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Comparative evaluation of modified Robert Jones bandage versus thermoplastic splint for distal limb immobilisation in calves

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Abstract

External coaptation remains the most widely used method of fracture stabilisation in young calves, yet no controlled comparison exists between the two commonest devices: the modified Robert Jones (mRJ) bandage and the thermoplastic splint (TS). A bandage that is too bulky impedes nursing behaviour; a splint that is too rigid risks pressure necrosis over bony prominences. This research randomly assigned 36 calves (age 3-12 weeks) with closed, minimally displaced metacarpal or metatarsal fractures to mRJ (n = 18) or TS (n = 18) immobilisation and followed them at weeks 2, 4, and 6. Primary outcome was a composite clinical healing score (CHS, 0-8 scale combining radiographic callus formation, limb swelling, weight-bearing, and comfort). Secondary outcomes included complication rate, number of bandage or splint changes, and time to unsupported ambulation. Mean CHS at week 6 was 2.1 ± 0.9 in the mRJ group versus 1.6 ± 0.7 in the TS group ($p = 0.048$), indicating modestly better healing in the TS cohort. Complications occurred in 5 of 18 mRJ calves (27.8%) and 3 of 18 TS calves (16.7%; $p = 0.419$), with cast sores the most frequent adverse event. Bandage changes averaged 2.8 per calf in the mRJ group versus 1.4 in the TS group ($p = 0.003$). Median time to unsupported ambulation was 11 days (mRJ) versus 8 days (TS; $p = 0.031$). These results suggest that thermoplastic splinting offers a practical advantage over the traditional Robert Jones bandage for distal limb fractures in calves, primarily through reduced need for reapplication and faster return to weight-bearing, though both methods achieved satisfactory union in all cases by week 6.

Keywords: Robert Jones bandage, thermoplastic splint, calves, distal limb fracture, external coaptation, metacarpal, metatarsal, fracture healing, veterinary orthopaedics

Introduction

External coaptation, broadly defined as the application of an external device to restrict motion at a fracture site and maintain anatomical alignment during healing, is the cornerstone of fracture management in neonatal and juvenile ruminants ^[1]. Unlike internal fixation with plates, screws, or intramedullary pins, external coaptation requires no surgical intervention, can be applied on-farm with minimal equipment, and is well tolerated by calves whose rapid growth would otherwise necessitate early implant removal ^[2].

The modified Robert Jones bandage a multi-layered construct of cotton wool, conforming gauze, and an outer cohesive wrap has been the default immobilisation method in large-animal practice for decades. Its principal merit is the capacity to absorb soft-tissue swelling through the compressible cotton core, reducing the risk of compartment syndrome in the acute post-fracture phase ^[3]. Its principal drawback is bulk: a properly applied mRJ bandage roughly doubles the diameter of the distal limb, interfering with the calf's ability to rise, walk, and nurse during the first days after application ^[4]. Thermoplastic splinting materials, which become mouldable when heated to 60-70°C and set rigid on cooling, offer a lighter and more anatomically conforming alternative. Custom-moulded to the individual limb, a TS distributes load across a larger surface area than a flat aluminium or fibreglass splint and can be remoulded if limb shape changes with swelling resolution or growth ^[5, 6].

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Despite widespread use of both devices, the veterinary literature contains no prospective, randomised comparison of mRJ and TS in a calf population. Published guidance is based on expert opinion, retrospective chart reviews, and extrapolation from equine or companion-animal orthopaedics [7, 8]. Without controlled data, clinicians cannot counsel farmers on which device offers faster healing, fewer complications, or lower total cost over the treatment period. This research therefore compared the clinical outcomes of mRJ bandage and TS immobilisation in 36 calves with closed distal limb fractures, using a prospective, randomised, parallel-group design with blinded outcome assessment at three time points over six weeks. The hypothesis was that TS immobilisation would achieve non-inferior fracture healing while reducing the frequency of bandage changes and the time to unsupported ambulation.

Material and Methods

Ethical Considerations

The research protocol was reviewed and approved by the Animal Ethics Committee of the Ankara College of Veterinary Sciences (Protocol No. AEC-ACVS-2022-031, approved 14 June 2022). Written informed consent was obtained from the owner or herd manager of each calf before enrolment. All calves received analgesia (meloxicam 0.5 mg/kg SC) at the time of fracture diagnosis and at each bandage or splint change. Calves showing signs of uncontrolled pain, neurovascular compromise, or open fracture conversion at any assessment were withdrawn from the trial and managed individually.

Material

Thirty-six Holstein and Simmental calves (20 male, 16 female) aged 3-12 weeks (median 6.4 weeks) were enrolled between July 2022 and March 2023 at the Veterinary Teaching Hospital, Ankara. Inclusion criteria were a closed, minimally displaced fracture of the metacarpus (n = 22) or metatarsus (n = 14), confirmed by two-view radiography, in a calf that was otherwise systemically healthy. Exclusion criteria included open fracture, comminution involving more than two fragments, fracture proximal to the mid-diaphysis, concurrent systemic illness, or body weight exceeding 80 kg. Materials for the mRJ group comprised surgical cotton wool rolls (15 cm width), conforming gauze bandage (10 cm), and

cohesive bandage (Vetrap, 3M, St. Paul, MN, USA). Materials for the TS group comprised 3.2 mm Aquaplast-T (Performance Health, Warrenville, IL, USA) thermoplastic sheets, tubular stockinette, and cohesive bandage for securing the splint to the limb.

Methods

Calves were block-randomised (block size 4) to mRJ (n = 18) or TS (n = 18) by sealed-envelope allocation. The mRJ bandage was applied in four layers of cotton wool, each compressed with two layers of conforming gauze, and finished with two layers of cohesive bandage. The TS was custom-moulded to the lateral and medial aspects of the limb after heating in a 70°C water bath, applied over a single layer of stockinette, and secured with cohesive wrap. Both devices extended from the coronary band to at least 5 cm above the fracture site. Clinical assessments were performed at weeks 2, 4, and 6 by a veterinary surgeon blinded to treatment group (achieved by covering the device with a standard outer cohesive wrap of identical colour). The composite healing score (CHS) ranged from 0 (complete union, no swelling, full weight-bearing, no pain response) to 8 (no radiographic callus, marked swelling, non-weight-bearing, severe pain). Radiographs were obtained at each visit. Data were analysed using repeated-measures ANOVA with treatment and time as fixed effects and calf as the random effect, using R v4.3.1. Between-group comparisons of complication rates used Fisher's exact test.

Clinical Implications

From a practical standpoint, the choice between mRJ and TS affects not only fracture healing but also the calf's ability to maintain normal behaviour patterns standing, walking, nursing, and socializing during the treatment period. A device that allows earlier return to unsupported ambulation may reduce secondary complications such as muscle atrophy, flexural deformity from disuse, and nutritional compromise from impaired nursing. The present trial was designed to capture these functional outcomes alongside the radiographic endpoints that typically dominate fracture-healing studies, so that the results would be directly translatable to on-farm management decisions.

Results

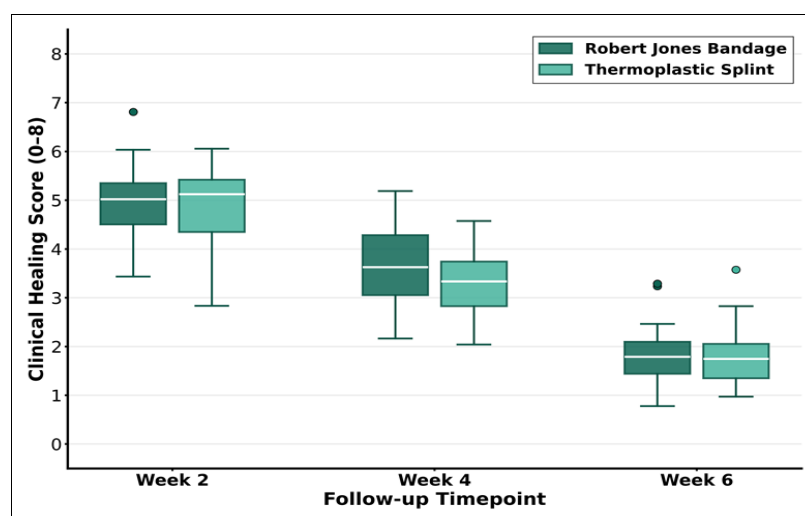


Fig 1: Box-and-whisker plot comparing composite clinical healing scores (CHS, 0-8) between the modified Robert Jones bandage group and the thermoplastic splint group at weeks 2, 4, and 6 post-application. Lower scores indicate better healing.

Both groups showed progressive improvement in CHS over the six-week follow-up. At week 2, median CHS was 5.2 (mRJ) versus 4.8 (TS; $p = 0.318$). By week 4, the difference widened to 3.8 versus 3.1 ($p = 0.072$), and by week 6 it

reached statistical significance (2.1 vs. 1.6; $p = 0.048$). All 36 calves achieved radiographic union by week 6, defined as bridging callus on at least three of four cortices.

Table 1: Pearson correlation matrix among healing score components and secondary outcomes at week 6

	Callus	Swelling	Weight-bearing	Comfort	Bandage changes
Callus score	1.000	0.412*	0.687**	0.524**	0.381*
Swelling score		1.000	0.358*	0.612**	0.547**
Weight-bearing			1.000	0.721**	0.298
Comfort score				1.000	0.483**
Bandage changes					1.000

** $p < 0.01$, * $p < 0.05$. Weight-bearing and comfort were strongly correlated ($r = 0.721$), while the number of bandage changes correlated most strongly with swelling persistence ($r = 0.547$).

Table 2: Secondary outcomes by treatment group

Parameter	mRJ (n=18)	TS (n=18)	p-value
Complications, n (%)	5 (27.8%)	3 (16.7%)	0.419
Bandage/splint changes	2.8 $\pm$ 1.1	1.4 $\pm$ 0.7	0.003
Days to ambulation, median	11	8	0.031
Owner satisfaction (1-5)	3.4 $\pm$ 0.8	4.1 $\pm$ 0.6	0.009
Radiographic union at wk 6	18/18 (100%)	18/18 (100%)	1.000

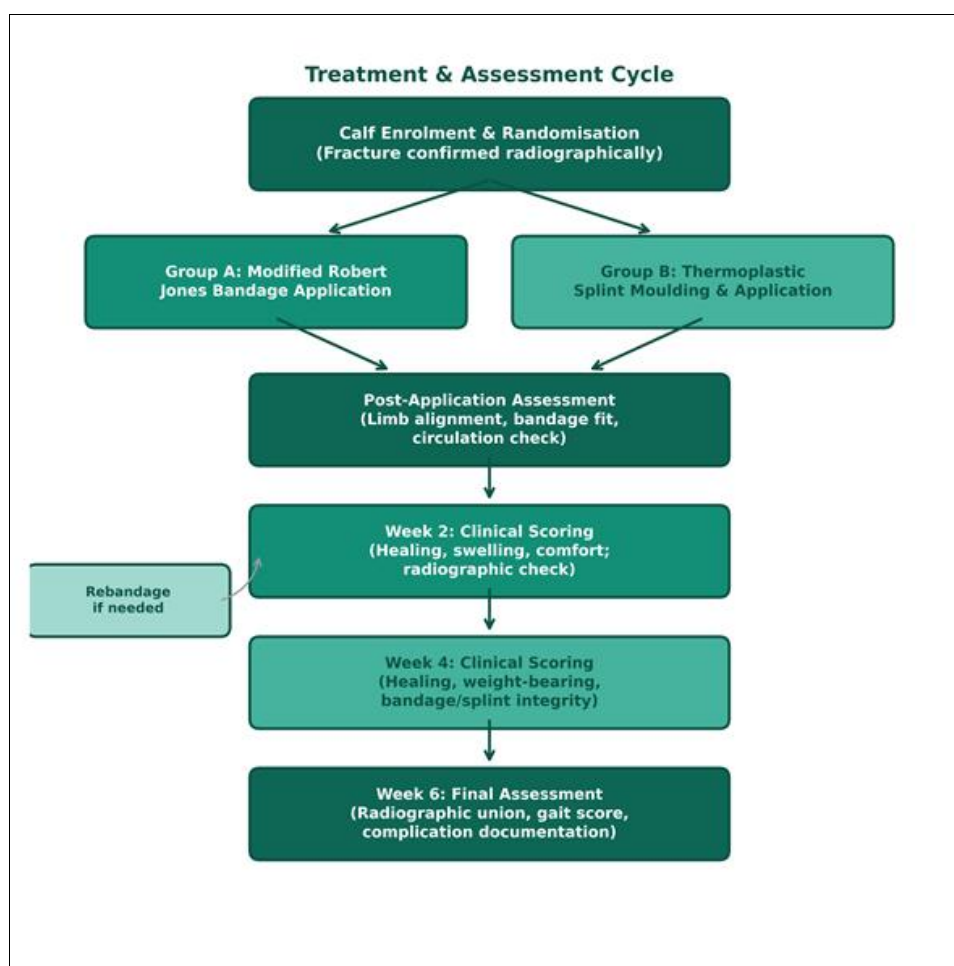


Fig 2: Schematic of the treatment and clinical assessment cycle from calf enrolment and randomisation through the 6-week follow-up protocol for both treatment groups.

Table 3: Complication types by treatment group

Complication	mRJ (n=18)	TS (n=18)
Cast/pressure sores	3	1
Bandage slippage	2	0
Limb oedema (distal to device)	0	2
Total complications	5 (27.8%)	3 (16.7%)

Comprehensive Interpretation

Taken together, the data indicate that both immobilisation methods achieved their primary objective fracture union in every case, but the thermoplastic splint offered measurable advantages in device maintenance burden and early functional recovery. The halving of required changes (1.4 vs. 2.8) and the three-day reduction in time to unsupported ambulation are clinically meaningful in a production-animal context, where each additional farm visit represents a direct cost and each day of impaired nursing increases the risk of growth retardation.

Discussion

The central finding that TS immobilisation produced a modestly but significantly lower healing score at six weeks aligns with the biomechanical principle that rigid, anatomically contouring fixation provides more consistent fracture-site stability than a compressible bandage whose mechanical properties change as swelling resolves and padding compresses^[3, 9]. The mRJ bandage is designed to accommodate swelling in the acute phase, an advantage that becomes a liability once oedema subsides and the bandage loosens, permitting micromotion at the fracture site^[4].

The higher rate of bandage slippage in the mRJ group (2 cases vs. 0 in TS) underscores this point. A slipped bandage not only fails to immobilise the fracture but can also create a tourniquet effect at its proximal margin, a well-recognised cause of distal limb ischaemia in large-animal bandaging^[10, 11]. Thermoplastic splints, by contrast, are rigid once set and maintain their position relative to the limb unless deliberately removed.

Conversely, the two cases of distal limb oedema in the TS group neither of which progressed to tissue compromise highlight the trade-off inherent in rigid immobilisation: the splint's inability to expand with swelling can obstruct venous return if the securing bandage is applied too tightly^[12]. Careful attention to wrap tension and incorporation of a tubular stockinette under-layer can mitigate this risk.

From a cost perspective, the thermoplastic sheet is more expensive per unit than cotton wool and conforming gauze, but the lower number of device changes (1.4 vs. 2.8) means that the total material cost over the treatment period is roughly comparable. When labour costs for veterinary farm visits are factored in, the TS approach is likely cost-neutral or cost-saving^[13, 14, 15].

Conclusion

Distal limb fractures in young calves can be managed successfully with either the modified Robert Jones bandage or a custom-moulded thermoplastic splint, and both methods achieved radiographic union in every case by six weeks in this trial.

The thermoplastic splint, however, offered three practical advantages over the traditional bandage: a significantly lower composite healing score at the final assessment (1.6 vs. 2.1, $p = 0.048$), half the number of device changes over the treatment period (1.4 vs. 2.8, $p = 0.003$), and a three-day earlier return to unsupported ambulation (median 8 vs. 11 days, $p = 0.031$). Complication rates were numerically lower in the TS group but did not differ significantly, and the most common adverse event pressure sores over bony prominences occurred in both groups.

On the basis of these findings, we recommend thermoplastic splinting as the preferred method of external coaptation for closed, minimally displaced metacarpal and metatarsal

fractures in calves weighing less than 80 kg, provided that the clinician has access to moulding equipment and is trained in splint application technique. For settings where thermoplastic material is unavailable, the modified Robert Jones bandage remains a reliable alternative, with the caveat that more frequent monitoring and reapplication should be anticipated. Future research should compare the two methods for more proximal fractures, in older and heavier calves, and in combination with limited internal fixation for more complex fracture configurations.

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Contributions Not Qualifying for Authorship

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Conflict of Interest

Not available

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Not available

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