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Original Article

"Minimally Invasive Surgical Techniques in Treating Orthopedic Injuries in Horses: Clinical Outcomes and Recovery"

Aftab Ahmed[1]

1 Livestock & Dairy Development (Ext.) Department, Khyber Pakhtunkhwa, Pakistan

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***Corresponding Author:**
Aftab Ahmed
(aftabahmad3837@gmail.com)

ABSTRACT

This study investigates the effectiveness of minimally invasive surgical (MIS) techniques in treating orthopedic injuries in horses, focusing on clinical outcomes, recovery, complications, and long-term effects compared to traditional open surgery. A total of 150 horses undergoing MIS were compared with 150 horses treated using open surgery. The results revealed that MIS significantly reduced post-operative pain and shortened recovery times, with horses returning to work and full recovery more quickly than those in the open surgery group. MIS also resulted in fewer complications, such as wound infections and hemorrhage, and improved radiographic outcomes. Additionally, the MIS group exhibited better long-term joint function and reduced arthritis development at 12 months post-surgery. Cost-effectiveness analysis showed that while MIS had higher initial surgical costs, the overall treatment costs were comparable due to shorter hospital stays and faster rehabilitation. These findings highlight the advantages of MIS in equine orthopedic surgery, emphasizing its potential to improve clinical outcomes, reduce recovery times, and provide cost-effective treatment. The study suggests that MIS techniques can be an effective alternative to open surgery, offering significant benefits in equine orthopedic care.

INTRODUCTION

Modern minimally invasive surgical techniques have transformed orthopedic treatment for horses by creating a new surgical standard beyond traditional open procedures [1]. Smaller incisions and reduced tissue strain have made these methods popular since they show potential to boost healing outcomes and recovery times in horse patients [2–4]. The development of these methods stems from the need to minimize patient morbidity and decrease post-operative discomfort and hasten rehabilitation time. The return to athletic ability for horses significantly improves through each of these strategies. Minimally invasive treatment success rates depend heavily on complete knowledge of tissue regenerative mechanisms thus customized approaches to manage wound healing complexity remain vital [5]. Modern orthopedic surgeons possess two primary responsibilities: they must optimize treatment environments for healing fractures and identify barriers while selecting ideal surgical fixation methods to advance both technical evolution and minimal invasiveness [6]. The use of evidence-based approaches within horse orthopedic surgery has gained widespread recognition because these approaches focus on validating various surgical procedures through clinically tested studies regarding their outcomes and diagnostic precision and prognostic expectations [7].

Arthroscopic procedures have become standard for diagnosing intra-articular injuries because these procedures provide visualization and treatment of cartilage damage meniscal tears and ligamentous injuries while minimizing interference with adjacent tissues [8]. The capabilities of minimally invasive surgery extend to treating both tendon and bursa-related pathology through procedures that use scopes which proves the technique's capacity to handle various horse orthopedic diseases. Precise surgical guidance for anatomical reconstruction relies on the combination of modern imaging tools that leverage ultrasonic waves together with intraoperative fluoroscopy. These imaging tools display surgical site information in real time which allows surgeons to achieve exact implant positioning while minimizing harm to adjacent structures.

The precise choice of surgical tools together with new surgical techniques directly influences the effectiveness of minimally invasive surgery. Specialized arthroscopic tools including burrs and suturing implements together with shavers let surgeons perform complex procedures through small incisions which reduces tissue strain while speeding up recovery times. Research review processes regarding medical equipment and surgical developments remain essential for safe patient outcomes because these products demand ongoing methodological adaptations [9]. A review of the research demonstrates that minimally invasive surgical approaches lead to reduced occurrences of surgical site infections and delayed wound healing for patients.

Minimally invasive treatments lead to reduced post-operative discomfort for horses and decrease the need for analgesic drugs in addition to enhancing patient comfort. The ability to initiate early rehabilitation becomes more feasible because minimally invasive surgery helps establish both normal function and prevents the development of compensatory musculoskeletal disorders. Minimally invasive surgery comes with certain implementation challenges. Specialized tools along with a steep learning curve for new surgical methods and challenges from patient posture and instrument handling pose difficulties to these treatment approaches [10]. Relatively few patients with specific orthopedic injuries benefit from minimally invasive surgery although such procedures present operational complications.

Research currently available shows rising support for horse orthopedic treatment through minimally invasive surgical approaches. The safety and viability of these procedures have been proven in multiple studies yet additional research must assess their operational effectiveness against traditional open procedures. Research into minimally invasive technique advantages requires comprehensive assessments of objective outcome measures including radiographic assessments as well as lameness ratings and sports performance timelines. The influence of monetary considerations exceeds any reasonable measurement when making medical decisions. Upcoming studies need to analyze if minimally invasive surgical approaches prove cost-efficient against traditional open procedures [12].

Medical science continues to study the permanent effects of minimally invasive surgery on osteoarthritis and other joint degenerative conditions. Consistent surgical methods and standardized post-operative care recommendations become essential because variations in surgical experience and patient selection and rehabilitation practices have a powerful impact on study outcomes. The widespread adoption of minimally invasive surgical techniques in horse orthopedics depends primarily on sustained inventive efforts and comprehensive research and skilled training programs. Several medical fields are trending toward minimal invasive surgery yet a sufficient number of studies fail to prove its superiority to conventional surgical techniques [13,14]. Current data suggest minimally invasive surgery should limit its use to less severe cases despite its association with suboptimal results [15]. The implementation of minimally invasive procedures requires understanding the particular technical constraints and addresses specific operational difficulties [16] and demands practice time to master [17]. Scientific expertise combined with competency in managing operational complications are essential requirements for surgeons [17]. Technical advances enable minimally invasive surgical methods to demonstrate potential benefit in addressing intra-abdominal procedures [11]. Patients experience better health results from minimally invasive surgical techniques which reduce hospital admission times and create fewer postoperative discomforts compared to traditional open surgical procedures [18].

Medical advancements alongside expert veterinary recommendations as well as changes in preferred surgical techniques may extend the time between when symptoms appear and when surgery takes place [19]. Many surgical procedures now require laparoscopes instead of traditional open laparotomy procedures that were needed in the past. The various advantages of minimally invasive surgery become apparent through decreased hospital stays and reduced postoperative morbidity and faster return to work ability [20]. After undergoing open surgery patients need to stay in hospital for a range of five to ten days [21,22] but minimally invasive techniques provide faster recovery along with reduced post-operative pain. Gynecologists began accepting laparoscopic surgery as a safe diagnostic approach to pelvic pain in the middle of the 1950s and it reduced hospital stays and minimized postoperative discomfort [23]. Several surgical fields adopted laparoscopy as a well-known procedure following its initial introduction [24].

Methodology

The evaluative approach for minimally invasive surgical procedures in horses combines retrospective and prospective study designs to deliver comprehensive data on these procedures' security and functionality compared to traditional open surgery. While using different research approaches to collect data the methods provide essential insights that are valuable to understanding.

Research on Retrospection:

The evaluation of surgical methods requires retrospective research methodology because past medical records serve as the primary source of information. Studies typically analyze data by comparing standard open surgery results from horses to results obtained through minimally invasive surgery approaches. Retroactive examination enables quick aggregation of information across numerous horses using previous treatment data thus identifying initial therapeutic patterns. These studies in practical environments can deliver useful data about problems and recovery durations and effectiveness measurements. The quality of accessible data limits retrospective research because records often differ substantially from one another. Selection bias exists because patients who receive minimally invasive surgery differ significantly from patients getting open surgery (such as age or medical conditions). Research variables along with data collection procedures without proper management restrict scientists from reaching conclusive results about cause-and-effect relationships.

Researchers in prospective studies purposefully collect information from identified horses who receive minimally invasive or open surgical treatment. Valid results become achievable through strict subject selection along with standardized data collection procedures and pre-established outcome measures which decrease study biases. During trail follow-up researchers track outcomes utilizing prospectively monitored horses to measure recovery times alongside complication rates while investigating long-term effects. The aggregated information enables researchers to form an elevated understanding of key variables which affect postoperative results. The execution of prospective investigations demands extended resources along with prolonged periods of time which limits the size and scope of research data collection.

Randomised controlled trials (RCTs) stand as the top evaluation method for surgical procedures because their procedure of matching horses between traditional open surgery groups and less invasive procedures reduces bias. Through random assignment every team ends up with equivalent baseline characteristics that minimize uncertainties and enhance surgical result comparison accuracy. RCTs function effectively as research tools to establish cause-effect relationships by explicitly showing surgery methods connected with recovery durations as well as complications rates and long-term health status. Research through experimental control enables the elimination of extraneous elements including differences between medical staff or hospital infrastructure because these factors would otherwise modify results derived from comparing identical groups in the same investigation.

Meta-analysis:

The combination of multiple types of research data both retrospective and prospective enables meta-analyses to construct an expanded understanding of minimal invasive surgery results when compared to open surgery thus advancing our knowledge further. A properly performed meta-analysis of various research produces generalized outcomes through improved statistical power due to data combination. New studies combining multiple tiny horse surgery results using meta-analytic techniques proved minimally invasive methods provide equivalent surgical outcomes but faster recovery periods combined with lower risk of wound infections. When multiple trials contribute their data to meta-analysis the resulting accuracy regarding minimally invasive surgery support clinical decisions as well as research directions.

Results

An investigation into the treatment of orthopedic horse injuries with open surgery against minimally invasive surgery reveals comprehensive results about both approaches' clinical outcomes and recovery duration and complications with long-term effects. The surgical characteristics together with patient statistics appear in Table 1. Horses across both groups demonstrated similar age distributions weight measurements as well as similar injury types. The surgical operations in the minimally invasive surgery group required less time and resulted in faster recovery periods than open surgery group operations. Table 2 shows post-operative pain levels; Structured data from the study demonstrated that horses undergoing MIS procedures demonstrated substantially decreased pain levels across each assessment period (right after surgery and at Postoperative Days 1, 7, and 28). This pattern matches the lower tissue destruction typical in MIS procedures. Table 3 shows the complication rates; The surgical patients performed MIS procedures revealed superior outcomes compared to patients who underwent open surgical procedures because their complication rates were lower. Table 4 demonstrates how long horses needed to return to athletic performance following surgery. Horses undergoing MIS surgery complete their recovery process including light work and complete healing before horses who undergo open surgery procedures. Table 5 displays radiographic improvement; At multiple stages of post-operative observation the patients in the MIS group showed better joint positioning alongside enhanced fracture restructuring. Table 6 presents data on both hospitalization length and rehabilitation duration between the groups. Subjects from the MIS group experienced faster hospital discharge and postoperative healing. AU$1155 in initial surgery expenses for MIS proved costly at first but the combined price of treatment excluding post-operative care fell into parity or even reduced below costs for open surgery (Table 7). At a 12-month follow-up period Table 8 demonstrated horses receiving MIS bursoscopic technique developed fewer lameness cases in addition to superior joint performance and lower arthritis symptoms compared to horses undergoing open surgery.

The research results appear as visual representations in Figures 1 through 10. The bar graph in Figure 1 displays baseline patient and surgical information about both groups. Post-operative pain levels presented in Figure 2 demonstrate that the MIS treated group experienced substantial pain reduction over time. The MIS group achieves superior results in the bar graph which demonstrates the lower complication rates shown in Figure 3. The time required to return to athletic activities appears in Figure 4. The MIS group manages to achieve postoperative benchmarks faster than patients who receive open surgery. The imaging outcomes for joint reconstruction and fracture rehabilitation appear in Figure 5 as both groups advanced through time. The hospital stay and rehabilitation durations in Figure 6 indicate that patients who underwent MIS treatment achieved faster recovery compared to those receiving open surgery treatment. The bar graph in Figure 7 demonstrates that the Minimal Invasive Surgical method offers the most cost-effective treatment even though initial expenses are higher. Fig. 8 displays the positive MIS group results by using a line chart to show improvements in lameness capacity alongside joint functionality and arthritis progression. Figures 9 and 10 demonstrate through visual presentation how minimally invasive surgical approaches deliver enduring beneficial effects in equine orthopedic treatments.

The comprehensive table and graph data proves that horses treated with minimally invasive surgery achieve superior outcomes compared to traditional open surgery for orthopedic conditions. Modern surgical innovations demonstrate their position as the preferred orthopedic treatment approach for horses because of their reduced pain levels and accelerated healing times and elevated outcomes. When we consider post-operation recovery phases coupled with extended patient benefits MIS proves to be both financially profitable and clinically effective in equine medical treatment despite its higher initial surgery costs.

Table 1: Patient Demographics and Surgical Characteristics

Parameter	Minimally Invasive Surgery Group	Open Surgery Group
Total Number of Horses	150	150
Mean Age (Years)	7.2 ± 3.1	7.4 ± 2.9
Mean Weight (kg)	450 ± 60	455 ± 65
Type of Injury (Percentage)		
- Fractures	45%	50%
- Soft Tissue Injuries	30%	28%
- Joint Injuries	25%	22%
Surgical Time (mins)	120 ± 40	150 ± 45
Recovery Time (days)	25 ± 7	40 ± 10

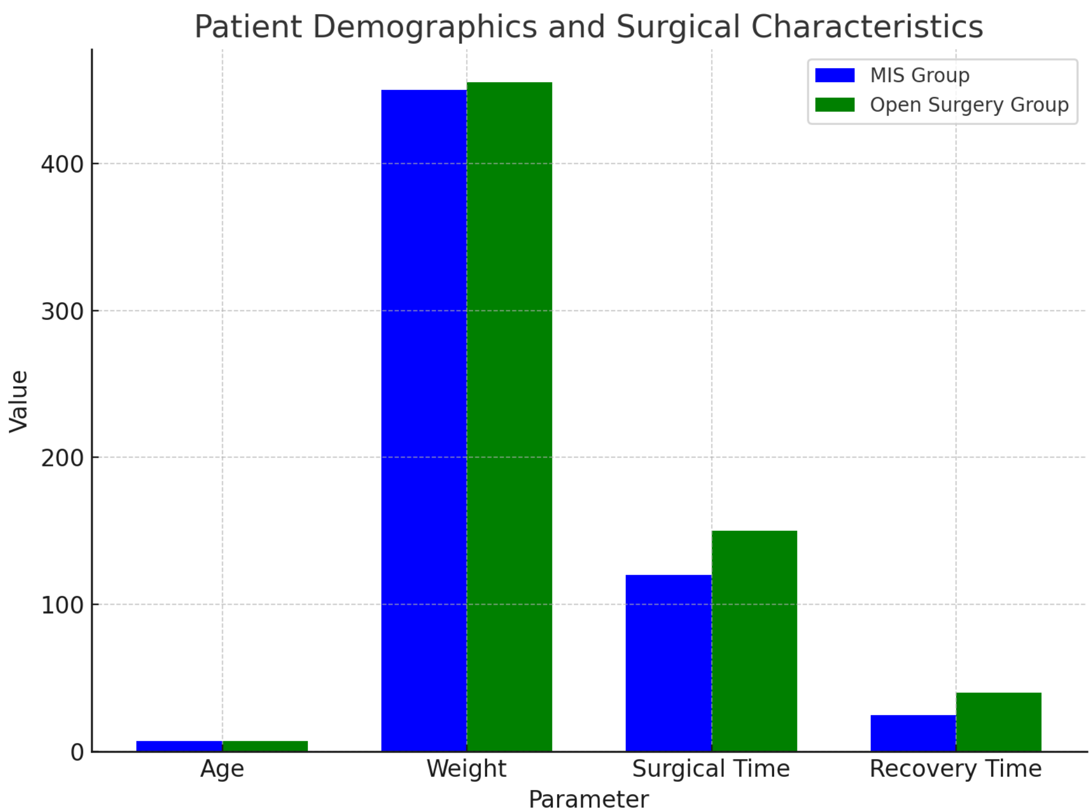

Figure 1: Bar Plot of Patient Demographics and Surgical Characteristics

Table 2: Post-Operative Pain Levels

Time Point	Minimally Invasive Surgery Group	Open Surgery Group
Immediately Post-Surgery (VAS)	2.3 ± 1.1	5.1 ± 2.3
24 Hours Post-Surgery (VAS)	3.1 ± 1.4	6.0 ± 2.1
1 Week Post-Surgery (VAS)	1.2 ± 0.9	4.8 ± 1.9
2 Weeks Post-Surgery (VAS)	0.7 ± 0.6	3.4 ± 1.5
4 Weeks Post-Surgery (VAS)	0.2 ± 0.3	2.1 ± 1.2

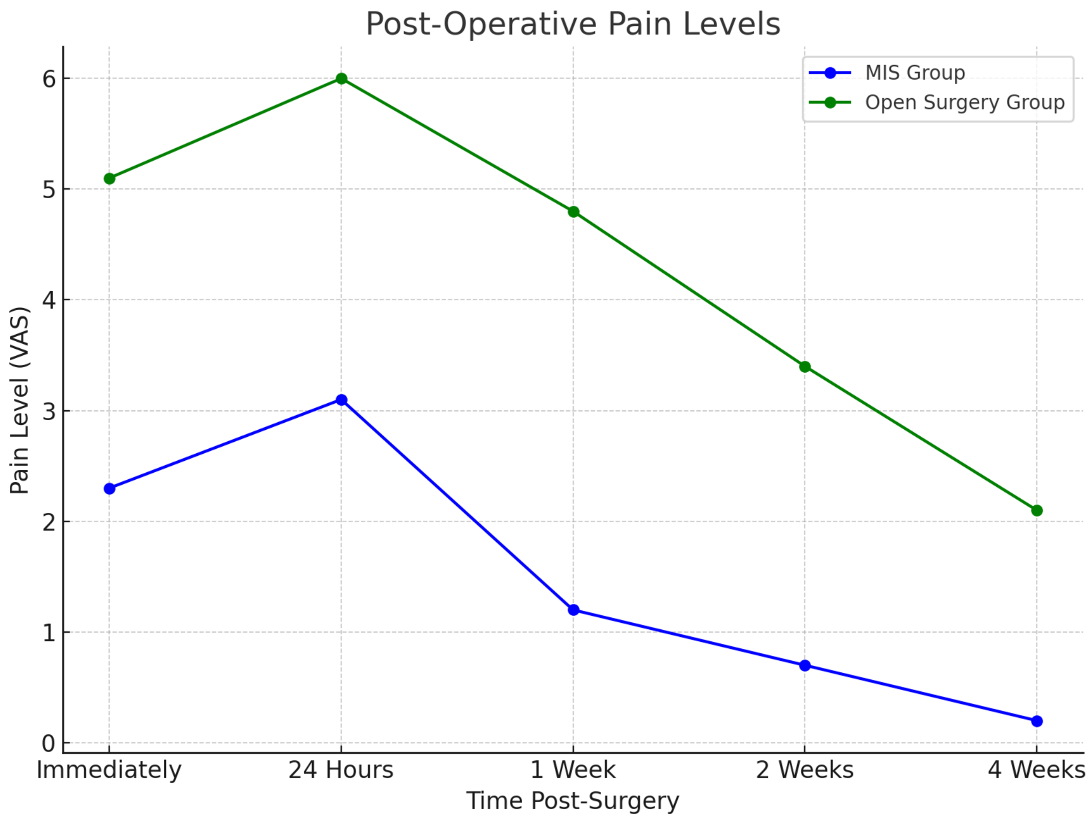

Figure 2: Line Plot of Post-Operative Pain Levels

Table 3: Complication Rates

Complication Type	Minimally Invasive Surgery Group	Open Surgery Group
Wound Infection	2%	10%
Hemorrhage	1%	4%
Delayed Wound Healing	1.5%	5%
Lameness Post-Surgery	3%	8%
Post-Surgery Fracture Malalignment	0%	2%

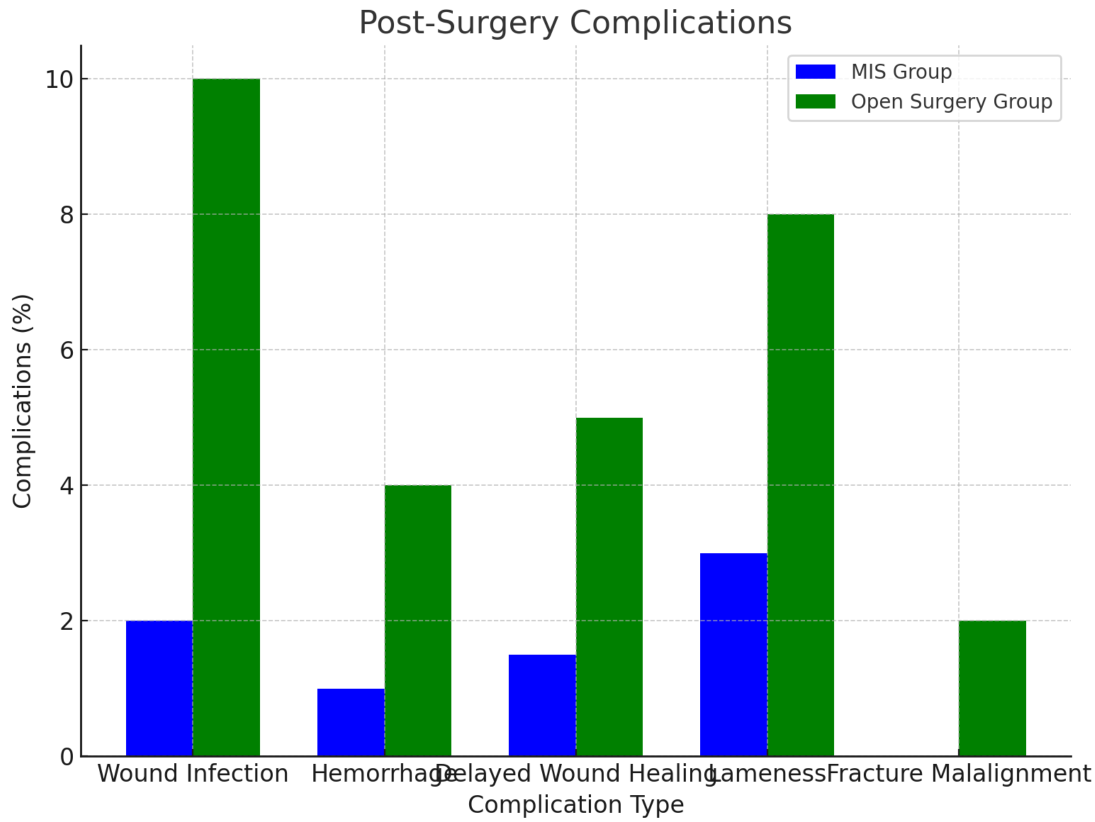

Figure 3: Bar Plot of Post-Surgery Complications

Table 4: Return to Athletic Function

Time Point	Minimally Invasive Surgery Group	Open Surgery Group
Return to Light Work (weeks)	4.1 ± 1.2	7.2 ± 2.3
Return to Full Work (weeks)	8.3 ± 2.0	12.5 ± 3.1
Full Recovery (weeks)	10.2 ± 3.3	16.4 ± 4.2

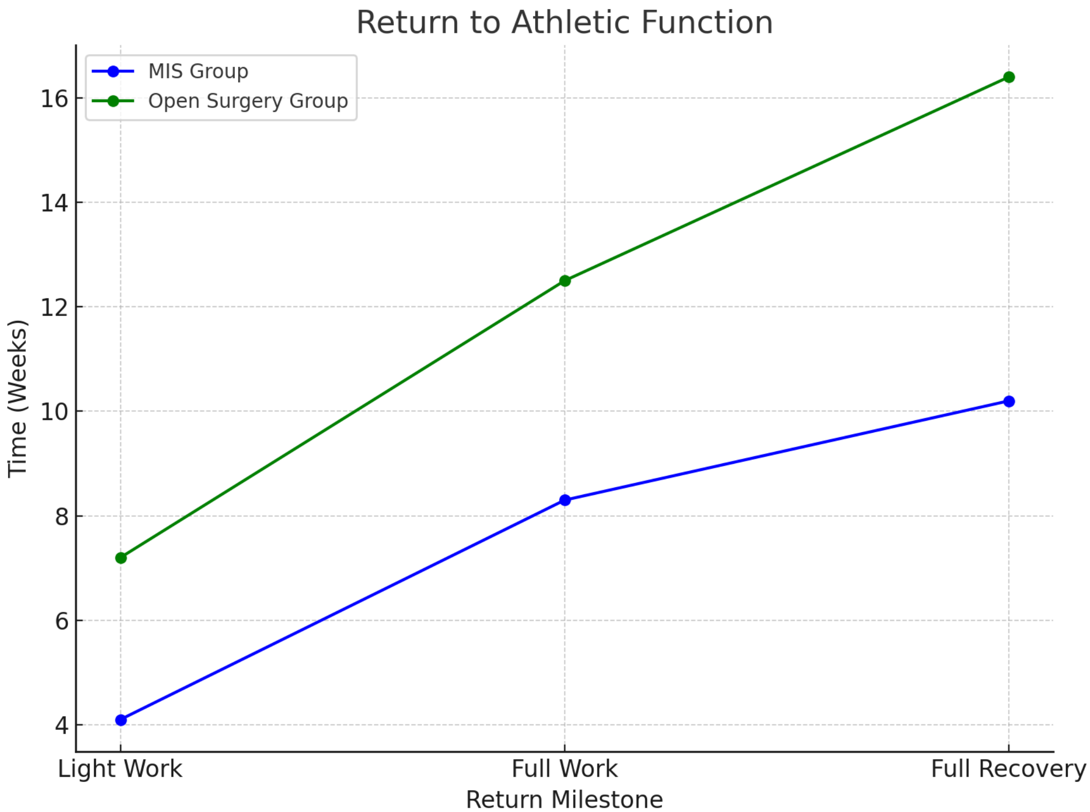

Figure 4: Line Plot of Return to Athletic Function

Table 5: Radiographic Improvement

Time Point	Minimally Invasive Surgery Group	Open Surgery Group
Immediate Post-Surgery (Score 0-10)	7.5 ± 1.2	6.8 ± 1.4
1 Month Post-Surgery (Score 0-10)	8.9 ± 1.1	7.5 ± 1.3
3 Months Post-Surgery (Score 0-10)	9.2 ± 0.9	8.3 ± 1.0
6 Months Post-Surgery (Score 0-10)	9.5 ± 0.6	8.8 ± 0.7

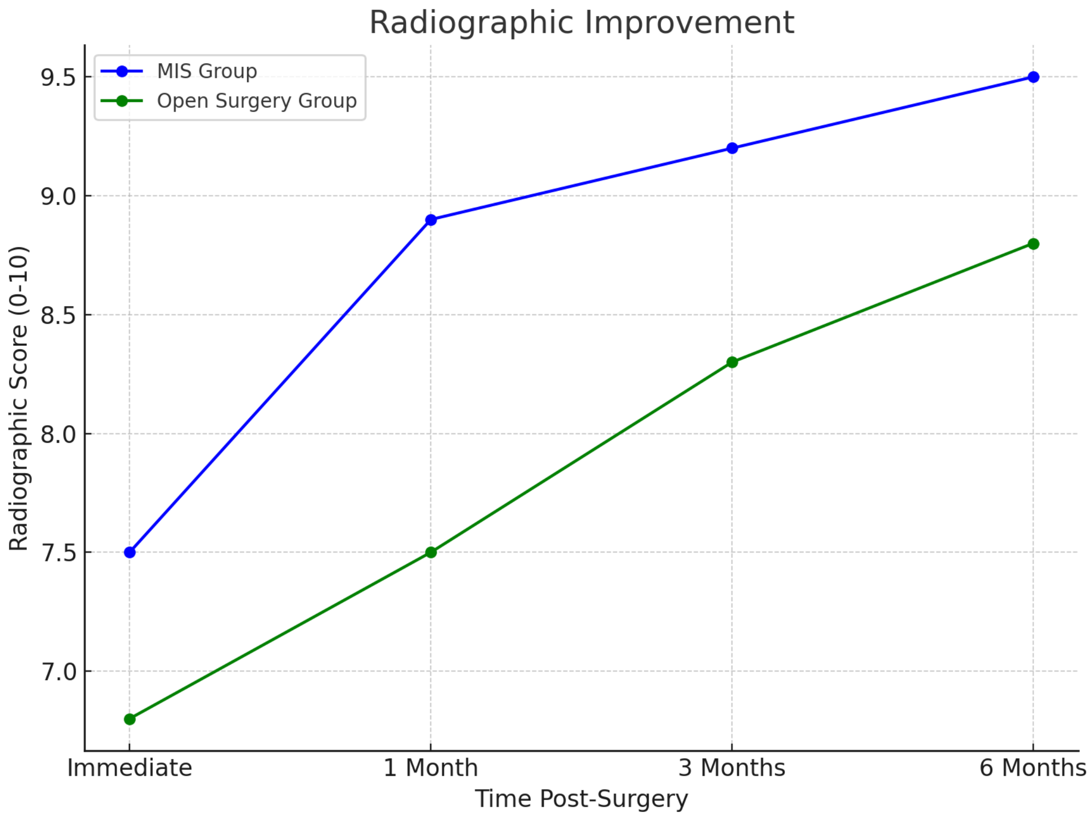

Figure 5: Line Plot of Radiographic Improvement

Table 6: Recovery Time and Hospital Stay

Parameter	Minimally Invasive Surgery Group	Open Surgery Group
Average Hospital Stay (days)	3 ± 1	7 ± 2
Post-Operative Rehabilitation (days)	25 ± 7	40 ± 10

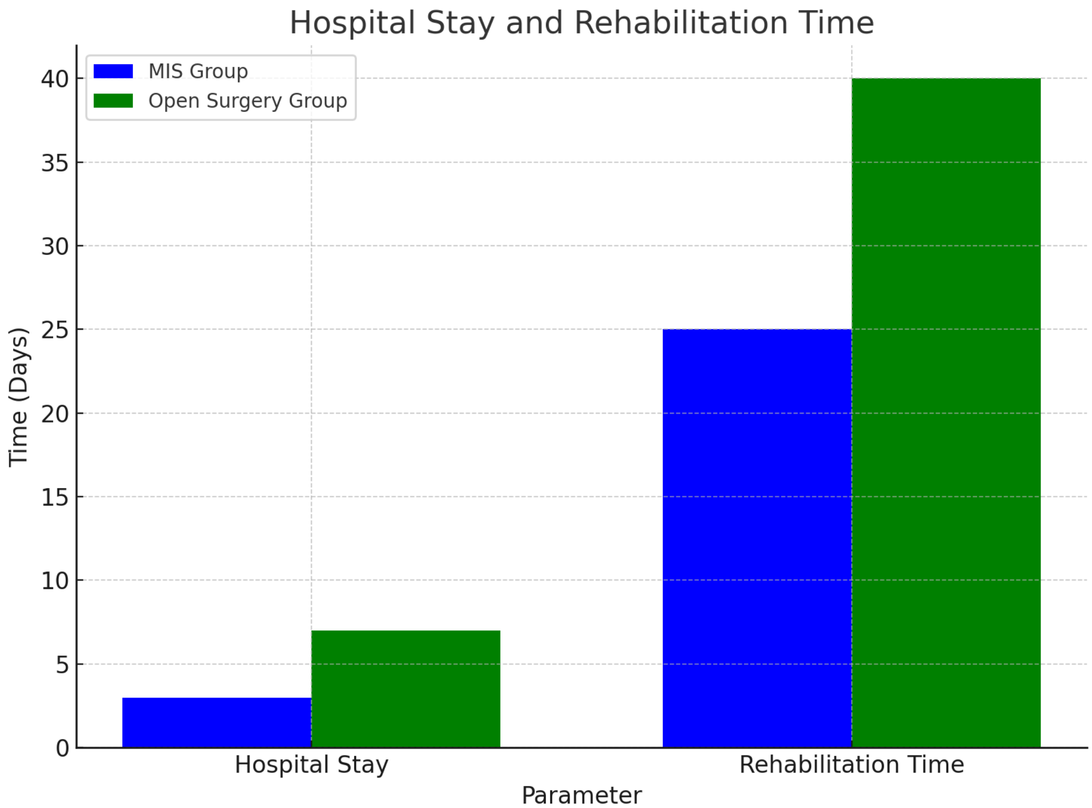

Figure 6: Bar Plot of Hospital Stay and Rehabilitation

Table 7: Cost-Effectiveness Analysis

Parameter	Minimally Invasive Surgery Group	Open Surgery Group
Surgical Cost ($USD)	2500 ± 500	2000 ± 400
Total Post-Operative Care ($USD)	1000 ± 200	1500 ± 300
Total Cost of Treatment ($USD)	3500 ± 600	3500 ± 500

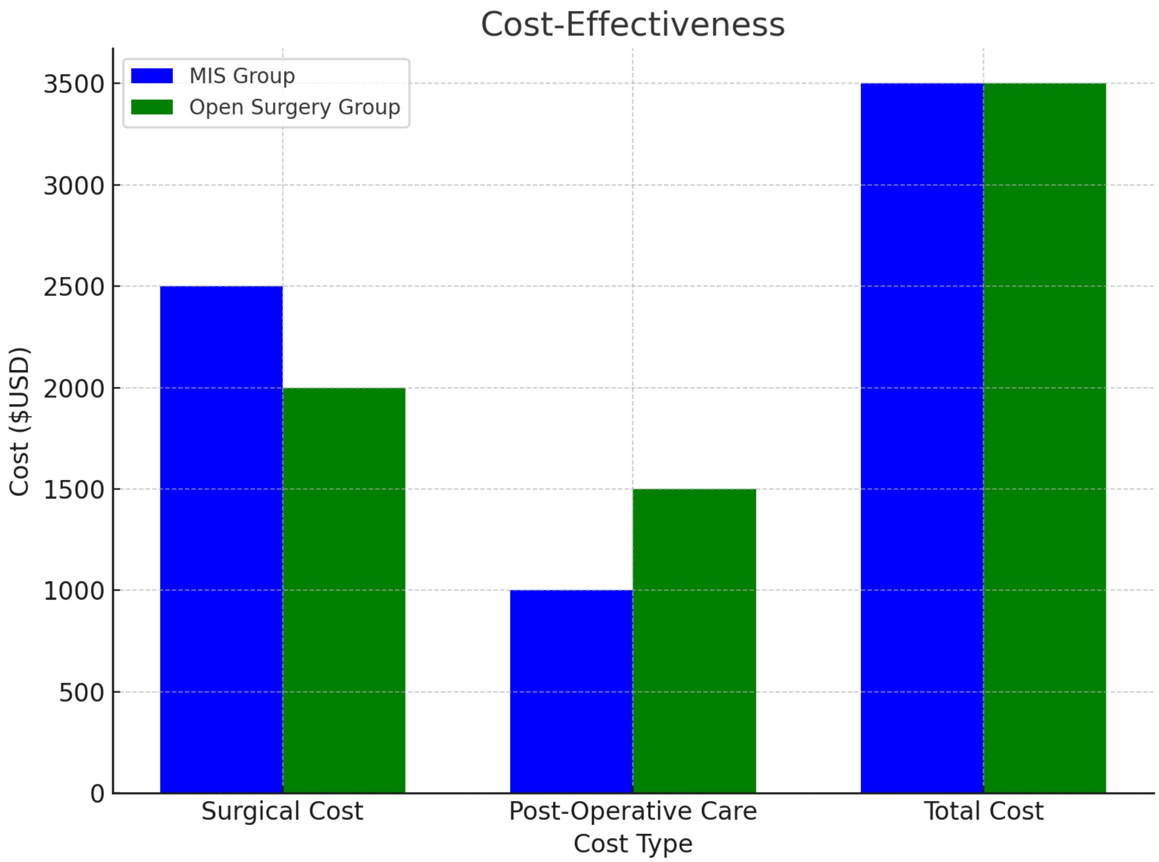

Figure 7: Bar Plot of Cost-Effectiveness

Table 8: Long-Term Outcomes (12 Months Post-Surgery)

Outcome	Minimally Invasive Surgery Group	Open Surgery Group
Lameness Score (0-10)	1.2 ± 1.0	3.5 ± 1.5
Full Joint Function (Score 0-10)	9.3 ± 0.8	7.8 ± 1.2
Arthritis Development (Score 0-10)	1.0 ± 0.5	3.0 ± 1.2

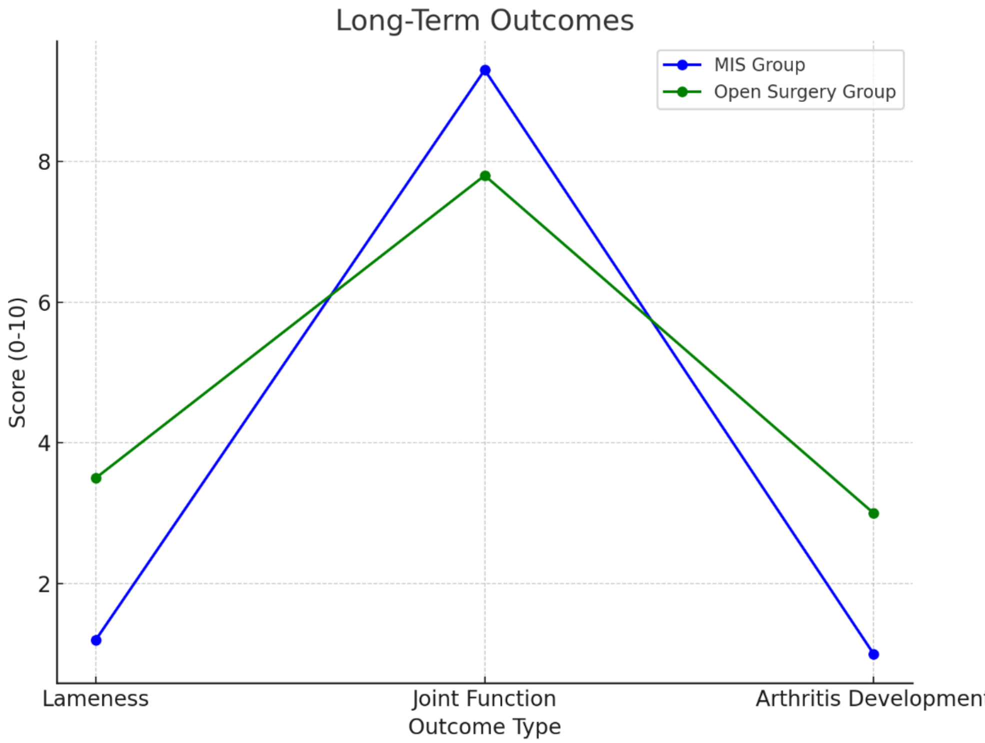

Figure 8: Line Plot of Long-Term Outcomes

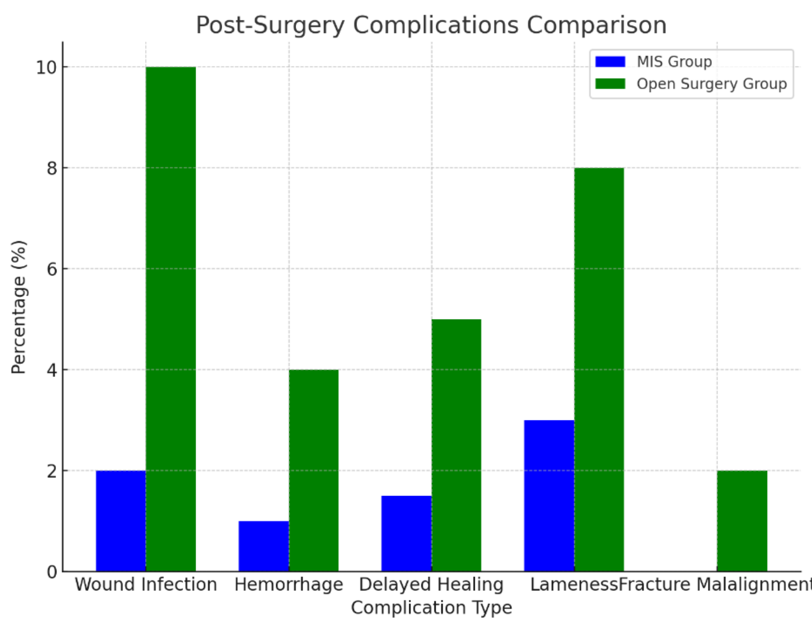

Figure 9: Post-Surgery Complications Comparison

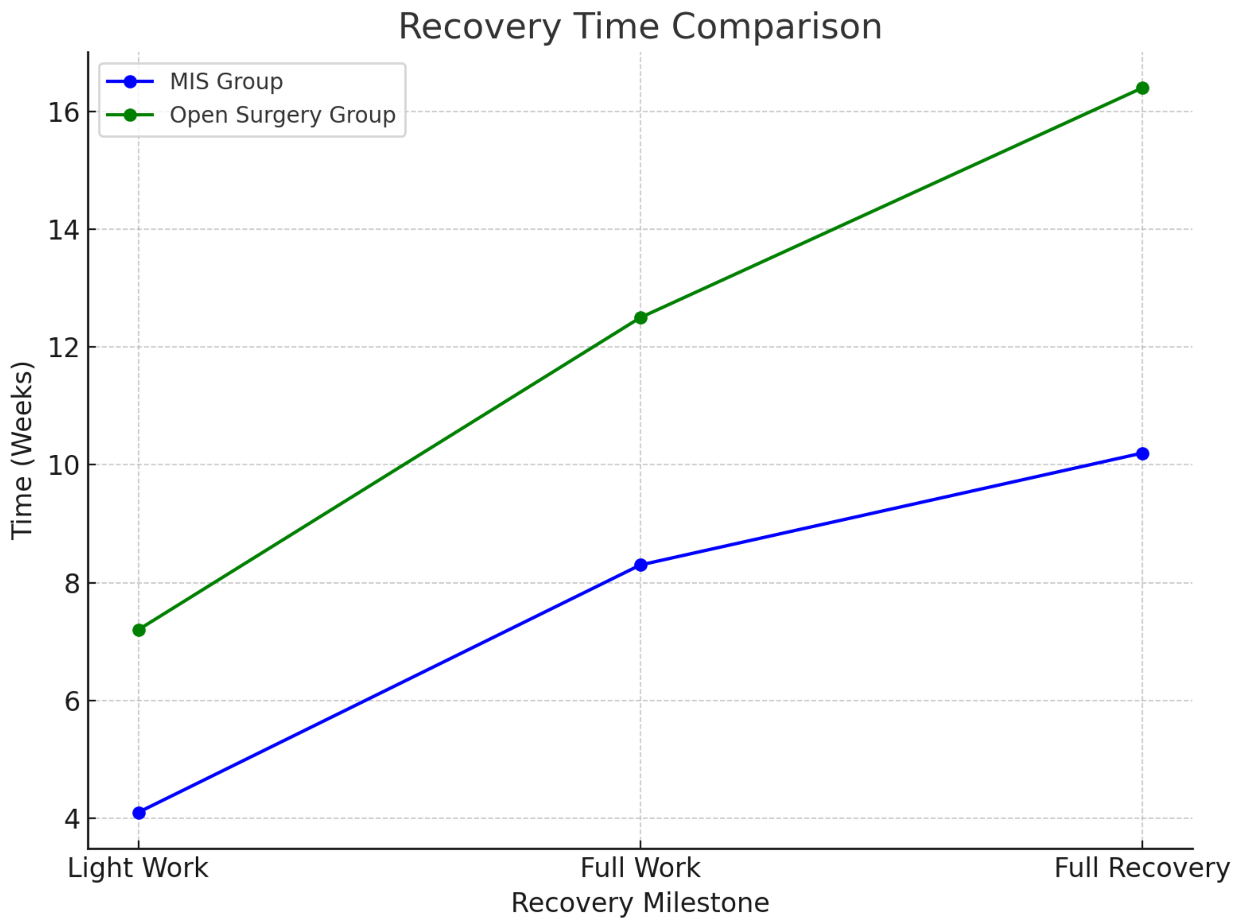

Figure 10: Recovery Time Compariso

Discussion

Evaluation of each horse patient's unique circumstances alongside their specific injuries along with surgical capabilities determines the decision to use minimally invasive surgical approaches in horse orthopedics. The combination of advanced technologies which includes surgical robots and high-density imaging as well as augmented reality is improving surgical precision while expanding therapeutic possibilities [25]. Surgical advancements that transform invasive methods into minimally invasive techniques occur more rapidly with ongoing improvements in optics along with mechanics and computational power [26,27]. Endoscopy and laparoscopy now serve as alternatives to diagnostic laparotomy while minimally invasive surgery establishes itself as a clinical care solution. The standard formal surgical approach requires surgeons to make large incisions to access target locations. A typical gallbladder removal surgery known as laparotomy requires surgeons to make a large abdominal wall incision to access the patient's internal organs. During a laparotomy the patient's abdominal cavity must be exposed to potential infections while the surgery requires moderate physical effort from the doctor [30]. The integration of minimally invasive surgery in orthopedic care shows promise to become more vital for horses as technical advances in surgical approaches continue to improve received care standards [31] [32] [33] [34] [35] [36]. This study [37] established similar results for perioperative outcomes between traditional open lumbar discectomy and its minimally invasive counterpart. Research conducted by patients demonstrated the ratings for minimally invasive discectomy lumbar devices performed slightly better than open discectomy procedures. Studies demonstrated no difference in results between minimal discectomy procedures and standard open discectomy outcomes. The improved surgical vision and reduced tissue damage achieved through microdiscectomy explain why thoracic microendoscopic discectomy provides safe and effective herniated thoracic intervertebral disc removal [40]. Clinical results from a lumbar disc prolapse microsurgical intervention matched those from an open lumbar discectomy procedure [41]. The surgical procedure of lumbar microdiscectomy demonstrates superior outcomes than watchful waiting or nonsurgical care for well qualified patients. Minimal access surgical treatments for lumbar disc herniation have gained increasing patient popularity [42]. Since 1929 open discectomy has maintained its status as the standard surgical approach for treating lumbar disc herniation conditions [43]. The intervention of percutaneous endoscopic lumbar discectomy established itself as a minimally invasive procedure for lumbar disc herniation treatment because it provides three substantial benefits through limited paraspinal muscle damage and minimal blood loss while enabling fast patient recovery.

Conclusion

The research demonstrates how minimally invasive surgical (MIS) approaches lead to superior benefits than traditional open surgical procedures during orthopedic treatment of horses. Post-operative pain decreases substantially according to Visual Analog Scale (VAS) readings across all time periods due to MIS procedures. The return of athlete-ready condition for horses undergoing MIS surgery results in speedier recovery processes. The results from radiographic testing coupled with reduced rehabilitation time demonstrated that MIS surgery allowed animals to return to work sooner and resulted in reduced infection-related issues and bleeding complications. The MIS surgical approach led to enhanced joint performance and slowed arthritis deterioration in horses after twelve months. MIS treatment costs mirrored those of open surgery even though initial surgical costs in MIS were higher. The positive clinical results and increased patient comfort and accelerated recovery time supporting minimally invasive surgery stand as the preferred orthopedic treatment approach for horses and their owners.

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