(ISSN: 0973-7049(P))

The Bioscan AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES 21(3): S.I (3), 1051-1058, 2026 www.thebioscan.com

EFFECT OF PROPRIOCEPTIVE TAPING ON PAIN REDUCTION, PROPRIOCEPTIVE RESTORATION, AND FUNCTIONAL PERFORMANCE IN INDIVIDUALS FOLLOWING ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

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DOI: https://doi.org/10.63001/tbs.2026.v21.i03.S.I(3).pp1051-1058

KEYWORDS

anterior cruciate ligament reconstruction; proprioceptive taping; proprioception; joint position sense; functional performance; Lysholm Knee Score; pain; rehabilitation.

Article Info

Received:26-06-2026

Accepted:14-07-2026

Published:24-07-2026

Abstract

Background
Anterior cruciate ligament (ACL) reconstruction is commonly performed to restore mechanical stability following ACL injury. However, postoperative deficits in proprioception, neuromuscular control, pain, and functional performance may persist despite successful reconstruction. Proprioceptive taping is a therapeutic intervention designed to provide continuous tactile and mechanical stimulation around the knee and may enhance sensory feedback during rehabilitation.
Objective
To evaluate the effect of proprioceptive taping on pain, proprioception, functional performance, and subjective knee function in individuals following ACL reconstruction.
Methods
A prospective interventional study was conducted among 30 individuals aged 18–40 years who were 6–12 weeks post-ACL reconstruction. Participants received proprioceptive taping in addition to a standardized physiotherapy rehabilitation programme for 12 weeks. Proprioception was assessed using the Joint Position Sense test, functional performance using the Single-Leg Hop Test, subjective knee function using the Lysholm Knee Scoring Scale, and pain intensity using the Visual Analog Scale. Assessments were performed at baseline, Week 3, and Week 12. Repeated-measures analysis of variance was used to evaluate changes over time, with statistical significance set at $p < 0.05$.
Results
Significant improvement was observed in all outcome measures over the 12-week intervention period. Joint Position Sense error decreased from 5.8 ± 1.2° at baseline to 4.1 ± 1.0° at Week 3 and 2.3 ± 0.8° at Week 12 ($p < 0.001$). Single-Leg Hop Test performance increased from 72.4 ± 8.5 cm to 88.6 ± 9.2 cm at Week 3 and 112.3 ± 10.4 cm at Week 12 ($p < 0.001$). Lysholm Knee Score improved from 58.2 ± 6.4 to 72.6 ± 7.8 and 90.4 ± 5.2, respectively ($p < 0.001$). VAS pain scores decreased from 6.4 ± 1.0 at baseline to 3.8 ± 0.9 at Week 3 and 1.6 ± 0.7 at Week 12 ($p < 0.001$).
Conclusion
Proprioceptive taping combined with structured physiotherapy rehabilitation significantly improved proprioception, functional performance, subjective knee function, and pain following ACL reconstruction. Proprioceptive taping may be a useful adjunctive intervention for enhancing sensorimotor recovery during postoperative rehabilitation.

INTRODUCTION

Anterior cruciate ligament (ACL) injuries are a common and clinically significant knee injury, especially in athletes and athletes who must jump, pivot, accelerate quickly, decelerate quickly, or make abrupt direction changes. The ACL is crucial for regulating the tibia's rotational movement and anterior translation in relation to the femur. Apart from its mechanical stabilizing role, the ligament also helps with proprioception by sending information about joint position and movement through sensory receptors. Restoring knee stability and allowing people to resume functional and athletic activity are common goals of [1–3]ACL restoration. However, normal neuromuscular function is not always restored by ligament restoration. Following ACL surgery, persistent deficiencies in proprioception, muscle strength, dynamic balance, discomfort, movement control, and functional confidence have been documented. [4–9]

These impairments may affect movement quality and postpone returning to regular activity. The capacity to perceive a joint's location and movement is known as proprioception. Muscles, tendons, joint capsules, ligaments, and skin are only a few of the sensory data sources that it depends on. Afferent feedback and neuromuscular control are facilitated by mechanoreceptors found in the ACL. When these sensory mechanisms are disrupted after an ACL damage, joint-position awareness may be compromised. Proprioceptive function may continue to be compromised in the postoperative phase even while restoration restores mechanical continuity.[10-15]Thus, a comprehensive approach is necessary for rehabilitation after ACL replacement. Proprioceptive exercises, neuromuscular training, balance training, range-of-motion exercises, progressive strengthening, and functional activities are all common components of conventional therapy.. Adjunctive therapies that improve sensory feedback may aid in recovery even though exercise-based rehabilitation is successful. A therapeutic taping method called proprioceptive taping is designed to give the knee constant sensory input and mechanical support. The skin and periarticular tissues may provide more tactile input when hard or comparatively non-elastic tape is applied. This extra afferent information could improve sensorimotor control and increase awareness of joint position and movement. The interaction between cutaneous sensory input and the central nervous system forms the basis of the suggested mechanism of proprioceptive taping. Cutaneous mechanoreceptors may be activated by tactile stimulation, increasing the amount of sensory data available for controlling movement. Joint alignment and movement awareness may also be impacted by the tape's mechanical correction.. [25–29]

Following ACL surgery, proprioceptive signals from the injured and rebuilt ligament may change, making these effects especially pertinent. Proprioceptive taping may affect pain and functional performance in addition to its possible effects on proprioception. The person's sense of knee stability may be enhanced by outside assistance, which may also lessen anxiety when moving. Increased confidence and more appropriate muscle activation during weight-bearing and functional activities may result from improved sensory feedback. Prior research has looked at taping methods in various musculoskeletal disorders, but there is still little data that precisely assesses the impact of proprioceptive taping during ACL rehabilitation. Additionally, few studies have looked at proprioception, functional performance, subjective knee function, and pain all at once during a planned time of postoperative rehabilitation.

Therefore, the present study was conducted to evaluate the effect of proprioceptive taping on pain reduction, proprioceptive restoration, functional performance, and subjective knee function in individuals following ACL reconstruction.

Objective

The objective of this study was to evaluate the effect of proprioceptive taping on:

1. Proprioception measured using the Joint Position Sense test.
2. Functional performance measured using the Single-Leg Hop Test.
3. Subjective knee function measured using the Lysholm Knee Scoring Scale.
4. Pain intensity measured using the Visual Analog Scale.

Hypothesis

It was hypothesized that proprioceptive taping combined with a structured physiotherapy rehabilitation programme would significantly

improve proprioception, functional performance, subjective knee function, and pain in individuals following ACL reconstruction

METHODS

Study Design and Setting

A prospective interventional study was conducted among individuals undergoing postoperative rehabilitation following ACL reconstruction. Participants were recruited from the outpatient physiotherapy department of Pacific Medical College and Hospital, Udaipur, Rajasthan, India.

The study was conducted over a period of nine months following institutional ethical approval. Each participant underwent a 12-week intervention programme.

Participants

The study included thirty people between the ages of 18 and 40 who had undergone ACL reconstruction six to twelve weeks prior to enrollment. Individuals who gave written informed consent and were medically cleared to take part in physiotherapy rehabilitation were eligible. Individuals who had undergone revision ACL reconstruction, had significant meniscal or ligamentous injuries that affected their ability to function, had neurological disorders that affected their lower limb motor control or balance, had a known adhesive tape allergy or intolerance, or had a medical condition that prevented them from participating in the rehabilitation program were all excluded.

Sampe Size

The sample size was calculated using G*Power software with an alpha level of 0.05, a statistical power of 80%, and an anticipated effect size of 0.80. The final intervention sample included 30 participants.

Intervention

All participants received proprioceptive taping in addition to a standardized physiotherapy rehabilitation programme.

Proprioceptive Taping Technique

Rigid, non-elastic tape was applied around the knee to provide mechanical correction and enhanced sensory feedback. The taping technique was designed to improve awareness of knee position and provide an external mechanical stimulus during movement.

The application was intended to:

- Enhance cutaneous sensory stimulation.
- Improve awareness of knee position.
- Provide external mechanical support.
- Facilitate appropriate tibial alignment.
- Improve perceived knee stability during functional activities.

The tape was maintained for approximately 24–48 hours and reapplied approximately three times per week according to the treatment protocol.

Standardized Rehabilitation Programme

All participants underwent the same structured rehabilitation programme. The programme included:

- Range-of-motion exercises.
- Quadriceps strengthening.
- Hamstring strengthening.
- Resistance exercises.
- Stationary cycling.
- Balance training.
- Proprioceptive exercises.
- Step-up and step-down activities.
- Neuromuscular control exercises.
- Progressive functional activities.

The rehabilitation programme was progressively advanced according to the participant's postoperative stage, tolerance, and functional ability.

Outcome Measures

Outcome assessments were performed at three time points: Baseline, Week 3, Week 12.

Joint Position Sense Test

Proprioception was assessed using a Joint Position Sense test. Participants were required to reproduce a predetermined knee position. The difference between the target angle and the reproduced angle was recorded as the proprioceptive error.A lower error value indicated better proprioceptive accuracy.

Single-Leg Hop Test

Functional performance was assessed using the Single-Leg Hop Test. Participants performed a maximal horizontal hop using the operated limb. The distance achieved was measured in centimetres.Greater hopping distance indicated better functional performance.

Lysholm Knee Scoring Scale

Subjective knee function was assessed using the Lysholm Knee Scoring Scale. The scale evaluates pain, instability, locking, swelling, stair climbing, squatting, and the requirement for support.Higher scores indicate better subjective knee function.

Visual Analog Scale

Pain intensity was assessed using a 10-cm Visual Analog Scale. Participants rated their

perceived pain intensity, with higher scores representing greater pain.

Statistical Analysis

Data were analysed using appropriate statistical methods. Continuous variables were expressed as mean ± standard deviation. Changes over the three assessment periods were analysed using repeated-measures analysis of variance. Where appropriate, post-hoc comparisons were performed to identify differences between assessment time points.A p-value of less than 0.05 was considered statistically significant. A p-value of less than 0.001 was considered highly statistically significant.

RESULTS

Thirty participants completed the intervention programme and were included in the final analysis.

Effect on Proprioception

A progressive improvement in proprioception was observed throughout the intervention period.The mean Joint Position Sense error was 5.8 ± 1.2° at baseline. This decreased to 4.1 ± 1.0° at Week 3 and further decreased to 2.3 ± 0.8° at Week 12.The reduction in proprioceptive error demonstrated improvement in joint-position accuracy. The change from baseline to Week 12 was statistically significant ($p < 0.001$).The greatest improvement occurred between Week 3 and Week 12, suggesting that continued application of proprioceptive taping in combination with progressive rehabilitation may contribute to progressive restoration of joint-position awareness.

Effect on Functional Performance

Single-Leg Hop Test performance improved progressively.The mean hopping distance increased from 72.4 ± 8.5 cm at baseline to 88.6 ± 9.2 cm at Week 3 and 112.3 ± 10.4 cm at Week 12.The improvement was statistically significant ($p < 0.001$).The increase in hopping distance suggests improvement in lower-limb functional performance, dynamic control, muscular power, and confidence in loading the operated limb.

Effect on Subjective Knee Function

Lysholm Knee Scores improved significantly during the intervention.The mean score increased from 58.2 ± 6.4 at baseline to 72.6 ± 7.8 at Week 3 and 90.4 ± 5.2 at Week 12.The improvement was statistically significant ($p < 0.001$).The improvement in Lysholm scores indicates better perceived knee function, including improvement in pain, instability, swelling, stair climbing, and squatting ability.

Effect on Pain

Pain intensity decreased progressively during the intervention period.The mean VAS score decreased from 6.4 ± 1.0 at baseline to 3.8 ± 0.9 at Week 3 and 1.6 ± 0.7 at Week 12The reduction in pain was statistically significant ($p < 0.001$).The findings demonstrate a substantial reduction in pain following the addition of proprioceptive taping to the rehabilitation programme.

DISCUSSION

The current study assessed how proprioceptive taping affected participants' pain, proprioception, functional performance, and subjective knee function after ACL reconstruction. Over the course of the 12-week intervention, the results showed a significant improvement in all four end measures.Joint Position Sense significantly improved, which was the main finding. By Week 12, proprioceptive error had dropped from 5.8° at baseline to 2.3°. Proprioceptive taping may enhance joint-position awareness during postoperative rehabilitation, according to this report.

The rehabilitation of the mechanical and sensory systems after ACL reconstruction affects proprioception. Mechanoreceptors found in the original ACL help provide sensory feedback on the position and movement of the knee. Ligament damage could interfere with this feedback. While mechanical stability can be restored with restoration, the native ligament's sensory function might not be fully restored.[10-15].Therefore, during rehabilitation, external sensory stimulation could be helpful.

By stimulating cutaneous mechanoreceptors, proprioceptive taping may enhance joint-position awareness. The skin and underlying tissues receive a constant tactile stimulus when rigid tape is applied. This stimulus may help understand knee position during movement and increase the amount of afferent information that reaches the central nervous system.The observed improvement could also be attributed to the mechanical effect of taping. The tape may improve awareness of joint alignment and movement by offering an external reference around the knee. This could enhance control during functional activities and assist the participant in identifying incorrect movement.

The Current research supports the idea that several sensory systems have an impact on

proprioception. Information from the skin, muscles, joints, tendons, ligaments, vestibular system, and visual system is integrated by the central nervous system. Additional cutaneous input from tape may assist supplement altered ligamentous sensory information after ACL damage and reconstruction.Additionally, there was a notable improvement in functional performance. Over the course of the 12-week intervention, the Single-Leg Hop Test distance rose from 72.4 cm to 112.3 cm. Muscular strength, power, balance, coordination, proprioception, and confidence must all be integrated for the Single-Leg Hop Test.

By enabling participants to more precisely perceive the position of the operated knee during loading, improved proprioception may have contributed to improved functional performance. Additionally, improved neuromuscular responses and decreased hesitation during single-limb activities may result from enhanced sensory feedback.Pain reduction was another noteworthy discovery. At Week 12, VAS pain scores dropped from 6.4 at baseline to 1.6. After ACL surgery, pain might diminish involvement in rehabilitation, restrict movement, and prevent muscle activation. Therefore, pain reduction may enable more efficient workout performance.

Proprioceptive taping may affect pain in a number of ways. Through sensory gating mechanisms, nociceptive input may be modulated by cutaneous stimulation. Additionally, tape's mechanical support may boost confidence when moving and lessen the sense of instability. Improved engagement in functional activities and more normal use of the operated limb may result from less anxiety.The overall functional advantage of the intervention is further supported by the improvement in Lysholm Knee Scores. By Week 12, the score had risen from 58.2 at baseline to 90.4. Pain, instability, locking, swelling, stair climbing, squatting, and other functional activities that are pertinent to patients are included in the Lysholm scale.

The combination of decreased pain, enhanced proprioception, enhanced functional performance, and increased confidence may have contributed to the improvement in subjective knee function. Individuals may be more inclined to load the leg throughout regular tasks if they believe their knee is more stable.Proprioceptive taping was employed as an adjuvant to exercise-based therapy rather than as a substitute, which is a significant feature of the current study. Progressive strengthening, balance training, proprioceptive exercises, and functional activities were all part of the rehabilitation regimen. Therefore, the reported benefits are probably a result of both proprioceptive taping and structured therapy.

The gradual increase in proprioception, however, raises the possibility that taping's sensory input had additional advantages. During the stages of rehabilitation when the patient is starting to execute single-limb functional tasks, establish dynamic balance, and enhance weight-bearing, taping may be especially helpful.Proprioceptive taping is a reasonably easy and non-invasive method that can be used in regular therapy from a clinical standpoint. People who exhibit poor joint-position awareness, sensations of instability, anxiety during mobility, or trouble transitioning to functional activities may find it particularly helpful.

However, gradual exercise therapy should not be replaced by taping. After ACL restoration, strength, range of motion, balance, neuromuscular control, and functional capacity must all be restored.There are several restrictions on the study. Participants were chosen from a single clinical setting, and the sample size was rather modest. Conclusions about long-term results were not possible due to the 12-week follow-up time. Return-to-sport status, graft stability, reinjury rate, and long-term preservation of proprioceptive gains were not assessed in this study.

Results may also have been impacted by elements including fear of reinjury, physical activity level, psychological preparedness, and adherence to at-home exercise. Larger sample sizes, multicenter recruitment, extended follow-up, and objective neuromuscular control measures should all be used in future research. Determining the precise role of proprioceptive taping in postoperative recovery would also be aided by randomized controlled trials that compare it with regular rehabilitation alone.

CLINICAL IMPLICATIONS

The findings suggest that proprioceptive taping may be incorporated into postoperative ACL rehabilitation to:

- Enhance joint-position awareness.
- Reduce pain.
- Improve functional performance.
- Improve perceived knee function.

- Increase confidence during single-limb activities.
- Provide additional sensory feedback during rehabilitation.

The technique may be particularly useful during the intermediate phase of rehabilitation when patients are progressing toward dynamic balance and functional movement.

STRENGTHS AND LIMITATIONS

The study's strengths include the combination of proprioceptive taping with a standardized rehabilitation program, the use of numerous clinically meaningful outcomes, and recurrent assessment during a 12-week intervention period.

The comparatively small sample size, single-center recruitment, lack of long-term follow-up, and lack of a no-taping control group are some of the shortcomings. As a result, it is impossible to completely isolate the effects of the rehabilitation program from the unique independent contribution of proprioceptive taping.

CONCLUSION

Following ACL surgery, proprioception, functional performance, subjective knee function, and pain were all markedly improved by proprioceptive taping in conjunction with structured physiotherapy rehabilitation.Over the course of 12 weeks, performance on the Single-Leg Hop Test and Lysholm Knee Scores dramatically improved, while Joint Position Sense error and pain intensity significantly decreased.These results imply that proprioceptive taping could be a useful supplemental treatment to improve functional and sensory recovery after ACL surgery. Increased cutaneous sensory input, improved knee position awareness, enhanced perceived stability, and facilitation of functional movement are some of its possible advantages. To ascertain the independent effects and long-term advantages of proprioceptive taping following ACL reconstruction, more randomized controlled trials with bigger sample sizes and longer follow-up are advised.

DECLARATIONS

Ethics Approval

The study was conducted following approval from the institutional ethics committee.

Informed Consent

Written informed consent was obtained from all participants before participation.

Funding

No external funding was reported.

Conflict of Interest

The authors declare no conflict of interest.

Data Availability

The study data may be made available from the corresponding author upon reasonable request, subject to institutional and ethical requirements.

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Table 1. Demographic Characteristics of Participants

Variable	Proprioceptive Taping Group (n = 30)
Age (years), mean ± SD	26.8 ± 4.7
Male, n (%)	21 (70.0)
Female, n (%)	9 (30.0)
Height (cm), mean ± SD	169.4 ± 8.2
Weight (kg), mean ± SD	68.7 ± 9.4
BMI (kg/m²), mean ± SD	23.9 ± 2.8
Time since ACL reconstruction (weeks), mean ± SD	8.4 ± 1.7

Table 2. Changes in Joint Position Sense Following Proprioceptive Taping

Assessment Time	Mean ± SD (°)	Mean Difference	Improvement (%)	p-value
Baseline	5.8 ± 1.2	—	—	—
Week 3	4.1 ± 1.0	1.7	29.3%	<0.001
Week 12	2.3 ± 0.8	3.5	60.3%	<0.001

Table 3. Changes in Single-Leg Hop Test Performance Following Proprioceptive Taping

Assessment Time	Mean ± SD (cm)	Mean Difference	Improvement (%)	p-value
Baseline	72.4 ± 8.5	—	—	—
Week 3	88.6 ± 9.2	16.2	22.4%	<0.001
Week 12	112.3 ± 10.4	39.9	55.1%	<0.001

Table 4. Changes in Lysholm Knee Scoring Scale Following Proprioceptive Taping

Assessment Time	Mean ± SD	Mean Difference	Improvement (%)	p-value
Baseline	58.2 ± 6.4	—	—	—
Week 3	72.6 ± 7.8	14.4	24.7%	<0.001
Week 12	90.4 ± 5.2	32.2	55.3%	<0.001

Table 5. Changes in Pain Intensity Measured Using the Visual Analog Scale

Assessment Time	Mean ± SD	Mean Difference	Reduction (%)	p-value
Baseline	6.4 ± 1.0	—	—	—
Week 3	3.8 ± 0.9	2.6	40.6%	<0.001
Week 12	1.6 ± 0.7	4.8	75.0%	<0.001

Table 6. Overall Changes in Outcome Measures from Baseline to Week 12

Outcome Measure	Baseline	Week 12	Mean Change	Improvement/Reduction (%)	p-value
Joint Position Sense Error (°)	5.8 ± 1.2	2.3 ± 0.8	−3.5	60.3% reduction	<0.001
Single-Leg Hop Test (cm)	72.4 ± 8.5	112.3 ± 10.4	+39.9	55.1% improvement	<0.001
Lysholm Knee Score	58.2 ± 6.4	90.4 ± 5.2	+32.2	55.3% improvement	<0.001
VAS Pain Score	6.4 ± 1.0	1.6 ± 0.7	−4.8	75.0% reduction	<0.001