

# BONE MARROW STIMULATION IN ISOLATED MENISCAL REPAIR: A DOUBLE-BLIND RCT



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## Introduction and Purpose

A variety of biological augmentation strategies have been proposed to enhance the healing potential of meniscal repairs. Among these, bone marrow stimulation (BMS)-performed by creating small perforations in the femoral intercondylar notch-aims to facilitate intra-articular release of mesenchymal stem cells and growth factors that may promote meniscal tissue healing. Despite its increasing use, high-quality evidence supporting its clinical effectiveness remains limited (1,2). This study aimed to compare clinical outcomes, patient-reported outcomes, and postoperative healing between standard arthroscopic meniscal repair and meniscal repair augmented with a bone marrow stimulation technique in patients with isolated meniscal tears.

## Methods

We conducted a prospective, two-center, randomized, double-blind controlled trial involving patients aged 18–60 years with clinically and MRI-confirmed isolated meniscal tears without knee osteoarthritis. Participants were randomized in a 1:1 ratio to receive either standard arthroscopic meniscal repair (control group, n = 20) or arthroscopic meniscal repair augmented with BMS performed at the intercondylar notch (BMS group, n = 20). All procedures were performed by fellowship-trained orthopedic surgeons specializing in sports medicine and arthroscopy. The primary outcome was the International Knee Documentation Committee (IKDC) score. Secondary outcomes included the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Lysholm score, Tegner activity scale, pain assessed using the visual analogue scale (VAS), patient satisfaction, complications, operative time, and meniscal healing evaluated on postoperative Magnetic Resonance Imaging (MRI) using a standardized classification system, independently assessed by two reviewers.

## Results

Forty patients (mean age 42 years; 47% male, 53% female) were enrolled, and all completed the follow-up. Baseline demographic characteristics were similar between groups, with the exception of meniscal tear complexity, in which a higher percentage was present in the BMS group. At 6 months post-operatively, the BMS group demonstrated significantly superior Lysholm score ( $83.2 \pm 10.8$  vs  $74.0 \pm 17.3$ ), and patient satisfaction scores ( $9.30 \pm 0.571$  vs  $8.15 \pm 1.35$ ). At 12 months, the BMS group demonstrated significantly superior outcomes compared with the control group across multiple validated metrics: IKDC score ( $82.1 \pm 13.5$  vs  $57.5 \pm 15.8$ ), WOMAC score ( $17.0 \pm 21.7$  vs  $38.8 \pm 29.4$ ), Lysholm score ( $91.4 \pm 6.52$  vs  $74.3 \pm 14.2$ ), Tegner activity scale ( $4.96 \pm 1.64$  vs  $3.40 \pm 1.86$ ), pain VAS ( $0.65 \pm 0.74$  vs  $2.15 \pm 2.13$ ), and patient satisfaction scores ( $9.65 \pm 0.87$  vs  $8.15 \pm 1.59$ ). MRI assessment demonstrated no significant difference in postoperative meniscal healing between groups (ICC = 0.81). Operative time did not differ significantly, and no postoperative complications were reported in either group.

## Conclusions

In this randomized, double-blind controlled trial involving patients with isolated meniscal tears, arthroscopic meniscal repair augmented with bone marrow stimulation resulted in significantly superior knee function, higher activity levels, reduced pain, and increased patient satisfaction at 12 months compared with standard arthroscopic meniscal repair. Although MRI-based healing rates were comparable, the overall clinical benefit observed suggests that BMS is a safe, simple, and effective biological adjunct that may enhance outcomes in meniscal repair procedures. Further studies with longer follow-up are warranted to evaluate durability of these early results.

PROM	BMS group				Control				Difference Between Group (95% CI)	p <sup>α</sup>	p <sup>β</sup>	p <sup>γ</sup>
	Pre-op	Post-op 6 mo	Post-op 12 mo	Change from baseline (95% CI)	Pre-op	Post-op 6 mo	Post-op 12 mo	Change from baseline (95% CI)				
IKDC <sup>Φ</sup>	49.25 ± 2.87	61.85 ± 3.62	62.05 ± 3.02	32.80 (25.63, 39.97)	46.25 ± 2.39	55.00 ± 3.89	57.55 ± 3.55	11.30 (4.13, 18.47)	24.50 (14.69, 34.31)	0.481	0.132	<0.001**
WOMAC <sup>¶</sup>	89.20 ± 12.22	38.40 ± 9.71	17.00 ± 4.85	-72.20 (-91.64, 52.86)	85.35 ± 12.14	42.40 ± 8.03	38.80 ± 6.57	-46.55 (-65.89, -27.21)	-21.80 (-40.17, -3.43)	0.817	0.751	0.020*
Lysholm <sup>§</sup>	63.95 ± 4.18	83.15 ± 2.42	91.40 ± 1.46	27.45 (19.52, 35.38)	62.40 ± 4.31	74.00 ± 3.87	74.30 ± 3.17	11.90 (3.97, 19.83)	17.10 (9.35, 24.85)	0.789	0.041*	<0.001**
Tegner <sup>Ω</sup>	2.25 ± 0.29	3.35 ± 0.30	4.95 ± 0.37	2.70 (1.88, 3.52)	2.45 ± 0.39	3.40 ± 0.45	3.40 ± 0.12	0.95 (0.13, 1.77)	1.55 (0.41, 2.69)	0.684	0.922	0.007*
Pain <sup>‡</sup>	4.95 ± 0.58	1.70 ± 0.39	0.65 ± 0.17	-4.30 (-5.56, -3.04)	4.25 ± 0.53	2.35 ± 0.39	2.15 ± 0.48	-2.10 (-3.36, -0.84)	-1.50 (-2.52, -0.48)	0.353	0.268	0.004*
Satisfaction <sup>††</sup>	-	9.30 ± 0.13	9.65 ± 0.13	0.35 (-0.24, 0.94)	-	8.35 ± 0.30	8.15 ± 0.36	-0.20, -0.79, 0.39)	1.50 (0.75, 2.25)	-	0.004*	<0.001**

Data are presented as mean ± standard error with 95% CI in brackets. Boldface indicates statistically significant (p < 0.05).

Φ IKDC score ranges from 0-100, with higher scores representing less symptoms and higher levels of knee functions.

¶ WOMAC score ranges from 0-230, with higher score representing more symptoms and poorer level of knee functions.

‡ Pain is measured using a visual analogue scale ranging from 0 to 10, with higher scores indicating more pain.

§ The Lysholm score ranges from 0 to 100, with higher scores indicating less knee symptoms and higher levels of functioning.

Ω The Tegner scores ranges from 0 to 10, with higher scores indicating a higher activity level.

†† Satisfaction with knee function is measured using a visual analogue scale ranging from 0 to 10, with higher scores indicating a higher patients' satisfaction with their knee function.

PROM, Patient-Reported Outcome; BMS, Bone Marrow Stimulation Technique; IKDC, International Knee Documentation Committee; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; VAS, Visual Analogue Scale

α For pre-op (BMS vs Control)

β For 6 months post-operative

γ For 12 months post-operative

**Table 1.** PROM Assessment at pre-op post-op 6 months and 12 months between groups

Outcome <sup>μ</sup>	BMS group (n)	Control (n)
Unhealed	2	2
Partially Healed	17	17
Healed	1	1
<sup>μ</sup> Graded using Crues Classification BMS, bone marrow stimulation technique Intra-class correlation coefficient (0.81), p-value 0.783		

**Table 2:** meniscal healing assessment with magnetic resonance imaging

## References

- Dean CS, Chahla J, Matheny LM, et al. Outcomes after biologically augmented isolated meniscal repair with marrow venting are comparable with those after meniscal repair with concomitant anterior cruciate ligament reconstruction. *Am J Sports Med* 2017; 45 (6): 1341–1348.
- Driscoll MD, Robin BN, Horie M, Hubert ZT, Sampson HW, Jupiter DC, et al. Marrow stimulation improves meniscal healing at early endpoints in a rabbit meniscal injury model. *Arthroscopy* 2013; 29 (1): 113–121.