

INTERNAL FIXATION SURGERY USING TIANJI ORTHOPEDIC ROBOT ON PATIENT SATISFACTION AND QUALITY OF LIFE

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Abstract. Internal fixation (IF) surgery has promoted with the combination of robotic technology, promising increased accuracy and improved patient prognosis. This study examined the effect of IF surgery using Tianji Orthopedic Robot on patient satisfaction and quality of life (QoL) over a longitudinal follow-up time. To estimate the changes in patient satisfaction and QoL following IF assisted by Tianji Orthopedic Robot. A cohort of patients undergoing IF guided by Tianji Orthopedic Robot surgery was followed from the pre-surgery phase through 12 months post-surgery. Patient-reported outcome measures, including the Oswestry Disability Index (ODI) and the Short Form Health Survey (SF-36) were administered at baseline, 6 months, and 12 months. Additionally, the Newcastle Satisfaction with Nursing Care (NSNCS) was used to assess the patient satisfaction. Data were analyzed using repeated measures ANOVA. 338 patients (53.19%) underwent robot-assisted surgery, 214 female (63.31%) and 124 male (36.68%), with an age of 63.76±14 years. The study indicated significant progress in both patient satisfaction and QoL. The mean ODI score decreased from 79.1±4.76 pre-surgery to 46.2±6.09 at 12 months ($p<0.001$), compared with the SF-36 score increased from 43.5±4.20 to 84±4.8 ($p<0.05$). Moreover, the NSNCS scores reflected high levels of satisfaction, with 86±4.32 of participants declare satisfaction with their surgical outcomes at the 12-month follow-up. The Tianji Orthopedic Robot significantly improves patient satisfaction and QoL, with improvements continued over a year. These findings assure the significance of robotic technology and surgical procedure and highlight the essential role of nurses in using telehealth for continuous follow-up.

Keywords: *Tianji orthopedic robot, spinal cord abnormalities, satisfaction, quality of life, nursing*

Introduction

The advancements in surgical techniques have altered the orthopedic surgery, particularly in spinal care. Internal fixation (IF) surgery, vital for stabilizing spine abnormalities, has traditionally involved complex procedures with different outcomes (Milicevic, 2024). Recent achievement, such as robot assisted surgery, enhanced the accuracy and may improve patient prognosis (Iftikhar et al., 2024; Liawrungrueang et al., 2023; Moglia et al., 2021; Qian et al., 2019; Diana and Marescaux, 2015). Spinal cord abnormalities cover a range of conditions that influence the structure or function of the spinal cord (Althala et al., 2024a; 2023; Qian et al., 2019). However, Common types of spinal cord abnormalities include spina bifida, tethered cord syndrome, and spinal

cord tumors. These abnormalities can cause different symptoms, such as pain, weakness, sensory loss, and deteriorate mobility, which significantly affect the patient's quality of life (QoL) (Najm et al., 2020). The range of spinal cord abnormalities differs according to a specific condition (Gola et al., 2020). For example, spina bifida occurs in about 1 in 1,000 live births, while spinal cord injuries (SCI), often after trauma which approximately affect 54 cases per million people annually. The awareness and medical technology and research innovations enhance and improve the early detection and management that affecting the incidence and outcomes (Nag et al., 2024). The Tianji Orthopedic Robot showed a significant forward steps, offering higher accuracy in screw placement and decreased intraoperative complications (Yang et al., 2024). This robotic technology not only improves surgical efficiency, but seeks to elevate the overall patient experience and prognosis (Huang et al., 2024; Yang et al., 2024). As patient satisfaction and QoL are paramount considerations in healthcare, understanding the effect of such developed technologies is definitive.

Among the most common contributions of robotics to orthopedics is its ability to raise the surgical accuracy. The traditional surgical techniques mainly depend on the surgeon's manual skills that increasing the chance for inattentive errors. Moreover, robotic systems combined with advanced imaging and real-time feedback technique, allow surgeons to properly plan and perform surgery with a high accuracy level (Lopez et al., 2023). This level of accuracy appeared on the minimal soft tissue disruption, leading to reduce post-surgery complications, and decrease recovery periods. Investigation a multidisciplinary strategy contains a structured communication and cooperation, where each healthcare givers share their skillfulness to improve patient safety and surgical sufficiency (Prakash and Agrawal, 2023; Reddy et al., 2023; Reinhold et al., 2023). Specifically, nurses play an fundamental responsibility in peri-operative care/period, providing essential assessments, monitoring, and support that connected with the surgical procedure (Buckthorpe et al., 2024). Patient satisfaction covers various dimensions, including pain management, functional recovery, and the overall experience of care, while QoL includes a patient's physical, emotional, and social well-being (Maggio et al., 2024; Zanatta et al., 2023). It is essential to provide the necessity of these factors, which assess how robotic-assisted IF surgery impacts them over time. This longitudinal follow-up study aims to examine and show the effects of IF surgery using the Tianji Orthopedic Robot on patient satisfaction and QoL. By involving validated patient-reported outcome measures and conducting assessments at multiple follow-up time, this research seeks to show overall insights into the long-term advantages of robotic-assisted surgery. Additionally, the study explores the role of nursing care and telehealth in assist and facilitate continuous follow-up, further improving the patient experience and outcomes. However, through this investigation, the study aims to contribute beneficial knowledge to the field of orthopedic surgery and consolidate evidence-based practices that prioritize patient-centered care.

Materials and Methods

Participants and data collection

Between the period December 2023 to November 2024, the patient's data were collected from two different hospitals. However, only experienced physicians and nurses were allowed to collect and record the data. This study included the patients according to spinal cord abnormalities whether the patient underwent surgery with or

without assisted robot with at least 12 months follow-up time. The demographic data, imaging studies, fracture characteristics, and operation data were collected and analyzed. Before the questionnaire, patients get a brief explanation of the research study and the purpose of using the collected data. The patients were required to answer all questions before submitting the survey at the pre-operation time. A self-administered questionnaire was spread using the Baidu Forms platform and shared via Chinese social media platforms (WeChat and QQ) for patient follow-up. However, patients who received the online questionnaire were required to confirm their desire to participate in the survey. Participation in this study was voluntary, based on individual choice, no compensation was provided, no identifying details were collected, and assuring that data collection was anonymous. Demographic and injury data were collected from patient records and imaging studies, in accordance with the principles outlined in the Helsinki Declaration. This study was approved by the ethics committee of The First Affiliated Hospital of Anhui Medical University.

Inclusion/exclusion criteria and sample size

The inpatients who were educative, ≥ 18 years old, and participant who agreed to take part in the study were included. However, patients who were unable to complete the questionnaire, with cognitive impairments, or didn't provide consent, either personally or through a family member were excluded. The Raosoft calculator was utilized to set the sample size for our study, based on the patients total number who underwent spine surgery. We considered a response distribution of 50%, a confidence interval (CI) of 95%, a standard deviation of 1.96, and a margin of error of 5%. This calculation showed a required sample size of 213. Additionally, we accounted for a 10% margin ($n=22$) to address any errors in questionnaire completion. Ultimately, a total of 338 participants voluntary responded and completed the survey and included in the final analysis.

Oswestry Disability Index (ODI) and Short Form Health Survey (SF-36)

The ODI consists of 10 sections including areas such as pain intensity, personal care, lifting, walking, sitting, standing, sleeping, social life, traveling and employment/homemaking. Participants select the statements that best describe their condition. However, responses are scored from 0 to 5, while higher scores mean maximal disability. The total score is changed to a percentage, and higher percentages indicating greater disability. In the Chinese version, the Cronbach's α value is 0.81 and the Validity index is 0.86 (Chow and Chan, 2005). The SF-36 is a widely used patient-reported outcome measure that assess HRQoL. Moreover, it provides an overall view of the physical and mental health status. This survey included 36 questions that are chopped into eight dimensions. While each dimension scored from 0 to 100 and higher scores mean maximal health status. Moreover, the scores summarized to create a physical component summary (PCS) and a mental component summary (MCS). However, in the Chinese version, the Cronbach's α value is 0.88 and the Validity index is 0.94 (Li et al., 2003).

Newcastle Satisfaction with Nursing Care (NSNCS) scale and data analysis

This scale was discovered by previous researcher, and Chinese validity and reliability studies of the scale were fulfill by Jiao. This scale is a 5-point Likert-type including 19 items, one of the them is nursing care. The final score evaluation is

consisting of 0-100 points. The total score elucidates the patient’s satisfaction of nursing care. The Cronbach’s α value is 0.94 and the Validity index is 0.93 in the Chinese version (24). However, NSNCS scale was used to compare the patient’s satisfaction of nurse caring between patients who underwent spine surgery assisted with Tianji robot. The ethical committee of The Second Affiliated Hospital of Hubei University of Science and Technology approved the study with ethical approval number: Hbust-IRB20210314. All procedures were conducted in accordance with the ethical principles outlined in the 1964 Declaration of Helsinki and its subsequent revisions. The study method abides the relevant guidelines and regulations. Informed consent was gained from all participants and their family members. Moreover, consent was acquired from legally authorized representatives, if the patient was illiterate. The researchers explained the study purposes to the patients and their family members prior to using their data.

SPSS version 29 was used to analyze the collected data. Categorical variables are reported as frequencies and percentages, while continuous data are presented as mean± standard deviation. One-way ANOVA was performed to compare QoL and participant satisfaction throughout the follow-up time. Multiple linear regression analyses were performed to identify key determinants of the ODI, SF-36, and NSNCS scores. Variables were selected based on patients theoretical or clinical significance, to control for confounding effects, and according to their statistical significance. P-value set at 0.05.

Results and Discussion

This study included 387 patients who is did spine surgery assisted with Tianji robot. However, a total of 338 patients (87.33%) completed the survey for this study.

Demographic characteristics

Among 338 participants there were 214 female (63.31%) and 124 male (36.68%), ratio female vs male 1.72:1 with mean age of 63.76±14 years. The mechanism of injury (MOI) was traumatic in 260 (76.92%) and non-traumatic in 78 patients (23.07%). However, associated fracture mostly involved in lower extremities 166 (49.11%). The most common affected spine region was lumbar 190 (56.21%) followed by thoracic 99 (29.28%), thoracolumbar 33 (9.76%), and cervical 14 (4.14%) (*Table 1*). Regarding robot assisted surgery, 76 patients (20.9%) underwent robotic navigation-system, 62 patients (18.34%) robot-assisted closed reduction and internal fixation, 47 patients (15.7%) robot-assisted balloon, 15 patients (4.43%) robot-assisted percutaneous balloon dilatation, 6 patients (1.77%) 5G remote robot-assisted closed reduction, 7 patients (2.07%) robot-assisted balloon vertebroplasty.

Table 1. Descriptive characteristics of patient’s carryout spinal surgery assisted with Tianji robot.

Variable (Category)	Frequency [N] (Percentage [%])	Mean±SD
Gender		
Male	124 (36.68%)	
Female	214 (63.31%)	
Age		63.76±14
Surgical type		
Robot-assisted closed reduction and internal fixation	62 (18.34%)	
Robotic navigation-assisted	70 (20.71%)	
Robot-assisted balloon	47 (15.7%)	
Robot-assisted percutaneous balloon dilatation	15 (4.43%)	

5G remote robot-assisted closed reduction	6 (1.77%)
Robot-assisted balloon vertebroplasty	7 (2.07%)
Associated fractures	
Upper extremity fractures	93 (27.51%)
Lower extremity fractures	166 (49.11%)
Others*	79 (23.37%)
Fracture type	
Traumatic	260 (76.92%)
Non traumatic	78 (23.07%)
Fracture region	
Lumbar	190 (56.21%)
Thoracic	99 (29.28%)
Thoracolumbar	33 (9.76%)
Cervical	14 (4.14%)
Admission to surgery	3.03±1.601

Comparing the QoL and satisfaction followup presurgery, 6 months and 12 months of patients with Tianji robot surgery

Figure 1 showed significant changes in the ODI, SF-36, and NSNCS across three follow-up times. Among the three time points pre-surgery, 6 months, and 12 months post-surgery there were a high significant changes in the ODI over different dimensions, including Pain Intensity, Personal Care, Lifting, Walking, Sitting, Standing, Traveling, and Employment/Homemaking. Additionally, the PCS subscale of the SF-36 showed significance throughout the three follow-up periods (p=0.014). In contrast, the MCS did not show any significant changes. Furthermore, the NSNCS reveal significant outcomes throughout the follow-up period (p=0.034) (Table 2).

Table 2. Comparing the QoL and Satisfaction during three periods of follow-up presurgery, 6 month, and 12-month of patients with Tianji robot surgery.

Scale & subscale	Baseline	6 month	12 month	p-value
ODI				
Pain intensity	76±2.76	48±7.98	32±4.28	0.012
Personal care	87±6.98	35±5.90	22±8.54	<0.001
Lifting	83±7.46	62±3.75	58±6.73	0.045
Walking	79±3.65	58±9.65	44±3.54	0.005
Sitting	77±4.98	54±2.65	49±6.32	0.032
Standing	88±4.43	76±8.56	63±5.42	0.028
Sleeping	70±4.21	66±7.35	59±5.82	0.087
Social life	504.206.98	43±8.65	32±9.54	0.531
Traveling	93±1.76	80±4.66	58±3.94	0.018
Employment/homemaking	88±4.43	71±6.32	45±6.82	0.021
SF-36				
PCS	34±5.87	51±3.23	79±4.78	0.014
MCS	53±2.54	75±5.87	89±4.82	0.067
NSNCS	48±7.43	65±6.09	86±4.32	0.034

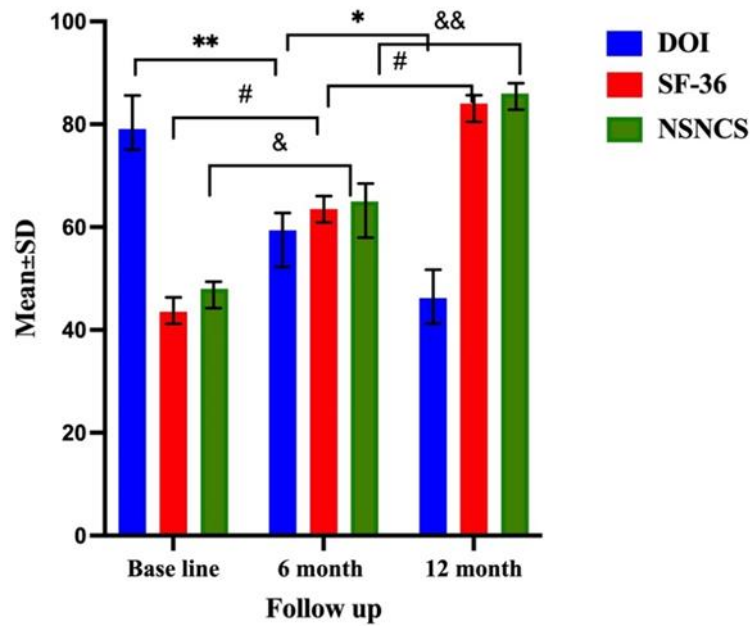


Figure 1. The mean±SD of ODI, SF-36, and NSNCS scales among three follow up periods. Note: ODI=Oswestry Disability Index; SF-36=Short Form Health Survey -36; NSNCS=Newcastle Satisfaction with Nursing Care; *=significant value among ODI score, #=significant value among SF-36 score; significant value among NSNCS: (*,#,&) are p=0.05**, (&&) are p=0.01.

Predictors of QoL and satisfaction using multiple regression analyses as dependent variables

Multiple linear regression analyses were performed to recognize the key factors impacting QoL and satisfaction scores. However, to control for potential confounding factors and the statistical significance, the variables were selected according to the theoretical and clinical relevance. However, the analysis showed many significant predictors, including age, surgical method, type of surgery, type of fracture, fracture region, and admission time were significantly connected with the ODI, SF-36, and NSNCS scores (Table 3).

Table 3. Predictors of QoL and Satisfaction using multiple regression analyses of patients with Tianji robot surgery.

Category	ODI		SF-36		NSNCS	
	β	p-value	β	p-value	β	p-value
Gender	3.31	0.103	0.85	0.667	14.67	0.393
Age	5.38	<0.001	6.58	0.027	5.38	0.039
Surgical type	0.37	0.44	1.88	0.203	1.28	0.486
Associated fractures	3.07	0.044	-0.02	0.989	2.36	0.147
Fracture type	3.92	0.038	5.98	0.017	7.69	0.011
Fracture region	5.76	0.032	7.32	0.050	7.96	0.025
Admission to surgery	4.19	<0.001	0.30	0.799	-2.07	<0.001

Note: ODI=Oswestry Disability Index; SF-36=Short form-36; NSNCS=Newcastle Satisfaction with Nursing Care.

SCI is a common health issue that shows significant physical, psychological, and economic challenges (Reza, 2024). Spinal cord abnormalities can cause mobility issues,

chronic pain, and neurological symptoms, which affect individuals overall QoL. Additionally, the psychosocial impacts include increased anxiety, depression, and social isolation, frequently aggravated by societal prejudice (Altahla et al., 2024b). The involvement of robot in IF surgery has raised as a significant achievement in orthopedic surgery and care (Liang et al., 2024; Schuijt et al., 2021). Robotic technology like the Tianji Orthopedic Robot ensure high surgical accuracy, which lead to high accurate level of screws placement (Liang et al., 2024). This accuracy reduces tissue damage, operative time, and risk of complications. There were significant reduction in the ODI scores, which indicates that patients experienced less pain and high functional ability, which approve the advancements in surgery can lead to sensible improvements in recovery and QoL, which consist with previous studies (Golinelli et al., 2025; Hurtuk et al., 2012). In comparison, Liow et al. (2017) conduct that no significant differences in the physical function throughout the follow-up periods. The significant increase in the SF-36 scores shows a considerable improvement in patients' QoL and well-being. Moreover, this improvement including psychological and social dimensions of health. Robo-assisted surgeries may contribute to these QoL enhancements by faster return to daily life activities and reducing the long-term effect, which connect with previous studies (Grosso et al., 2022; Joo et al., 2022; Karunaratne et al., 2019).

The high levels of satisfaction in the NSNCS highlight the essentiality of surgical and nursing care in the overall patient experience. The positive effect of robot-assisted surgery on patients' care conceptions may arise from various factors, including reduced pain, faster recovery times, and improved post-operative assistance, which aligns with previous researcher findings (Smith et al., 2021; Marchand et al., 2017). Furthermore, the involvement of telehealth for persistent follow-up confirms the part of nurses in providing continuous care and monitoring, which can improve patient satisfaction. However, patients age, associated fractures, fracture type, fracture region, and admission to surgery time play as a predictive factors and connected with low QoL and patients satisfactions. This study confirm the importance of a multidisciplinary cooperation to patient care. Collaboration between surgeons, nursing staff, and rehabilitation staffs is essential in optimizing patient prognosis. The involvement of nurses in the telehealth follow-up time allows for timely interventions, declaiming any concerns that may appear during recovery, and enhance a proper environment for patients. As robot technology continues to develop, however, further research is required to assure the long-term effects on different patient and different types of orthopedics surgery. Mastering how robot technology can integrated into clinical practice will be substantial for maximizing robot benefits. However, future studies should explore the cost of robot-assisted surgeries compared to traditional methods, as well as the training and support required for healthcare professionals to confirm the advantages of these technologies.

This is the first study to evaluate changes in patient satisfaction and QoL following IF surgery with the Tianji Orthopedic Robot, estimated by a nursing staff using telehealth services. This study have some limitations. The first limitation is the dependence on the patient outcomes measure, such as the ODI and the SF-36. This reliance may show response bias, as patients might overvalue or undervalue their satisfaction and QoL. The second limitation is the lack of a control group, making it hard to attribute the improvements of the robot assisted surgery. Moreover, some other factors may affect the patient outcomes and complicate the interpretation of the outcomes.

Conclusion

This study demonstrates that IF surgery utilizing the Tianji Orthopedic Robot, which substantially improves patient satisfaction and QoL, with these benefits persistent over a 12-month follow-up time. The significant decreases in ODI and increases in SF-36 scores reveal promoted functional status and patients well-being. Moreover, The NSNCS shows high satisfaction levels that reflect positive patient experiences. These findings indicate the importance of using robotic technology into surgical technique and highlight the crucial role of nursing in providing continues support and using telehealth for long-term follow-up. Overall, the study advocates for the continued use of robot-assisted surgery and promote nursing care strategies to improve patient outcomes.

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Conflict of interest

The authors confirm that there is no conflict of interest involve with any parties in this research study.

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