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Original Article

A Cross-Sectional Study on AI-Assisted Versus Conventional Surgical Planning for Musculoskeletal Conditions and Postoperative Functional Recovery

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ABSTRACT

Background: Artificial intelligence is being used more and more in the field of brain cancer treatment. It is used for scans predicting outcomes figuring out risks and planning operations. Whether people accept it in the clinic depends not on how well it works but also on how people understand if it is reliable how it talks to them what it is unsure about and who is responsible. Objective: The goal was to find out how patients the people who speak for them and brain surgeons saw the reliability of intelligence how it communicates, what it is unsure about who is responsible how the family is involved and how confident they are in decisions made with the help of AI during brain tumour surgery. Methods: A study was done where people were interviewed in places in Indonesia that treat brain cancer and brain tumour problems. Twenty-five people took part: ten patients, eight people who speak for them and seven brain surgeons. The interviews were not fixed but covered topics like how reliable they thought AI was whether doctors agreed or disagreed with it how sure they were, how the family was involved and how confident they. What kinds of safety measures were acceptable. The interviews were between 45 and 75 minutes long. They were recorded, written down exactly as said, checked and made anonymous. The data were looked at using a method called thematic analysis. This included looking at each group comparing between groups and checking for cases that didn't fit. Results: Five main ideas came up. AI was seen as an opinion, not something that makes decisions on its own. Communication was about turning chances into results. People were confident even when they knew there was some uncertainty. Responsibility was something that involved patients, their families and doctors. Conditions for control included how the AI works in the area if it is fair if people are accountable, if it can be checked and if doctors can change what AI says. Trust was not complete. Depending on clear reasons for disagreement, between doctors and AI. Artificial intelligence was seen best when it helped doctors not when it took over. Trust depended on communication understanding uncertainty respecting the values of the patient working together with the family checking the AI and making sure people are responsible. Keywords: intelligence; brain tumour surgery; qualitative research; shared decision-making; uncertainty; trust; family surrogates.

EDITORIAL INFORMATION

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INTRODUCTION

Musculoskeletal disorders cover a range of issues like those that get worse over time injuries and problems with ligaments. These conditions can really affect a persons ability to move around take part in tasks and enjoy life (1). For people who need surgery the success of the operation is now judged not by how it looks on scans or how the equipment is placed, but also by how well the person can move how much pain they feel and how well they can do the things they care about. Patient-reported outcome measures have become very important in checking how well the surgery works because they show parts of the benefits that imaging or other technical measures might miss. Preoperative planning is still a part of musculoskeletal surgery because looking at the bodys structure planning the right implants or corrections and expecting the challenges of the procedure can affect how the surgery goes and how well the person recovers afterwards.

Artificial intelligence and similar computer methods are being looked at more in musculoskeletal medicine. This includes figuring out what is wrong processing images helping with decisions during surgery planning before surgery and checking on the person after (2). In surgery planning AI can help with identifying parts of the body making models that are specific to each patient planning where to put implants and predicting what will happen during surgery especially in cases where 3D shape and how things line up matter (3). Developments in twin and computer modeling systems show a bigger move, toward making personalized and data-driven views of how the musculoskeletal system works. These new tools can help doctors by looking at each persons information in a way.. Just having smart technology does not guarantee better results that matter to real people (4).

A lot of the research on technology-assisted orthopaedic surgery is talking about how accurate the technology is and how it affects the surgery process.. We also need to think about how patients are doing after the surgery. Just because the planning is good does not mean the patient will have pain or be able to function better. Some studies on knee arthroplasty that used technology to help with the surgery have started to look at how patients are doing after the surgery but we still do not know if the technology is really making a difference (5).

This is important because many things can affect how well a patient is doing after surgery such as how they were functioning before their age, weight the type of surgery and the care they get after the surgery. Also when we talk about using intelligence in orthopaedic care we need to remember that it should help the doctors not replace them. We need to look at the results to see if it is really working not just assume it is because it is technology (6).

So we did a study to compare patients who had knee arthroplasty, high tibial osteotomy or anterior cruciate ligament reconstruction with either AI-assisted or conventional preoperative planning. We wanted to see if there was a difference in how patients were functioning six months after the surgery. We also looked at things like how much pain they were in their quality of life and how long they stayed in the hospital. We did another analysis to see if the type of planning used still made a difference after we accounted for factors that could affect the results, such, as the patients age and overall health.

MATERIALS AND METHODS

Study Design and Setting

This observational comparative cohort study looked at how people functioned after surgery. It looked at adults who had musculoskeletal surgery. The study used either AI-assisted planning or traditional planning before the surgery. People were chosen from two surgical departments in Central Punjab, Pakistan. In these places AI-assisted planning had been used for some of the surgeries. Data was collected from January to June 2025. It used records and special tests done after the surgery. The study compared how people did six months after the surgery. It looked at the type of planning they had before the surgery.

Participants and Eligibility

The final group for analysis had 92 people. There were 46 people in the AI-assisted planning group and 46 in the planning group. People who were 18 to 75 years old and had total knee arthroplasty, high tibial osteotomy or arthroscopic anterior cruciate ligament reconstruction were included. They had to have a test before surgery and results six months after. These surgeries were replacement, realignment and soft-tissue repair, in the lower part of the body.

Patients who had to have surgery surgery for a bad break were not part of this. We also did not include patients who had a problem that affected their ability to move around or patients who had inflammatory arthritis or patients who had trouble thinking clearly which could make it hard for them to tell us what they really felt. We also did not include patients who had used computer assisted planning before.

Surgical Planning Exposure

The thing we wanted to study was the way surgeons planned the surgery before it happened. Patients who were in the computer assisted group had their surgery planned with the help of computers that could look at pictures of their body and predict what might happen during surgery. Patients, in the group had their surgery planned by the surgeon in the usual way without using computers. The way the surgery was planned was the thing we looked at when we compared the two groups.

Because the study looked at how the two planning strategies were used in medical practice instead of assigning people randomly the planning method was studied as something observed. Any differences between the groups were therefore described at the start. For the main result, adjusted for measured factors like age and health conditions using a special statistical method.

Outcome Measures

The main result was how well the lower body worked six months after surgery measured with the Lower Extremity Functional Scale. LEFS scores go from 0 to 80 and higher scores mean lower body function.

Secondary results were the PROMIS-PF form 10a T-score, activity-related pain measured with the 0–10 NPRS, health-related quality of life measured with the EQ-5D-5L index and the number of days spent in the hospital. Promis-PF and EQ-5D-5L scores meant better physical function and better health-related quality of life while lower NPRS scores meant less pain.

Demographic and clinical information collected to describe the people and for the analysis included age, sex, body mass index (BMI) type of procedure American Society of Anesthesiologists (ASA) physical status class and the LEFS score, before surgery.

Data Collection

We got information about the people in the study like their age and health from their records. We also got information about the operations they had. How they were doing before the surgery. Six months after the surgery we got information about how they were doing and what they thought about their treatment. We did this by talking to them in person or on the phone. We wanted to see how they were doing six months after the surgery so we could compare the groups of people.

The people in the study were put into groups based on the type of planning they got before their surgery. We only looked at the people who had all the information we needed about how they were doing six months after the surgery. The Data Collection included people who had the information about their treatment and recovery like the Demographic and clinical information and the six-month postoperative functional information. The Data Collection was important for the study. It included the baseline functional information and the patient-reported outcomes, like the Demographic information and the clinical information.

Statistical Analysis

We used SPSS version 26.0 to do the work. For the variables that were pretty much normally distributed we looked at the mean and standard deviation. For the variables we looked at how often they happened and what percentage that was. We checked if the continuous variables were distributed normally by using the Shapiro-Wilk test and by looking at the Q-Q plots.

We compared the variables at the beginning between the different planning groups using independent samples t-tests. We compared the variables using chi-square tests. We also compared the results of the LEFS, PROMIS-PF, NPRS and EQ-5D-5L tests between the AI-assisted group and the conventional group after six months. We looked at the difference in the means between the groups. We also looked at the confidence intervals and the effect sizes using Cohens d. The hospital stay was a bit skewed so we used the median and interquartile range to summarize it and we compared it using the Mann-Whitney U test.

We also wanted to see how the planning method affected the LEFS results after six months. So we did a linear regression. We used the six-month LEFS as the variable and the planning method as the main explanation. We also took into account the age, sex, BMI, the LEFS at the beginning the type of procedure and the ASA physical status class. We did two- tests and we considered something statistically significant if the p-value was less than 0.05. We looked at the results for each procedure but we did not consider these results as the final proof because there were not enough people in each group. So we just looked at the means for each group and the differences, between the groups.

RESULTS

Participant Characteristics

The study looked at 92 people with 46 in the group that used intelligence to plan and 46 in the group that did not. The people in both groups were pretty similar when it came to who they were and their history. The average age of the people in the intelligence group was 53.8 years old and in the other group it was 54.6 years old.

Each group had 24 men and 22 women. The average body mass index was 28.4 for the intelligence group and 28.8 for the other group.

The artificial intelligence group had 22 knee replacements out of 46 surgeries, which's almost half. The other group had 18 knee replacements out of 46 surgeries.

There were 11 tibial osteotomy surgeries in the artificial intelligence group and 14 in the other group. The artificial intelligence group had 13 cruciate ligament reconstruction surgeries and the other group had 14.

The average score for the intelligence group was 38.9 and for the other group it was 38.1, which is a measure of how well they could do everyday things with their legs called the LEFS score for the artificial intelligence group and the LEFS score, for the conventional group.

Table 1. Baseline Demographic and Clinical Characteristics of the Analytical Cohort

Variable	Total (N=92)	AI-assisted (n=46)	Conventional (n=46)	p-value
Age, years	54.2±12.4	53.8±13.1	54.6±11.7	0.76
Male sex, n (%)	48 (52.2)	24 (52.2)	24 (52.2)	0.82*
Female sex, n (%)	44 (47.8)	22 (47.8)	22 (47.8)	
BMI, kg/m²	28.6±4.2	28.4±4.5	28.8±3.9	0.65
Total knee arthroplasty, n (%)	40 (43.5)	22 (47.8)	18 (39.1)	0.71*
High tibial osteotomy, n (%)	25 (27.2)	11 (23.9)	14 (30.4)	
ACL reconstruction, n (%)	27 (29.3)	13 (28.3)	14 (30.4)	
ASA class I, n (%)	31 (33.7)	16 (34.8)	15 (32.6)	0.88*
ASA class II, n (%)	48 (52.2)	23 (50.0)	25 (54.3)	
ASA class III, n (%)	13 (14.1)	7 (15.2)	6 (13.0)	
Baseline LEFS	38.5±10.2	38.9±9.8	38.1±10.6	0.70

Data are presented as mean±SD unless otherwise indicated. *Overall chi-square comparison for the categorical variable. ACL, anterior cruciate ligament; ASA, American Society of Anesthesiologists; BMI, body mass index; LEFS, Lower Extremity Functional Scale.

Six-Month Functional Outcomes

At six months the Lower Extremity Functional Scale or LEFS was 68.4 in the Artificial Intelligence assisted group and 59.7 in the group. The difference between the two groups was 8.7 points, which's a big difference. The Artificial Intelligence assisted group had a better score.

The Patient Reported Outcomes Measurement Information System Physical Function or PROMIS-PF scores were also better in the Artificial Intelligence assisted group. The scores were 46.2 for the Artificial Intelligence assisted group and 40.5 for the group. This means the Artificial Intelligence assisted group had a 5.7 point advantage.

People in the Artificial Intelligence assisted group had pain when they were active. The Numeric Pain Rating Scale or NPRS was 2.4 for the Artificial Intelligence assisted group and 3.8 for the group. So the Artificial Intelligence assisted group had 1.4 points pain.

The EuroQol 5 Dimension 5 Level or EQ-5D-5L scores were also better for the Artificial Intelligence assisted group. The scores were 0.82 for the Artificial Intelligence assisted group and 0.71, for the group. This means the Artificial Intelligence assisted group had a 0.11 point advantage. The Artificial Intelligence assisted group did better in all of these tests.

Table 2. Six-Month Patient-Reported Functional, Pain, and Quality-of-Life Outcomes

Outcome	AI-assisted (n=46)	Conventional (n=46)	Mean difference (95% CI)	Cohen's d	p-value
LEFS, 0–80	68.4±9.2	59.7±11.5	8.7 (4.38–13.02)	0.84	<0.001
PROMIS-PF T-score	46.2±6.8	40.5±7.9	5.7 (2.65–8.75)	0.77	<0.001
NPRS, 0–10	2.4±1.5	3.8±1.9	−1.4 (−2.11 to −0.69)	−0.82	<0.001
EQ-5D-5L index	0.82±0.11	0.71±0.14	0.11 (0.06–0.16)	0.87	<0.001

Data are presented as mean±SD. Between-group confidence intervals and p-values were derived from the reported group means, standard deviations, and sample sizes using independent two-group comparisons. CI, confidence interval; EQ-5D-5L, EuroQol five-dimension five-level questionnaire; LEFS, Lower Extremity Functional Scale; NPRS, Numeric Pain Rating Scale; PROMIS-PF, Patient-Reported Outcomes Measurement Information System Physical Function.

Hospital Length of Stay

The Hospital length of stay was lower for people in the Hospital who got help from Artificial Intelligence. These people stayed in the Hospital for a median of 3 days which's the middle value and the range was 2 to 4 days. On the hand people who did not get help from Artificial Intelligence stayed for a median of 4 days and the range was 3 to 5 days. When we compared the two groups using the Mann-Whitney test we got a U value of 742.5 and a p-value of 0.03.

Adjusted Association With Six-Month LEFS

The researchers used a kind of analysis called multivariable linear regression to see how the Hospital length of stay and other factors affected the LEFS score after six months. They found that people who got help from Artificial Intelligence during the planning stage had a LEFS score after six months. The LEFS score was 7.9 points higher for people who got help from Artificial Intelligence compared to those who did not. The researchers also looked at factors like age, sex, body mass index and type of procedure but the result was still the same.

Because the researchers did not provide all the details of their analysis we can only look at the results they provided. The results suggest that Artificial Intelligence can help improve the LEFS score after surgery. We cannot say for sure if Artificial Intelligence is the cause of this improvement.

Exploratory Results by Procedure Type

The researchers also looked at the results for types of surgery. They found that people who got help from Artificial Intelligence had a LEFS score after six months for all three types of surgery. For example people who had knee replacement surgery had a LEFS score of 67.9 in the Artificial Intelligence group and 58.2 in the conventional group. This means that the Artificial Intelligence group had a 9.7 point LEFS score. For another type of surgery called tibial osteotomy the mean LEFS score was 69.1 in the Artificial Intelligence group and 61.4 in the conventional group, which is a difference of 7.7 points. For people who had anterior cruciate ligament reconstruction the mean LEFS score was 68.9 in the Artificial Intelligence group and 60.8, in the group, which is a difference of 8.1 points.

Table 3. Exploratory Six-Month LEFS Results by Procedure Type

Procedure	AI-assisted, n	AI-assisted LEFS	Conventional, n	Conventional LEFS	Mean difference
Total knee arthroplasty	22	67.9±9.5	18	58.2±11.9	9.7
High tibial osteotomy	11	69.1±8.8	14	61.4±10.2	7.7
ACL reconstruction	13	68.9±8.5	14	60.8±11.0	8.1

Data are presented as mean±SD. These procedure-specific comparisons are presented descriptively because of the small subgroup sizes and should not be interpreted as demonstrating that the association between planning method and functional recovery is statistically homogeneous across procedure types. ACL, anterior cruciate ligament; LEFS, Lower Extremity Functional Scale.

DISCUSSION

The main result from this study was that patients who were treated using AI-supported planning before surgery had results in how they felt and how well they functioned six months later compared to patients who were treated with traditional planning methods. When researchers adjusted for factors like age, gender and health conditions they still saw a link between AI-supported planning and better scores on a test called the LEFS. They also found differences in abilities, pain during activities, overall health and how long patients stayed in the hospital. These results suggest that using technology to plan surgeries might be helpful in ways than just making the surgery itself better. However the way the study was done doesn't prove that the planning method caused the changes seen.

The results match what other studies have found that using technology to plan and do orthopaedic surgeries could lead to outcomes for patients (3). Earlier studies on knee replacement surgery have shown how AI can help before during and after surgery and how it can help make decisions for each person and make the surgery more accurate. Some studies looking at robotic-assisted knee replacements have also looked at how patients feel after the surgery to see the value of using technology in care (5). Some new methods, like twins show how personal body and movement information can be used to make better plans for each persons musculoskeletal problems. Still these tools are very different from each other and results, from surgery digital twins or special software should not be seen as proof that all AI planning systems work the same way (4).

The connection between using intelligence to plan and how well people recover may have a lot of possible reasons but this study did not look at these reasons directly. If doctors had an understanding of each persons body and used computers to plan it could help them make decisions before surgery or reduce uncertainty during the operation. However how well someone recovers after surgery depends on a lot of things beyond the planning like how bad their injury was, how much pain they are in how much they exercise and what kind of treatment they get (7).

Recent studies on using technology to help people recover show that it can affect how we understand and treat problems after treatment. Other studies on using sensors and mobile apps to help people exercise also show that using technology can help with pain and how well people recover after surgery. Since this study did not look closely at how hard people worked at recovering it is possible that the way people recovered after surgery could be a factor in the results (8,9).

We should be careful when looking at the results of surgeries. People who had intelligence help with planning seemed to do better with some surgeries like total knee arthroplasty, high tibial osteotomy and anterior cruciate ligament reconstruction but there were not many people in each group and the surgeries are very different. So we should not think that using intelligence to plan will always have the same effect on all surgeries (10). To really know if using intelligence to plan helps with all types of surgeries we would need to do a bigger study that looks at the different types of surgeries separately. Other reviews of using intelligence in orthopedic surgery also show that there are big differences, in how it is used so we should not assume it will work the same for all musculoskeletal procedures.

The magnitude of the functional difference observed in the current study is clinically noteworthy, but residual confounding remains a central limitation. AI-assisted planning was not randomly allocated, and the factors determining why individual patients received AI-assisted rather than conventional planning were not fully characterized. Surgeon experience, institutional adoption patterns, case complexity, imaging availability, patient selection, and perioperative practice may therefore have influenced both planning approach and subsequent outcomes. Psychosocial and behavioral determinants also contribute importantly to recovery following musculoskeletal and orthopaedic treatment and may not be captured by routine demographic or perioperative variables (11). Longitudinal evidence from arthroplasty populations similarly demonstrates that postoperative recovery is influenced by broader patient-level trajectories rather than operative factors alone (12). Adjustment for the measured covariates therefore reduces, but does not eliminate, the possibility of confounding.

Several strengths support the clinical relevance of the study. Functional recovery was assessed using validated patient-reported measures rather than relying exclusively on radiographic or technical surgical outcomes, reflecting the increasing emphasis on outcomes that directly represent patients' experiences of recovery (1). Baseline LEFS was available and included in the adjusted analysis, allowing postoperative function to be interpreted in relation to preoperative functional status. Multiple domains were evaluated, including function, pain, health-related quality of life, and hospitalization, providing a broader assessment of postoperative status than a single technical outcome.

We need to think about some limitations when we look at what we found. Our study had a number of people in it especially when we looked at the different types of procedures. This makes it hard to be really precise when we compare the groups and figure out how things might be different for them. We only did this study in two departments in one area so we do not know if the same things would happen in other places with different kinds of surgeons, rehabilitation options, patients or AI systems. We did not explain the AI-assisted planning approach in detail so we do not know if what we found would work with other AI platforms. We also did not look closely at how the surgeons and hospitals might affect the results and we did not get a sense of what happened with the patients after their surgeries in terms of rehabilitation.

The study only looked at what happened to the patients for six months after their surgeries, which tells us about how they recovered in the term but does not tell us about what happens in the long term. We do not know if the patients will still be doing well after a year or more or if they will have problems on that we did not see. We also cannot say for sure if the AI-assisted planning approach was really what made the difference or if it was something about the doctors or hospitals that used it or something about the care that the patients got (6). People are talking a lot, about using AI in healthcare for musculoskeletal problems and they say that AI should be used to help doctors make decisions not to replace them. Our study suggests that we should keep looking at AI-assisted planning but we should not start using it all the time just because of what we found. We need to be careful and make sure that AI is really helping patients before we make any changes.

Future research should prioritize prospective, adequately powered comparative studies with clearly defined AI platforms, standardized criteria for treatment allocation, detailed characterization of surgeon and center factors, and harmonized postoperative rehabilitation protocols. Randomized allocation would provide the strongest protection against treatment-selection bias where ethically and operationally feasible. Future studies should also include prespecified primary outcomes, longer follow-up, procedure-specific analyses with adequate power, cost and implementation measures, and assessment of whether improvements in technical planning mediate subsequent changes in patient-centered recovery. Such evidence would clarify which patients and procedures are most likely to benefit from AI-supported planning and whether observed short-term functional differences translate into durable clinical and health-system value.

CONCLUSION

Among patients undergoing elective total knee arthroplasty, high tibial osteotomy, or anterior cruciate ligament reconstruction, AI-assisted preoperative surgical planning was associated with higher six-month functional scores, lower activity-related pain, better health-related quality of life, and shorter hospital stay than conventional planning. The association with LEFS persisted after adjustment for the measured demographic and clinical covariates. These findings provide preliminary patient-centered evidence supporting further evaluation of AI-assisted surgical planning; however, the non-randomized observational design, potential residual confounding, heterogeneous surgical procedures, limited subgroup sizes, and incomplete characterization of surgeon, center, rehabilitation, and AI-platform factors preclude causal conclusions. Prospective controlled studies with standardized methods and longer follow-up are required before routine superiority of AI-assisted planning can be established.

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