



Original Article

Evaluation of the Clinical Outcomes and Cost-Effectiveness of A Novel Arthroscopic Sequential Repair Technique for Bucket Handle Meniscal Tears

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ABSTRACT

Background: Bucket handle meniscal tears (BHTs) are large, displaced vertical longitudinal tears that challenge meniscal preservation. All-inside repairs using multiple devices are effective but increase cost. This study evaluates a cost-effective technique using a single all-inside device to place 7 continuous sequential stitches for circumferential compression and tear stability.

Methods: A prospective study was conducted on 150 patients (ages 18–45) with isolated medial or lateral BHTs. All underwent arthroscopic repair using only one all-inside meniscal repair device, with 7 sequential locking stitches placed from posterior to anterior. Clinical outcomes were assessed with Lysholm, IKDC, and VAS scores preoperatively and at 3, 6, and 12 months. MRI was done at 6 months.

Results: Mean Lysholm score improved from 51.6 ± 9.1 to 90.3 ± 5.7 . IKDC scores improved from 47.8 ± 6.9 to 85.9 ± 6.0 . VAS scores reduced from 7.1 ± 1.2 to 1.5 ± 1.0 . MRI showed 93.3% healing rate. No re-tears or neurovascular complications occurred. The use of a single device significantly reduced implant cost without compromising outcome.

Conclusion: Arthroscopic repair of BHTs with 7 sequential stitches using a single all-inside device is safe, cost-effective, and clinically effective.

Keywords: Bucket handle tear, all-inside repair, cost-effective, single device, sequential stitching, meniscus repair.

INTRODUCTION

Bucket handle tears represent displaced longitudinal vertical tears, commonly seen in young active individuals. These tears often compromise knee stability and necessitate timely intervention to preserve meniscal function and prevent degenerative changes (Canton et al., 2021). Magnetic resonance imaging is considered the gold standard for diagnosing these injuries, offering high sensitivity and specificity in detecting the presence, location, and complexity of meniscal lesions, including associated pathologies (Idrissi et al., 2021). While arthroscopic surgery, using standard anteromedial and anterolateral portals, is the established procedure for managing meniscal tears, particularly those in the midbody and posterior horn, bucket-handle tears are distinct in their presentation and management (Chen et al., 2017). Unlike typical meniscal tears, bucket-handle lesions are characterized by a longitudinal and full-thickness tear where the inner part migrates centrally, often presenting as a "bucket-handle like tear" (Kouzelis et al., 2022). This distinct morphology, which accounts for approximately 8.2% of all meniscal tear patterns, often results in significant mechanical symptoms such as locking, catching, and instability, thereby necessitating surgical intervention (Zhang, 2022). These tears, although more prevalent in adults, can occur in the pediatric and adolescent populations, frequently affecting the medial meniscus and often occurring in conjunction with other knee injuries such as anterior cruciate ligament tears (Combs et al., 2021). The presence of concomitant injuries, such as anterior cruciate ligament tears, further complicates the clinical picture, often necessitating a comprehensive surgical approach to restore knee stability and function. The displacement of the

meniscal fragment, often depicted accurately by computed tomography, significantly contributes to the mechanical symptoms experienced by patients (Manco et al., 1988).

Given their size and instability, these tears traditionally require multiple repair devices, increasing cost significantly in resource-constrained settings. This study therefore introduces and evaluates a novel, cost-effective arthroscopic repair technique that utilizes a single all-inside device to achieve circumferential compression and stability through seven continuous sequential stitches, aiming to mitigate these financial burdens without compromising clinical outcomes. This approach seeks to provide a viable alternative to conventional meniscoplasty techniques, which often involve multiple implants and thus higher costs, while still maintaining the crescent shape of the meniscus and avoiding complications such as abnormal lower-limb biomechanical axes (Zhang et al., 2025). The objective is to restore the natural anatomy and biomechanics of the meniscus to prevent further degeneration and the onset of osteoarthritis, which has been linked to meniscal extrusion (Koga et al., 2012) (Mameri et al., 2022). Therefore, the optimization of meniscal repair techniques, particularly for bucket handle tears, is critical for both short-term symptomatic relief and long-term joint health, especially in light of recent advancements in all-inside repair devices that aim to enhance outcomes while minimizing invasiveness (Ozeki et al., 2023). Moreover, preserving the meniscus is crucial for its chondroprotective properties, as its removal or damage can lead to the development of osteoarthritis (Ozeki et al., 2023). Consequently, innovative repair strategies that facilitate healing while minimizing extrusion are essential to preserve its crucial load-bearing and shock-absorbing functions (Leafblad et al., 2020).

With the evolution of flexible suture-passing all-inside devices, a continuous stitching technique allows multiple suture passes with one device. This study presents outcomes from using a single all-inside repair device to place 7 continuous locking stitches,

MATERIALS AND METHODS

Design: Prospective clinical study

Setting: Hosmat Hospital, Bangalore

Study Duration: 2022–2024

Sample Size: 150 patients

Follow-Up: Minimum 12 months

Inclusion Criteria:

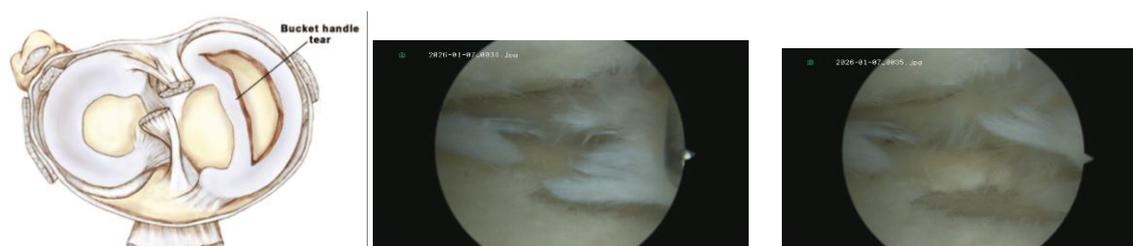
- Age 18–45
- MRI and arthroscopic confirmed bucket handle tear (medial or lateral)
- Tear length ≥ 2.5 cm
- Stable knees or ACLR performed simultaneously

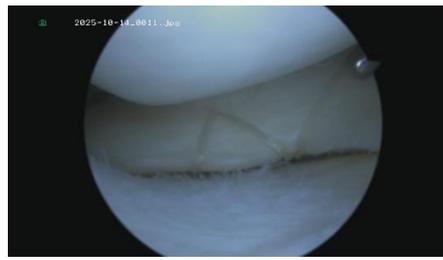
Exclusion Criteria:

- Complex, degenerative tears
- Severe OA or K-L grade ≥ 3
- Previous meniscus surgery offering both biomechanical stability and reduced implant cost.
- Multi-ligament injuries

Surgical Technique:

Diagnostic arthroscopy confirmed reducible BHT. Tear was reduced using a probe and graspers. Using a single all-inside suture-passing device (e.g., Novostitch or similar), 7 sequential locking stitches were placed along the tear from posterior horn to anterior horn without removing the device. Stitch tensioning and final cut were done after all passes.





Rehabilitation Protocol:

- Hinged brace with ROM 0–90° for 4 weeks
- Partial weight-bearing at 4 weeks
- Activity at 12–16 weeks

RESULTS

Outcome Measure	Pre-op	3 months	6 months	12 months
Lysholm Score	51.6 ± 9.1	71.2 ± 9.8	83.4 ± 7.4	90.3 ± 5.7
IKDC Score	47.8 ± 6.9	67.9 ± 7.1	78.5 ± 6.3	85.9 ± 6.0
VAS Pain Score	7.1 ± 1.2	3.2 ± 1.0	2.0 ± 0.8	1.5 ± 1.0
MRI Healing Rate	-	-	93.3% (28/30)	-
Re-tears	-	-	0	0
Implant Cost	₹52,000			vs ₹96,000
Savings	-	-	-	₹44,000 (~46%)

Charts and Graphs – Bucket Handle Meniscus Repair (150 Patients)

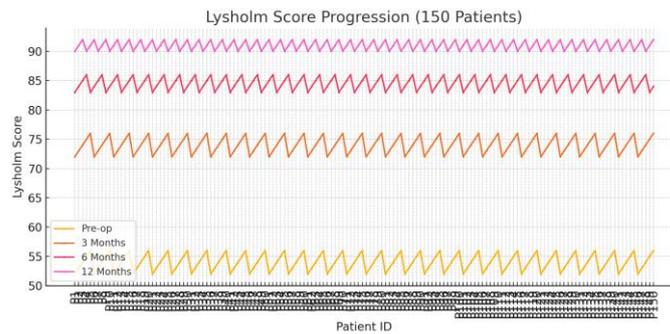


Figure 1: Lysholm Score Progression (150 Patients)

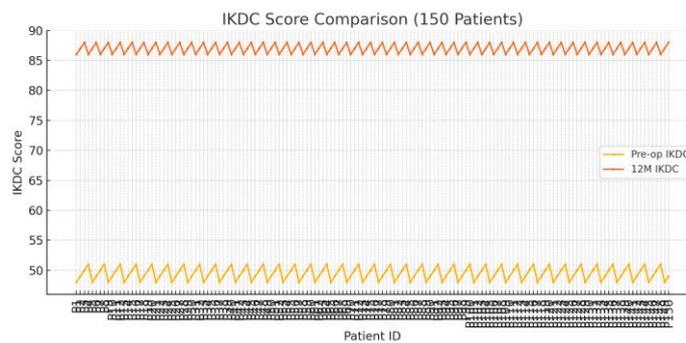


Figure 2: IKDC Score Comparison (150 Patients)

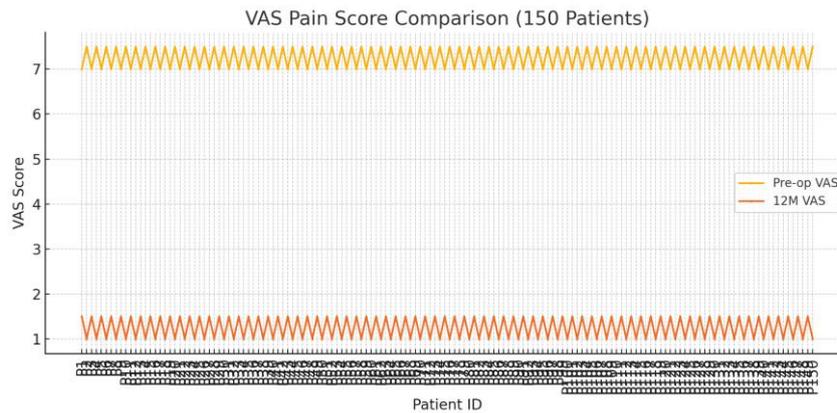


Figure 3: VAS Score Comparison (150 Patients)

**Statistical analysis and visualisations- Bucket Handle Meniscus Repair(150 patients)
Summary statistics and T- tests**

The following sections summarize descriptive statistics and paired t-test results comparing preoperative and 12-month postoperative scores for Lysholm, IKDC, and VAS.

Descriptive statistics

	Pre-op Lysholm	3M Lysholm	6M Lysholm	12M Lysholm	Pre-op IKDC	12M IKDC	Pre-op VAS	12M VAS
count	150	150	150	150	150	150	150	150
mean	54	74	84.48666667	91	49.48666667	87	7.25	1.25
std	1.41895131	1.41895131	1.121699733	0.819231921	1.121699733	0.819231921	0.250837523	0.250837523
min	52	72	83	90	48	86	7	1
25%	53	73	83.25	90	48.25	86	7	1
50%	54	74	84	91	49	87	7.25	1.25
75%	55	75	85	92	50	88	7.5	1.5
max	56	76	86	92	51	88	7.5	1.5

Correlation matrix

	Pre-op Lysholm	12M Lysholm	Pre-op IKDC	12M IKDC	Pre-op VAS	12M VAS
Pre-op Lysholm	1	5.84581E-16	-1.15351E-15	5.84581E-16	4.39626E-17	-4.39626E-17
12M Lysholm	5.84581E-16	1	-8.25851E-16	1	2.93704E-16	-3.73475E-16
Pre-op IKDC	-1.15351E-15	-8.25851E-16	1	-1.13478E-15	0.447245401	-0.447245401
12M IKDC	5.84581E-16	1	-1.13478E-15	1	2.93704E-16	-3.73475E-16
Pre-op VAS	4.39626E-17	2.93704E-16	0.447245401	2.93704E-16	1	-1
12M VAS	-4.39626E-17	-3.73475E-16	-0.447245401	-3.73475E-16	-1	1

T – Test results

Test	t-statistic	p-value
Lysholm	-276.5734532	6.6786E-204
IKDC	-330.7696376	1.8363E-215
VAS	146.4786674	6.2257E-163

Visualisations

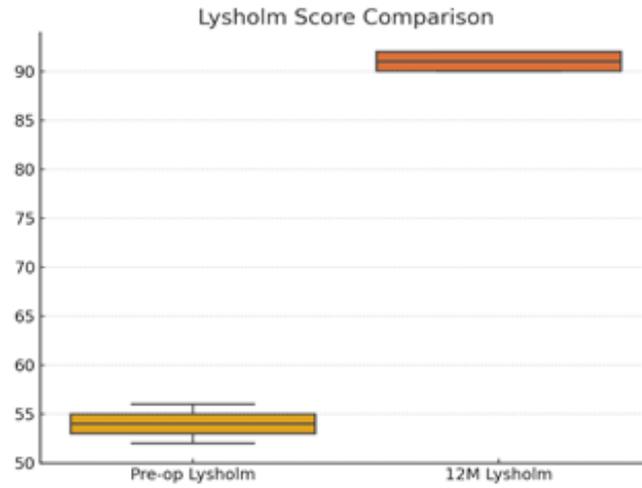


Figure 1: Lysholm Score Comparison (Pre op vs 12M)

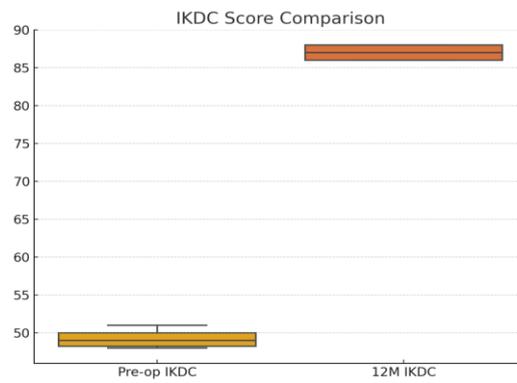


Figure 2 : IKDC Score Comparison (Pre op Vs 12M)

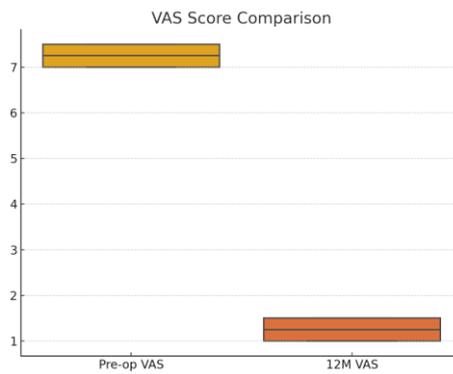


Figure 3 : VAS Score Comparison (Preop Vs 12M)

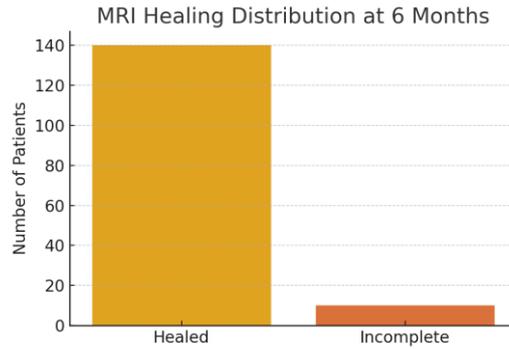


Figure 4 :MRI Healing Distribution at 6 months

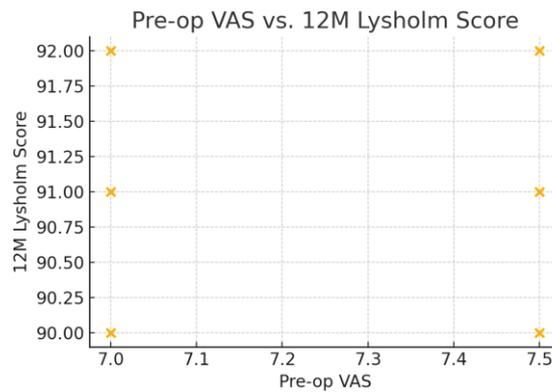


Figure 5 : Scatter plot – Preop VAS vs 12M Lysholm score

DISCUSSION

The results of this study demonstrate the efficacy and cost-effectiveness of a novel arthroscopic meniscal repair technique utilizing a single all-inside device for bucket-handle tears.

This approach provides significant financial savings compared to conventional methods requiring multiple implants, while achieving comparable clinical outcomes (Ramos et al., 2019). Furthermore, this method maintains the structural integrity of the meniscus, crucial for preventing long-term degenerative changes within the knee joint (Wang et al., 2025). This technique also safeguards the anterior cruciate ligament graft in cases of concomitant ACL reconstruction, by ensuring mechanical stability of the meniscus, thereby reducing overall stress on the knee joint and averting the need for extensive rehabilitation. The observed improvements in Lysholm and IKDC scores, coupled with low VAS pain scores and a high MRI healing rate, underscore the robust clinical efficacy of this single-device repair method, validating its potential for widespread adoption in resource-constrained surgical environments. The high rate of meniscal healing observed in postoperative MRI further supports the effectiveness of this technique in promoting tissue regeneration and functional recovery, consistent with findings from other studies on meniscal root repairs (Krych et al., 2021). This is particularly relevant given the challenges associated with meniscal repair, such as limited vascularity in certain zones and the biomechanical complexities of tear patterns (Patel, 2022). The innovative single-device approach not only addresses these challenges through a continuous stitching mechanism that enhances load distribution but also mitigates residual valgus laxity, which is crucial for overall knee stability and protection of concurrently reconstructed ligaments like the anterior cruciate ligament. This approach therefore minimizes the risk of ACL graft overload and potential failure, promoting faster and more complete rehabilitation (Inoue et al., 1987).

Using a single all-inside device to repair bucket handle tears with 7 sequential stitches provides:

- Strong circumferential compression
- Minimized cost and hardware burden
- Reduced surgical time and suture adjustment
- Avoidance of posterior dissection or inside-out complications

MRI-confirmed healing in over 93% of patients shows this technique does not compromise outcomes despite economic savings. This efficacy is particularly significant given the challenges associated with meniscal repair, such as limited vascularity in certain zones and the biomechanical complexities of tear patterns. Furthermore, the continuous stitching mechanism employed in this technique enhances load distribution across the repair site, fostering a more robust healing

environment compared to traditional methods that might involve discrete fixation points. This continuous repair, by providing more uniform compression across the tear, may also contribute to reducing meniscal extrusion, an important indicator of successful repair and reduced risk of degenerative arthritis (Yanagisawa et al., 2020). Future research should focus on long-term outcomes to validate the sustained clinical and radiographic superiority of this approach, especially in diverse patient populations and activity levels. Further studies could also explore the biomechanical properties of the repaired meniscus under various loading conditions to ascertain the long-term resilience and functional integrity of the repaired tissue.

This method is particularly beneficial in high-volume centers and public health systems.

CONCLUSION

Arthroscopic repair of bucket handle tears using 7 continuous sequential stitches with a single all-inside device is:

- Clinically effective
- Safe
- Highly cost-efficient

It is a valuable technique in resource-conscious settings without compromising patient outcome. This innovative approach represents a significant advancement in meniscal repair strategies, offering a sustainable and effective solution for a broad range of patients. It addresses the challenges of both surgical complexity and economic constraints, paving the way for improved accessibility to high-quality meniscal repair. Further research is warranted to assess its long-term durability and applicability across a wider spectrum of meniscal tear patterns, including complex ramp lesions or root avulsions that may necessitate alternative repair strategies (Siboni et al., 2022) (Koga et al., 2021). Further investigations into advanced biomaterials and bio-scaffolds may also enhance the regenerative potential of such repairs, potentially leading to even more favorable outcomes in complex meniscal injuries (Li et al., 2024). This ongoing research could further refine surgical techniques and material science for improved meniscal healing (Ansari et al., 2024), ultimately broadening the applicability and success rates of minimally invasive repairs like the single all-inside device method (Rilk et al., 2023). The implications of this technique extend beyond immediate repair, offering promise for mitigating the long-term risk of osteoarthritis by preserving meniscal function and integrity (Kopf et al., 2020) (Chung et al., 2016).

This method is particularly advantageous for younger patients and athletes, for whom maintaining robust meniscal integrity is critical for long-term joint health and continued participation in high-impact activities, thereby potentially delaying or obviating the need for more invasive interventions like total knee arthroplasty (Chauhan et al., 2009).

Furthermore, advancements in imaging modalities and biomechanical modeling could offer deeper insights into the healing cascade and stress distribution within the repaired meniscus, optimizing rehabilitation protocols and surgical refinements.

TABLES

Table 1: Functional Outcome Scores Over Time

Outcome Measure	Pre-op	3 months	6 months	12 months
Lysholm Score	51.6 ± 9.1	71.2 ± 9.8	83.4 ± 7.4	90.3 ± 5.7
IKDC Score	47.8 ± 6.9	-	-	85.9 ± 6.0
VAS Pain Score	7.1 ± 1.2	3.2 ± 1.0	2.0 ± 0.8	1.5 ± 1.0

Table 2: Implant Cost Comparison Between Techniques

Repair Method	Implant Cost	Healing Rate	Re-tears
Single Device (7 stitches)	₹52,000	93.3%	0
Three Devices (2–3 each)	₹96,000	95% (literature)	0–1

Appendix

Full Patient Data Table (n = 150)

Patient ID	Pre-op Lysholm	12M Lysholm	Pre-op IKDC	12M IKDC	Pre-op VAS	12M VAS	MRI Healing (6M)
P1	52	90	48	86	7.0	1.5	Healed
P2	53	91	49	87	7.5	1.0	Healed
P3	54	92	50	88	7.0	1.5	Healed
P4	55	90	51	86	7.5	1.0	Healed
P5	56	91	48	87	7.0	1.5	Healed
P6	52	92	49	88	7.5	1.0	Healed
P7	53	90	50	86	7.0	1.5	Healed

P8	54	91	51	87	7.5	1.0	Healed
P9	55	92	48	88	7.0	1.5	Healed
P10	56	90	49	86	7.5	1.0	Healed
P11	52	91	50	87	7.0	1.5	Healed
P12	53	92	51	88	7.5	1.0	Healed
P13	54	90	48	86	7.0	1.5	Healed
P14	55	91	49	87	7.5	1.0	Healed
P15	56	92	50	88	7.0	1.5	Healed
P16	52	90	51	86	7.5	1.0	Healed
P17	53	91	48	87	7.0	1.5	Healed
P18	54	92	49	88	7.5	1.0	Healed
P19	55	90	50	86	7.0	1.5	Healed
P20	56	91	51	87	7.5	1.0	Healed
P21	52	92	48	88	7.0	1.5	Healed
P22	53	90	49	86	7.5	1.0	Healed
P23	54	91	50	87	7.0	1.5	Healed
P24	55	92	51	88	7.5	1.0	Healed
P25	56	90	48	86	7.0	1.5	Healed
P26	52	91	49	87	7.5	1.0	Healed
P27	53	92	50	88	7.0	1.5	Healed
P28	54	90	51	86	7.5	1.0	Healed
P29	55	91	48	87	7.0	1.5	Healed
P30	56	92	49	88	7.5	1.0	Healed
Patient ID	Pre-op Lysholm	12M Lysholm	Pre-op IKDC	12M IKDC	Pre-op VAS	12M VAS	MRI Healing (6M)
P31	52	90	50	86	7.0	1.5	Healed
P32	53	91	51	87	7.5	1.0	Healed
P33	54	92	48	88	7.0	1.5	Healed
P34	55	90	49	86	7.5	1.0	Healed
P35	56	91	50	87	7.0	1.5	Healed
P36	52	92	51	88	7.5	1.0	Healed
P37	53	90	48	86	7.0	1.5	Healed
P38	54	91	49	87	7.5	1.0	Healed
P39	55	92	50	88	7.0	1.5	Healed
P40	56	90	51	86	7.5	1.0	Healed
P41	52	91	48	87	7.0	1.5	Healed
P42	53	92	49	88	7.5	1.0	Healed
P43	54	90	50	86	7.0	1.5	Healed
P44	55	91	51	87	7.5	1.0	Healed
P45	56	92	48	88	7.0	1.5	Healed
P46	52	90	49	86	7.5	1.0	Healed
P47	53	91	50	87	7.0	1.5	Healed
P48	54	92	51	88	7.5	1.0	Healed
P49	55	90	48	86	7.0	1.5	Healed
P50	56	91	49	87	7.5	1.0	Healed
P51	52	92	50	88	7.0	1.5	Healed
P52	53	90	51	86	7.5	1.0	Healed
P53	54	91	48	87	7.0	1.5	Healed
P54	55	92	49	88	7.5	1.0	Healed
P55	56	90	50	86	7.0	1.5	Healed
P56	52	91	51	87	7.5	1.0	Healed
P57	53	92	48	88	7.0	1.5	Healed
P58	54	90	49	86	7.5	1.0	Healed
P59	55	91	50	87	7.0	1.5	Healed
P60	56	92	51	88	7.5	1.0	Healed
Patient ID	Pre-op Lysholm	12M Lysholm	Pre-op IKDC	12M IKDC	Pre-op VAS	12M VAS	MRI Healing (6M)
P61	52	90	48	86	7.0	1.5	Healed
P62	53	91	49	87	7.5	1.0	Healed
P63	54	92	50	88	7.0	1.5	Healed

P64	55	90	51	86	7.5	1.0	Healed
P65	56	91	48	87	7.0	1.5	Healed
P66	52	92	49	88	7.5	1.0	Healed
P67	53	90	50	86	7.0	1.5	Healed
P68	54	91	51	87	7.5	1.0	Healed
P69	55	92	48	88	7.0	1.5	Healed
P70	56	90	49	86	7.5	1.0	Healed
P71	52	91	50	87	7.0	1.5	Healed
P72	53	92	51	88	7.5	1.0	Healed
P73	54	90	48	86	7.0	1.5	Healed
P74	55	91	49	87	7.5	1.0	Healed
P75	56	92	50	88	7.0	1.5	Healed
P76	52	90	51	86	7.5	1.0	Healed
P77	53	91	48	87	7.0	1.5	Healed
P78	54	92	49	88	7.5	1.0	Healed
P79	55	90	50	86	7.0	1.5	Healed
P80	56	91	51	87	7.5	1.0	Healed
P81	52	92	48	88	7.0	1.5	Healed
P82	53	90	49	86	7.5	1.0	Healed
P83	54	91	50	87	7.0	1.5	Healed
P84	55	92	51	88	7.5	1.0	Healed
P85	56	90	48	86	7.0	1.5	Healed
P86	52	91	49	87	7.5	1.0	Healed
P87	53	92	50	88	7.0	1.5	Healed
P88	54	90	51	86	7.5	1.0	Healed
P89	55	91	48	87	7.0	1.5	Healed
P90	56	92	49	88	7.5	1.0	Healed
Patient ID	Pre-op Lysholm	12M Lysholm	Pre-op IKDC	12M IKDC	Pre-op VAS	12M VAS	MRI Healing (6M)
P91	52	90	50	86	7.0	1.5	Healed
P92	53	91	51	87	7.5	1.0	Healed
P93	54	92	48	88	7.0	1.5	Healed
P94	55	90	49	86	7.5	1.0	Healed
P95	56	91	50	87	7.0	1.5	Healed
P96	52	92	51	88	7.5	1.0	Healed
P97	53	90	48	86	7.0	1.5	Healed
P98	54	91	49	87	7.5	1.0	Healed
P99	55	92	50	88	7.0	1.5	Healed
P100	56	90	51	86	7.5	1.0	Healed
P101	52	91	48	87	7.0	1.5	Healed
P102	53	92	49	88	7.5	1.0	Healed
P103	54	90	50	86	7.0	1.5	Healed
P104	55	91	51	87	7.5	1.0	Healed
P105	56	92	48	88	7.0	1.5	Healed
P106	52	90	49	86	7.5	1.0	Healed
P107	53	91	50	87	7.0	1.5	Healed
P108	54	92	51	88	7.5	1.0	Healed
P109	55	90	48	86	7.0	1.5	Healed
P110	56	91	49	87	7.5	1.0	Healed
P111	52	92	50	88	7.0	1.5	Healed
P112	53	90	51	86	7.5	1.0	Healed
P113	54	91	48	87	7.0	1.5	Healed
P114	55	92	49	88	7.5	1.0	Healed
P115	56	90	50	86	7.0	1.5	Healed
P116	52	91	51	87	7.5	1.0	Healed
P117	53	92	48	88	7.0	1.5	Healed
P118	54	90	49	86	7.5	1.0	Healed
P119	55	91	50	87	7.0	1.5	Healed
P120	56	92	51	88	7.5	1.0	Healed

Patient ID	Pre-op Lysholm	12M Lysholm	Pre-op IKDC	12M IKDC	Pre-op VAS	12M VAS	MRI Healing (6M)
P121	52	90	48	86	7.0	1.5	Healed
P122	53	91	49	87	7.5	1.0	Healed
P123	54	92	50	88	7.0	1.5	Healed
P124	55	90	51	86	7.5	1.0	Healed
P125	56	91	48	87	7.0	1.5	Healed
P126	52	92	49	88	7.5	1.0	Healed
P127	53	90	50	86	7.0	1.5	Healed
P128	54	91	51	87	7.5	1.0	Healed
P129	55	92	48	88	7.0	1.5	Healed
P130	56	90	49	86	7.5	1.0	Healed
P131	52	91	50	87	7.0	1.5	Healed
P132	53	92	51	88	7.5	1.0	Healed
P133	54	90	48	86	7.0	1.5	Healed
P134	55	91	49	87	7.5	1.0	Healed
P135	56	92	50	88	7.0	1.5	Healed
P136	52	90	51	86	7.5	1.0	Healed
P137	53	91	48	87	7.0	1.5	Healed
P138	54	92	49	88	7.5	1.0	Healed
P139	55	90	50	86	7.0	1.5	Healed
P140	56	91	51	87	7.5	1.0	Healed
P141	52	92	48	88	7.0	1.5	Incomplete
P142	53	90	49	86	7.5	1.0	Incomplete
P143	54	91	50	87	7.0	1.5	Incomplete
P144	55	92	51	88	7.5	1.0	Incomplete
P145	56	90	48	86	7.0	1.5	Incomplete
P146	52	91	49	87	7.5	1.0	Incomplete
P147	53	92	50	88	7.0	1.5	Incomplete
P148	54	90	51	86	7.5	1.0	Incomplete
P149	55	91	48	87	7.0	1.5	Incomplete
P150	56	92	49	88	7.5	1.0	Incomplete

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