*, **42**, 964-967.
2. Mundhra, R., Gupta, D.K., Bahadur, A., Kumar, A. and Kumar, R. (2024) Effect of Enhanced Recovery after Surgery (ERAS) Protocol on Maternal Outcomes Following Emergency Caesarean Delivery: A Randomized Controlled Trial. *European Journal of Obstetrics & Gynecology and Reproductive Biology*: *X*, **22**, Article ID: 100295. https://doi.org/10.1016/j.eurox.2024.100295
3. Qi, J.X. (2023) Clinical Research on the Application of Accelerated Rehabilitation Surgery Concept in Lumbar Spinal Stenosis Surgery. Youjiang Ethnic Medical College.
4. Singh, S.M., Liverpool, A., Romeiser, J.L., Thacker, J., Gan, T.J. and Bennett-Guerrero, E. (2021) Types of Surgical Patients Enrolled in Enhanced Recovery after Surgery (ERAS) Programs in the USA. *Perioperative Medicine*, **10**, Article No. 12. https://doi.org/10.1186/s13741-021-00185-5
5. Salamanna, F., Contartese, D., Brogini, S., Visani, A., Martikos, K., Griffoni, C., *et al.* (2022) Key Components, Current Practice and Clinical Outcomes of ERAS Programs in Patients Undergoing Orthopedic Surgery: A Systematic Review. *Journal of Clinical Medicine*, **11**, Article 4222. https://doi.org/10.3390/jcm11144222
6. Bogani, G., Sarpietro, G., Ferrandina, G., Gallotta, V., DI Donato, V., Ditto, A., *et al.* (2021) Enhanced Recovery after Surgery (ERAS) in Gynecology Oncology. *European Journal of Surgical Oncology*, **47**, 952-959. https://doi.org/10.1016/j.ejso.2020.10.030
7. Lampilas, A., Bouyer, B., Ferrero, E., Khalifé, M., Bergeot, A., Guigui, P., *et al.* (2021) Evaluation of Enhanced Recovery after Spine Surgery: Specificities in an Academic Public Hospital. *Orthopaedics & Traumatology*: *Surgery & Research*, **107**, Article ID: 103027. https://doi.org/10.1016/j.otsr.2021.103027
8. Tian, W., Liu, Y., Liu, B., He, D., Wu, J., Han, X., *et al.* (2019) Guideline for Thoracolumbar Pedicle Screw Placement Assisted by Orthopaedic Surgical Robot. *Orthopaedic Surgery*, **11**, 153-159. https://doi.org/10.1111/os.12453
9. Zhang, X.N., Liu, Y.Z., Li, Y., *et al.* (2023) A Clinical Comparative Study of Robotic Assisted Orthopedic Surgery and X-Ray Fluoroscopy Assisted Manual Cortical Bone Trajectory Screw Placement for the Treatment of Single Segment Degenerative Lumbar Spine Diseases. *Journal of Capital Medical University*, **44**, 836-844.
10. Zhao, T., Huang, C.K. and Su, G.S. (2024) The Application Effect of Robot Assisted Percutaneous Pedicle Screw Placement and Conventional Open Pedicle Screw Placement in Lumbar Spine Fractures. *Minimally Invasive Medicine*, **19**, 19-26.
11. Wang, S., Wang, P., Li, X., Sun, W., Kong, C. and Lu, S. (2022) Enhanced Recovery after Surgery Pathway: Association with Lower Incidence of Wound Complications and Severe Hypoalbuminemia in Patients Undergoing Posterior Lumbar Fusion Surgery. *Journal of Orthopaedic Surgery and Research*, **17**, Article No. 178. https://doi.org/10.1186/s13018-022-03070-z
12. Wang, R.S., Huang, C.J., Su, X.J., *et al.* (2019) Research on the Application of Accelerated Rehabilitation Surgery Concept in Elderly Single Segment Degenerative Lumbar Spine Diseases. *Chinese Journal of Bone and Joint Medicine*, **8**, 454-458.
13. Tarıkçı Kılıç, E., Demirbilek, T. and Naderi, S. (2019) Does an Enhanced Recovery after Surgery Protocol Change Costs and Outcomes of Single-Level Lumbar Microdiscectomy? *Neurosurgical Focus*, **46**, E10. https://doi.org/10.3171/2019.1.focus18665
14. Bansal, T., Sharan, A.D. and Garg, B. (2022) Enhanced Recovery after Surgery (ERAS) Protocol in Spine Surgery. *Journal of Clinical Orthopaedics and Trauma*, **31**, Article ID: 101944. https://doi.org/10.1016/j.jcot.2022.101944

15. Chakravarthy, V.B., Yokoi, H., Coughlin, D.J., Manlapaz, M.R. and Krishnaney, A.A. (2019) Development and Implementation of a Comprehensive Spine Surgery Enhanced Recovery after Surgery Protocol: The Cleveland Clinic Experience. *Neurosurgical Focus*, **46**, E11. https://doi.org/10.3171/2019.1.focus18696
16. Feng, C., Zhang, Y., Chong, F., Yang, M., Liu, C., Liu, L., *et al.* (2019) Establishment and Implementation of an Enhanced Recovery after Surgery (ERAS) Pathway Tailored for Minimally Invasive Transforaminal Lumbar Interbody Fusion Surgery. *World Neurosurgery*, **129**, e317-e323. https://doi.org/10.1016/j.wneu.2019.05.139
17. Wu, C.L., Wang, X., Li, Z.Z., *et al.* (2024) Clinical Efficacy Study of Percutaneous Vertebroplasty Assisted by Surgical Robots for Osteoporotic Vertebral Compression Fractures in the Upper and Middle Thoracic Vertebrae. *Zhejiang Trauma Surgery*, **29**, 235-238.
18. Tan, H.S., Lai, J.Y., Feng, H.L., *et al.* (2024) Application of Percutaneous Nail Placement Assisted by the Third Generation Tianji Orthopedic Robot in Lumbar Fusion Internal Fixation through Intermuscular Approach. *Chinese Journal of Orthopedics and Traumatology of Traditional Chinese Medicine*, **32**, 20-24.