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Enhanced stability of the distal radioulnar joint with double suture button construct: a cadaveric study

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Abstract

Background Distal radioulnar joint (DRUJ) instability is a common post-traumatic complication, often leading to chronic pain and dysfunction. Current reconstructive techniques, such as the single suture button construct, offer suboptimal stabilization in certain motions. This study aimed to evaluate whether a double suture button construct provides greater stability than the single construct in a cadaver model of DRUJ instability. We hypothesized that the double suture button construct would more effectively minimize dorsal translation of the radius relative to the ulna.

Methods We used nine freshly frozen human cadaver upper extremities, destabilized the DRUJ, and then reconstructed the joint using three different suture button constructs: single transverse, double (transverse + oblique), and single oblique. The specimens were secured in a custom-designed testing apparatus to measure dorsal translation of the radius. The study proceeded in five stages: stable DRUJ, unstable DRUJ, and reconstruction using a single transverse, double (transverse + oblique), and single oblique suture button construct. Dorsal translation was measured at neutral, 45° pronation, and 45° supination. Statistical comparisons of mean values were conducted for each stage.

Results Reconstruction with the transverse, transverse plus oblique, and oblique suture button constructs resulted in statistically significant reductions in dorsal translation compared to the unstable DRUJ ($p < 0.001$ for all). The double-suture button construct significantly minimized dorsal translation in all positions, restoring stability comparable to a stable DRUJ: neutral ($p = 1.000$), pronation ($p = 0.963$), and supination ($p = 1.000$). In contrast, single constructs failed to fully restore stability in pronation and supination.

Conclusion The double suture button construct provides significantly greater stabilization of the DRUJ compared to the single construct. These findings suggest that the double construct could be a more effective option for treating DRUJ instability, particularly in restoring normal joint function during various motions. Further research is warranted to confirm these results in clinical settings.

Keywords Cadaver, Distal radioulnar joint, Instability, Suture button construct

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Introduction

Distal radioulnar joint (DRUJ) instability is a common post-traumatic complication resulting from falls onto an outstretched hand during hyperpronation, leading to damage to intrinsic stabilizers, such as the triangular fibrocartilage complex (TFCC), and extrinsic stabilizers, including the interosseous membrane (IOM) and pronator quadratus muscle [1]. Left untreated, DRUJ instability can severely impair forearm pronation and supination, resulting in significant functional disability and loss of quality of life [2]. The primary treatment objective is to restore stability to the DRUJ while preserving a full, painfree range of motion in the wrist.

Surgical treatments for acute DRUJ instability typically begins with TFCC repair, aiming to reattach the torn structure to the ulnar fovea [3]. In cases where direct repair is not feasible, various reconstructive approaches have been developed, including direct radio-ulnar connections [4], ulnocarpal slings, tenodesis procedures [5–7], and radioulnar ligament reconstructions [8]. While these techniques can restore stability, they often limit forearm rotation [8, 9]. A widely used method involves the use of a palmaris longus tendon graft to reconstruct the volar and dorsal radioulnar ligaments anatomically, as described by Adams [3]. Despite favorable outcomes [8, 10], this method is highly invasive and requires prolonged post-operative immobilization [3, 8].

Research has increasingly focused on less invasive techniques for DRUJ stabilization. Watanabe et al. emphasized the critical role of the distal oblique band (DOB), a component of the distal IOM, in stabilizing the DRUJ during forearm rotations [11]. Building on this, Malone et al. demonstrated that the proximal and distal radioulnar joints function as a unified osseoligamentous system [12]. In light of these findings, Brink and Hannemann developed a surgical approach for targeting the DOB with a palmaris longus tendon graft, which yielded significant clinical improvements in 14 patients with chronic DRUJ instability [13].

Despite these advances, tendon graft harvesting and invasive procedures remain a challenge, prompting interest in alternative methods [14, 15]. In 2017, a biomechanical study introduced DOB reconstruction using a minimally invasive suture button construct for DRUJ instability [16]. This method offers dynamic stabilization with minimally invasiveness, but it has limitations [16]. In some chronic cases, subluxation during pronation and supination persists, despite achieving stability in the neutral position [17]. Satria et al. addressed this issue by adding a second suture button, perpendicular to the ulna and radius, achieving enhanced stability across all directions [17]. They concluded that a single suture button might not provide sufficient stabilization for chronic DRUJ instability, highlighting the need for a second construct [17].

Given this background, we hypothesize that a double-suture button construct will offer greater stability than a single-suture button construct in a cadaver model of post-traumatic DRUJ instability. We anticipate that this technique will better reduce dorsal translation of the radius relative to the ulna in the DRUJ, particularly in positions of pronation and supination, where single constructs often fall short. This cadaveric study investigates the effectiveness of a double suture button construct, comparing it to single constructs in stabilizing the DRUJ.

Materials and methods

Specimens

This biomechanical study used nine freshly frozen human cadaver upper extremities. Both upper extremities from four cadavers and the left upper extremity from an additional cadaver were included in the study. The donors comprised three females and two males, with an average age of 64.4 ± 9.45 years (range: 48–72). None of the specimens exhibited skeletal deformities or soft-tissue defects. All specimens were obtained from the Department of Anatomy at Dokuz Eylül University School of Medicine with prior approval from the institutional review board (IRB). Ethical guidelines, including proper consent for use of cadaveric tissue, were strictly followed. The specimens were stored at −20 °C and were thawed at room temperature for approximately 24 h prior to dissection.

Experimental site setup

A custom-designed testing system (Fig. 1a–c) was developed by the authors to enable the measurement of dorsal translation of the radius relative to the ulna. Initially, the humerus of the cadaver was stabilized on a table using two plastic clamps. Two Schanz screws were inserted transversely into the proximal ulna, approximately 3 cm apart, and mounted onto the testing system to stabilize the elbow joint at 90 °flexion. Subsequently, a Kirschner (K) wire was inserted dorsally into the palm through the third metacarpal. A second K-wire was inserted perpendicularly to the first wire, extending from the second to the fifth metacarpals. Both the wires were connected to a circular external fixator with wire clamps attached to the testing system. This custom-designed testing system allowed both the ulna and hand to be securely fixed, enabling isolated measurement of the dorsal translation of the radius.

To ensure the independence of each testing stage and minimize potential carryover effects, after each stage, the specimen was returned to its neutral position, and a resting period was introduced to allow any residual tension or effects from the previous stage to dissipate. Additionally, the ligamentous and bony structures were inspected

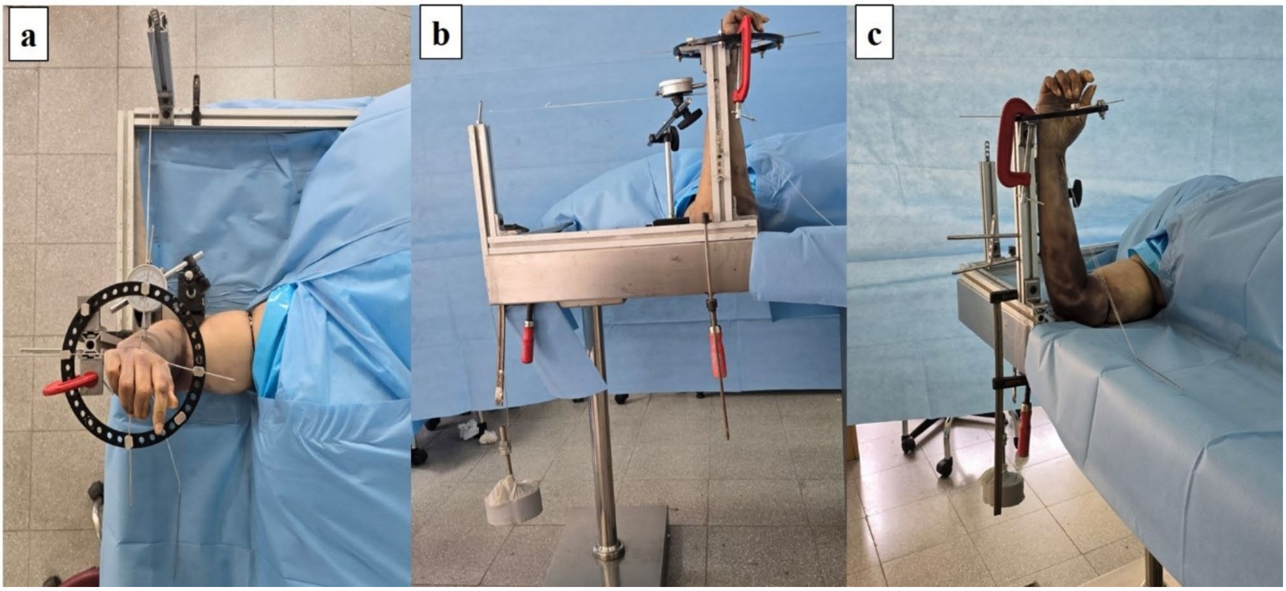

Fig. 1 Testing system: (**a**) view from above, (**b**) view from the side, (**c**) view from the front

between stages to confirm that no significant wear or damage occurred, which could have affected the outcomes of subsequent stages.

Finally, a 1 cm skin incision was made over Lister's tubercle, extending through the deep layers to the periosteum of the radius. A bone tunnel was then created through this incision, from the dorsal to volar plane, using a 2.7 mm cannulated drill, perpendicular to the horizontal axis. A suture button was passed through the tunnel from dorsal to volar. Once the suture button was secured to the volar cortex of the radius, the dorsal threads were tied to a fishing line, which was attached to the test system. To generate dorsal translation of the radius relative to the ulna, a standard load of 20 N was applied to the fishing line, chosen based on a previous biomechanical study showing that this magnitude approximates the physiological loads on the DRUJ [18].

The load was gradually released, and the dorsal translation was measured using a comparator while the maximum force was applied. Tests were conducted with the forearm in neutral, 45° pronated, and 45° supinated positions.

The study was divided into five stages: stable DRUJ, unstable DRUJ, unstable DRUJ repaired with a single transverse suture button construct, unstable DRUJ repaired with a double (transverse+oblique) suture button construct, and unstable DRUJ repaired with a single oblique suture button construct. A schematic overview of each stage is presented in Fig. 2 (a–e). Measurements were performed three times under a 20 N load, and the average values were recorded after each stage.

Step 1

In the first stage, measurements were obtained with a stable DRUJ. The initial measurements were taken with the forearm in a neutral position (Fig. 3a). Subsequently, the wire holders on the circular external fixator were released, and the forearm was positioned at 45° pronation (Fig. 3b). The hand was secured to the circular external fixator using wire holders, and measurements were repeated. After releasing the wire holders again, the forearm was placed in 45° supination (Fig. 3c), and the hand was resecured for the final measurements in this stage.

Step 2

After measuring the dorsal translation of the radius with a stable DRUJ, the joint was intentionally destabilized (Fig. 4). An incision was made between the fifth and sixth extensor compartments, over the DRUJ. The fifth compartment was opened, and the extensor digiti minimi tendon was retracted. A capsulotomy was performed to access the DRUJ, after which both the volar and dorsal radioulnar ligaments, as well as the articular disc, were transected. The extensor carpi ulnaris subsheath was detached from the ulna, and the DOB was incised. Translational measurements were then repeated.

Prior to the placement of the suture button constructs, specific measures were taken to ensure consistency across all specimens, as described below. The suture button constructs were placed by a single experienced orthopedic surgeon to ensure consistency across the specimens. During each procedure, the tension applied to the construct was carefully controlled to prevent overtightening, which could lead to excessive tension on the soft tissues or affect joint mobility. Visual and manual

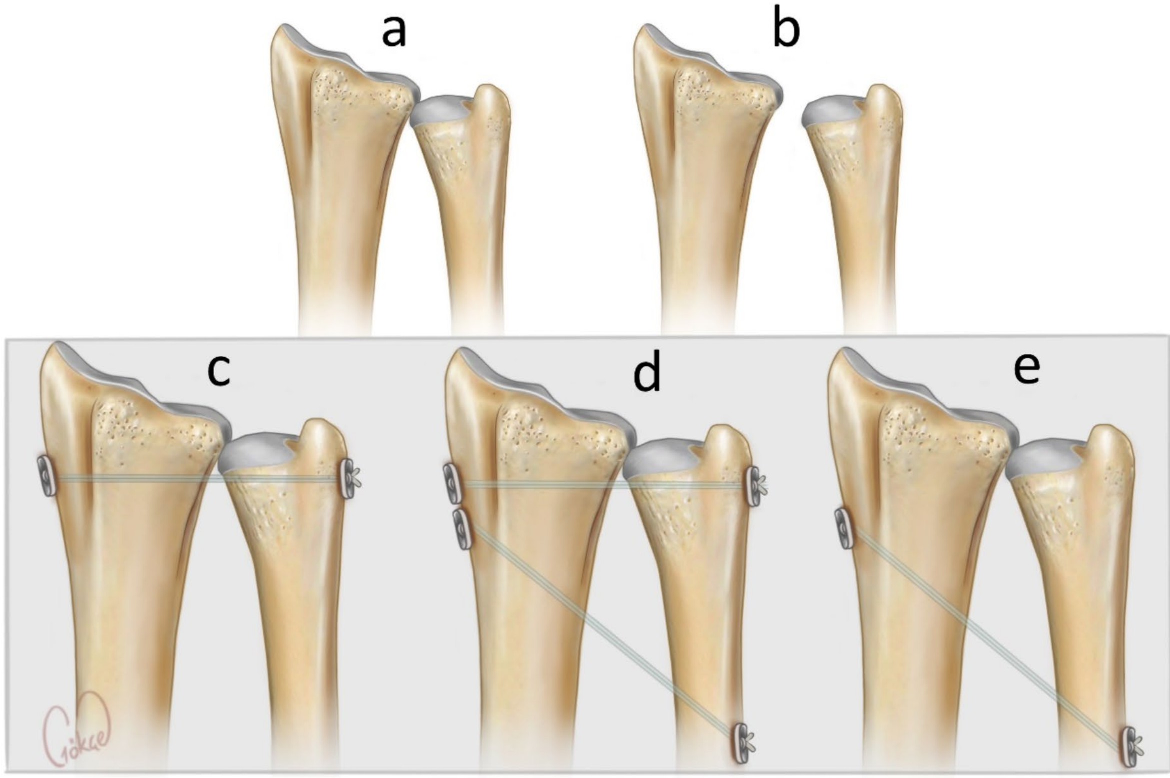

Fig. 2 A schematic overview of the study stages: (**a**) Stable DRUJ; (**b**) Unstable DRUJ; (**c**) Unstable DRUJ repaired with a single transverse suture button construct; (**d**) Unstable DRUJ repaired with a double (transverse + oblique) suture button construct; (**e**) Unstable DRUJ repaired with a single oblique suture button construct

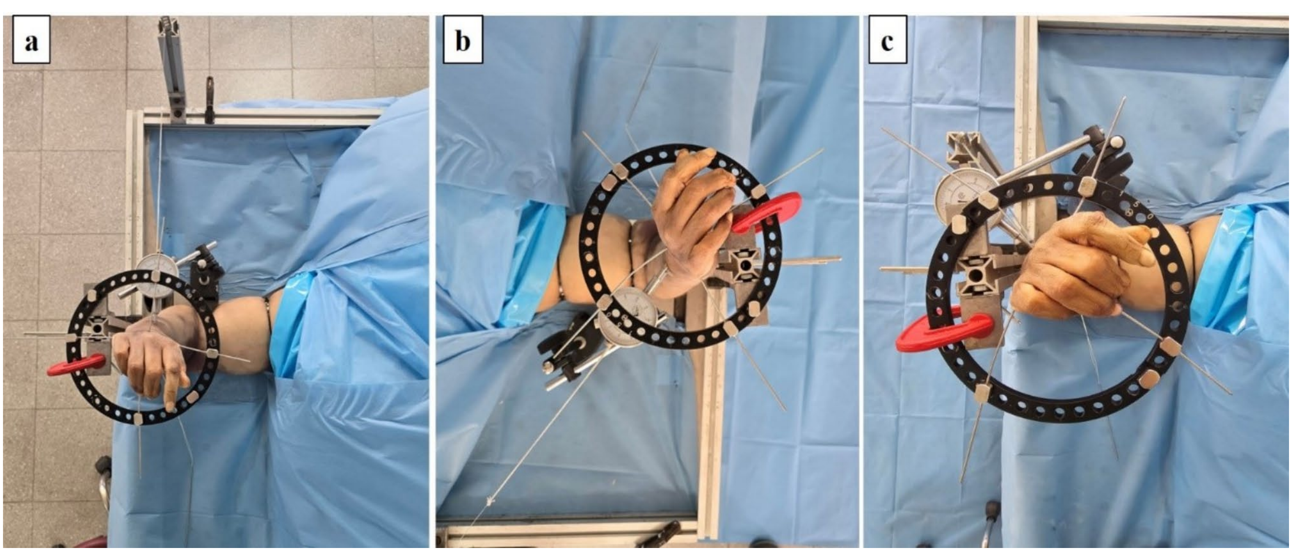

Fig. 3 Views of the forearm in different positions within the testing system: (**a**) neutral position; (**b**) 45^0 pronation; (c) 45^0 supination

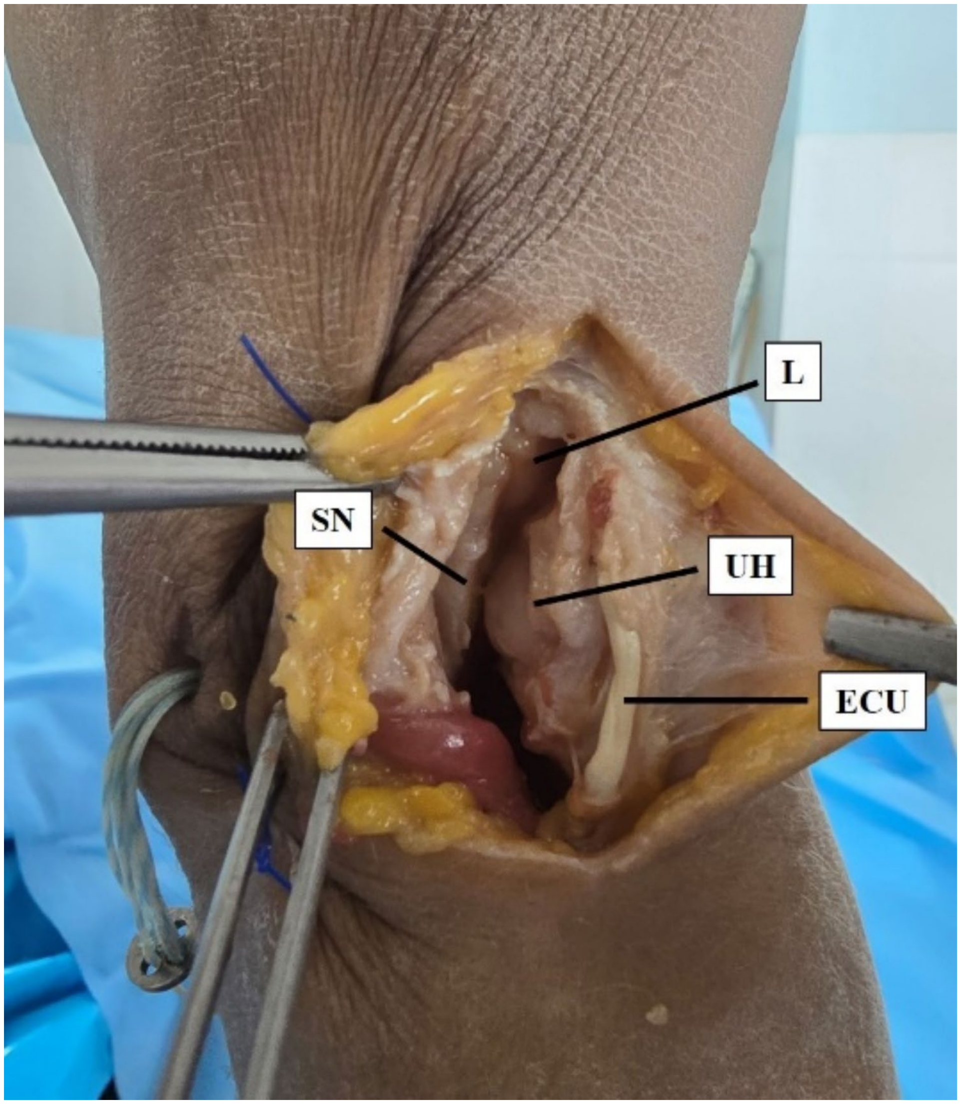

Fig. 4 Dorsal view of the DRUJ. UH: ulnar head, SN: sigmoid notch, L: lunatum, ECU: extensor carpi ulnaris

assessments were used to ensure that the tension was appropriate for maintaining joint stability without over-constraining the joint.

Step 3

In this stage, the disrupted DRUJ was repaired using a single transverse suture button (Fig. 5a). A 1 cm incision was made over the ulna, approximately 1 cm proximal to the ulnar head, followed by sharp dissection to the periosteum. A 1.2 mm K-wire was passed transversely from the ulna to the radius. Over this wire, a 2.7 mm cannulated drill was used to create a bone tunnel in both bones. The suture button was carefully passed through both tunnels to the far surface of the radius. The buttons were then anchored to the cortex, and the sutures were manually tightened while the forearm was held in a neutral position. The suture button construct was secured with four square knots, with the DRUJ in a reduced position. Translational measurements were then repeated.

Step 4

An oblique suture button construct was added to the specimens that had been treated with the transverse suture button, resulting in a double (transverse+oblique) suture button repair of the disrupted DRUJ (Fig. 5b-c). A 1 cm incision was made over the ulna, approximately 5 cm proximal to the ulnar head, followed by sharp dissection to the periosteum. A tibial tunnel guide was positioned on the ulnar cortex and adjusted to a 45 ° angle, targeting the radial insertion point. Using this guide, a 1.2 mm K-wire was passed obliquely from the ulna to the radius, and a 2.7 mm cannulated drill was used to create a bone tunnel. The suture button was passed through both tunnels and anchored to the cortex. The sutures

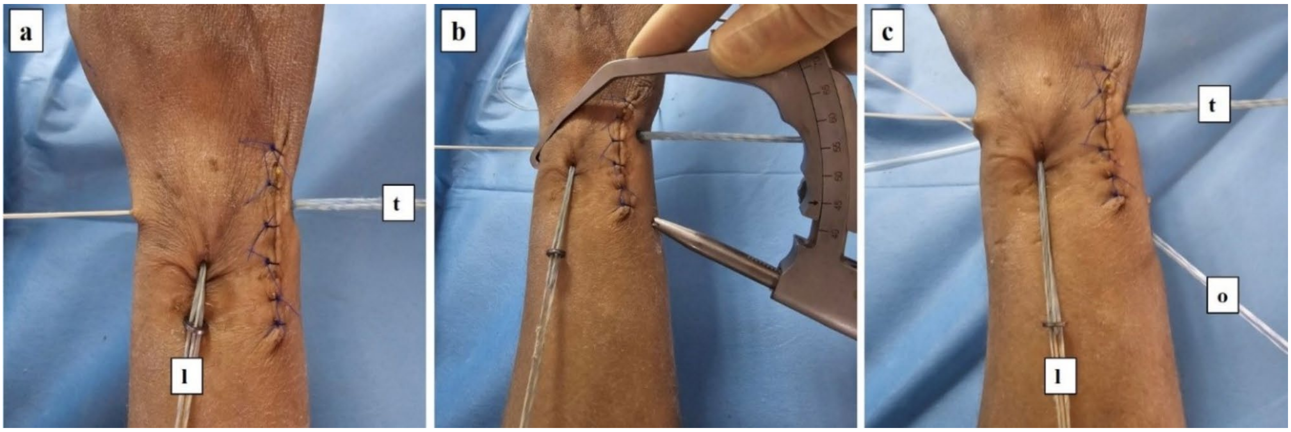

Fig. 5 Dorsal view of the reconstructed DRUJ with different suture button constructs: (**a**) Unstable DRUJ repaired with a single transverse suture button construct; (**b**) The tibial tunnel guide device was placed on the ulnar cortex and adjusted to a 45° angle; (**c**) Unstable DRUJ repaired with a double (transverse + oblique) suture button construct. (t: transverse suture button, o: oblique suture button, l: loading suture button)

Table 1 Mean dorsal translation values by stage and position (mm)

DRUJ[a]	Neutral	Pronation	Supination
Stable	1.98 ± 0.27 (1.57–2.37)	1.47 ± 0.22 (1.23–1.89)	1.58 ± 0.21 (1.23–1.98)
Unstable	4.16 ± 0.75 (3.23–5.25)	2.93 ± 0.55 (2.35–3.78)	3.28 ± 0.79 (2.24–4.23)
Unstable: Transverse SBC[b]	2.13 ± 0.23 (1.81–2.53)	2.04 ± 0.28 (1.44–2.26)	2.10 ± 0.15 (1.87–2.29)
Unstable: Transverse + Oblique SBC[b]	2.01 ± 0.25 (1.64–2.35)	1.57 ± 0.15 (1.39–1.88)	1.56 ± 0.13 (1.39–1.75)
Unstable: Oblique SBC[b]	2.14 ± 0.23 (1.89–2.57)	1.99 ± 0.16 (1.77–2.23)	2.12 ± 0.18 (1.86–2.44)

[a]DRUJ, Distal radioulnar joint; [b]SBC: Suture button construct; translation (mm)

were manually tightened with the forearm in a neutral position, and the construct was secured with four square knots. Translational measurements were again repeated.

Step 5

The suture button construct from Step 3 was removed using a scalpel, leaving the DRUJ stability dependent solely on the oblique suture button construct inserted at a 45° angle. The measurements performed in the first stage were then repeated in cadavers with a repaired DRUJ using a single oblique suture button.

Statistical analysis

Dorsal translation of the radius relative to the ulna was measured in neutral, pronation, and supination positions for each stage. Three measurements were taken at each position by the same observer, and mean values were used for analysis. Statistical analyses were performed using SPSS software (version 20.0; IBM Corp., Armonk, NY, USA). Descriptive statistics are presented as means, standard deviations, and ranges. The Shapiro–Wilk test was applied to verify normal distribution, and the mean values across different stages for the nine cadavers were compared using one-way ANOVA. Effect sizes (Partial Eta Squared) were calculated to assess the magnitude of the observed effects. Statistical significance was set at $p<0.05$. The most significant results are presented in the corresponding tables.

Results

The mean dorsal translation values of the radius relative to the ulna for each DRUJ position and stage are summarized in Table 1.

The dorsal translation of the radius relative to the ulna increased significantly in the unstable DRUJ compared to the stable DRUJ ($p<0.001$ for all three positions; Table 2).

Following reconstruction with the suture button constructs, dorsal translation in the neutral position returned to baseline values for the transverse ($p=0.930$), oblique ($p=0.915$), and transverse + oblique ($p=1.000$) constructs (Table 2). No statistically significant difference in mean dorsal translation was observed between the unstable DRUJ reconstructed with the transverse and oblique suture button constructs and the stable DRUJ in the neutral position ($p=1.000$), as well as in pronation ($p=0.963$) and supination ($p=1.000$) (Table 2).

Table 2 Statistical comparison of dorsal translation between stages

DRUJ [a]	*P* value		
	Neutral	Pronation	Supination
Stable vs. Unstable	< 0.001	< 0.001	< 0.001
Stable vs. Unstable: Transverse SBC[b]	0.930	**0.003**	**0.048**
Stable vs. Unstable: Transverse + Oblique SBC[b]	1.000	0.963	1.000
Stable vs. Unstable: Oblique SBC[b]	0.915	**0.008**	**0.038**
Unstable vs. Unstable: Transverse SBC[b]	**< 0.001**	**< 0.001**	**< 0.001**
Unstable vs. Unstable: Transverse + Oblique SBC[b]	**< 0.001**	**< 0.001**	**< 0.001**
Unstable vs. Unstable: Oblique SBC[b]	**< 0.001**	**< 0.001**	**< 0.001**
Unstable: Transverse vs. Unstable: Oblique SBC[b]	1.000	0.998	1.000
Unstable: Transverse vs. Unstable: Transverse + Oblique SBC[b]	0.965	**0.020**	**0.025**
Unstable: Oblique vs. Unstable: Transverse + Oblique SBC[b]	0.955	**0.044**	**0.028**

[a]DRUJ, Distal radioulnar joint; [b]SBC: Suture button construct. Bold values indicate statistical significance

Table 3 ANOVA results and effect sizes for DRUJ positions

DRUJ [a] position	Sum of Squares (Between)	Sum of Squares (Error)	F-value	*p*-value	Partial Eta Squared
Neutral	31.683	6.396	49.535	< 0.001	0.832
Pronation	11.959	3.820	31.305	< 0.001	0.758
Supination	17.580	5.907	29.762	< 0.001	0.749

[a]DRUJ, Distal radioulnar joint

However, when the unstable DRUJ was reconstructed with either the transverse or oblique suture button constructs alone, there was no significant difference in mean dorsal translation compared to the stable DRUJ in the neutral position, but significant differences were noted in pronation and supination (Table 2). These results indicate that reconstruction of the unstable DRUJ using the transverse and oblique suture button constructs together provides a more stable joint than using either construct individually.

The differences in mean dorsal translation measured in the neutral, pronation, and supination positions between the unstable DRUJ and the DRUJ reconstructed with the transverse, transverse + oblique, and oblique suture button constructs were all statistically significant ($p<0.001$ for all three techniques; Table 2), suggesting that each method is effective in reconstructing an unstable DRUJ.

After reconstruction, the differences in mean dorsal translation measured in the neutral position among the three techniques were not statistically significant ($p=1.000$ for transverse vs. oblique, $p=0.965$ for transverse vs. transverse + oblique, and $p=0.955$ for oblique vs. transverse + oblique, Table 2). This indicates that none of the techniques was superior to the others in the neutral position. However, reconstruction of the unstable DRUJ using the transverse and oblique suture button constructs significantly reduced mean dorsal translation in pronation ($p=0.020$ for transverse + oblique vs. transverse, $p=0.044$ for transverse + oblique vs. oblique) and supination ($p=0.025$ for transverse + oblique vs. transverse, $p=0.028$ for transverse + oblique vs. oblique) compared to reconstruction using either the transverse or oblique suture button constructs alone. This finding suggests that the combined transverse + oblique suture button technique provides greater stability in pronation and supination than either construct used individually.

In addition to the statistical significance observed across all positions ($p<0.001$ for neutral, pronation, and supination), effect sizes (Partial Eta Squared) were calculated to assess the practical significance of the findings. The Partial Eta Squared values were 0.832 for the neutral position, 0.758 for the pronation position, and 0.749 for the supination position, indicating large effects across all conditions (Table 3). These results suggest that the DRUJ stages had a substantial impact on dorsal translation in all positions.

Discussion

In our cadaveric model of surgically created unstable DRUJ, reconstruction using the double suture button construct (transverse + oblique) restored the dorsal translation of the radius to baseline values. However, when the single (either transverse or oblique) was used, the dorsal translation returned to baseline only in the neutral position and did not fully normalize in pronation and supination. This suggests that the double-suture button construct offers superior stability compared to the single-suture button construct, particularly in pronation and supination. Our findings clearly demonstrate that the double-suture button construct provides optimal stability in cases of unstable DRUJ, confirming its superiority over the single-suture button construct.

The primary stabilizers of the DRUJ include the bone architecture of the sigmoid notch of the radius and the ulnar head, along with surrounding soft tissues [19]. The TFCC is the main soft tissue stabilizer, but when the TFCC is damaged or the ulna head is removed, the distal IOM becomes an important secondary stabilizer [11, 20, 21]. The strongest portion of the distal IOM, known as the DOB, originates near the proximal border of the pronator quadratus muscle and attaches to the dorsal rim of the ulnar notch [22, 23]. The prevalence of DOB ranges from 29 to 70%, and studies have shown that its presence significantly improves DRUJ stability [24, 25].

In a biomechanical study, Kitamura et al. found that DRUJ stability was greater in specimens with a DOB compared to those without it [20]. As a result, DOB reconstruction has garnered increasing attention, particularly in cases of chronic DRUJ instability. Recent biomechanical and clinical studies have underscored the importance of DOB reconstruction in enhancing DRUJ stability [13, 14, 16, 17, 26, 27]. Similarly, a recent systematic review has demonstrated that DOB reconstruction significantly enhances DRUJ stability, with improvements nearly equivalent to natural stability [28]. In line with these findings, Verbeek et al. reported favorable long-term outcomes in patients treated with DOB reinforcement, highlighting significant functional improvements and a relatively low failure rate at a median follow-up of 82 months [29].

In a study by de Vries et al., DRUJ instability was induced in five fresh-frozen cadaveric specimens, followed by DOB reconstruction with a single suture button construct [16]. Dorsal translation of the radius was measured in neutral, 45° pronation, and 45° supination using a custom testing device. After reconstruction, they found that the dorsal translation returned to baseline values across all positions [16].

In contrast, our study showed that dorsal translation in the unstable DRUJ reconstructed with a single suture button (transverse or oblique) only returned to baseline in the neutral position and not in the pronation and supination positions. This discrepancy may be due to differences in stabilization techniques. In our setup, the hand was secured to a circular external fixator using two perpendicular K-wires, allowing us to isolate the dorsal translation of the radius while keeping both the ulna and hand immobile. This arrangement minimized incorrect measurements by preventing dorsal hand translation.

Furthermore, our results demonstrated that using a double suture button construct (transverse+oblique) restored dorsal translation to baseline across all positions, suggesting it provides greater DRUJ stability compared to the single suture button construct (transverse or oblique).

In the study by de Vries et al., the mean dorsal translation in a stable DRUJ was 2.88±0.77 mm in neutral, 1.59±0.95 mm in pronation, and 2.42±0.71 mm in supination [16]. For the unstable DRUJ, these values increased to 6.61±0.60 mm in neutral, 2.74±1.69 mm in pronation, and 4.56±0.87 mm in supination [16]. After reconstruction with the single oblique suture button, the translation returned to 3.25±0.77 mm in neutral, 1.48±0.60 mm in pronation, and 2.80±1.00 mm in supination [16]. The results from our study align with those of de Vries et al., though our measurements were slightly lower, possibly due to differences in our custom test system, which allowed isolated measurement of dorsal radius translation. Differences in cadaveric demographic characteristics, such as age and anatomical variations, may also have contributed to this slight variation.

As described above, de Vries et al. outlined a minimally invasive technique for stabilizing the DRUJ in cadaveric specimens using a percutaneous single-suture button construct placed along the DOB of the IOM [16]. Subsequently, Igbal et al. reported achieving DRUJ stability in a patient with chronic DRUJ instability using a similar approach and recommended it for both acute and chronic dislocations [27].

Liu et al. published results from a study of six patients treated with a single transverse suture button construct [30]. The researchers reported that this new suspension fixation method, using button plates for the surgical reconstruction of a DRUJ dislocation, was simple, minimally invasive, and provided DRUJ stability without requiring intra- or extra-articular ligament reconstruction [30]. Additionally, they observed that the method facilitated early functional exercise and resulted in satisfactory postoperative recovery [30].

Similarly, Kokly et al. reported the successful treatment of a patient with acute unstable DRUJ dislocation using a single transverse suture button construct for extra-articular stabilization [31]. In another case series, Hayward et al. successfully treated five patients with chronic DRUJ instability using the same single transverse suture button construct, demonstrating that this method offers a viable solution to a complex pathology [32].

Hsiao et al. treated three patients with acute DRUJ instability by placing a suture button construct along the direction of the DOB, achieving sufficient stability [33]. However, they recommended using a tendon allograft or a knotless suspension system due to complications with the suspension system, such as irritation from the knot plate and the inability to achieve adequate tension [33].

In patients with chronic DRUJ instability, TFCC repair is often not feasible, and TFCC reconstruction can be challenging due to the risk of ulnar head fracture during tunnel creation, particularly when accompanied by ulnar styloid fractures [13]. In such cases, DOB reconstruction using a single suture button construct may be performed [16]. However, in some chronic cases, subluxation may persist during pronation and supination [17].

In these cases, Satria et al. performed a second suture button construct perpendicular to the long axis of the ulna and radius, reporting full stability in all directions of the DRUJ [17]. Satria et al. emphasized that for chronic cases, a single suture button construct may not provide sufficient DRUJ stability, and additional distal radioulnar ligament with a second suture button construct is necessary [17].

The statistical results of our biomechanical study demonstrate that reconstructing an unstable DRUJ with double (transverse+oblique) suture button constructs significantly reduces dorsal translation in neutral, pronation, and supination positions, providing greater stability than reconstruction with a single (transverse or oblique) suture button construct. This suggests that double-suture button construct offers optimal stability for unstable DRUJ. In line with this, Rigó et al. found that newer techniques like the DX Swivelock provided superior initial stability compared to traditional methods, such as the Adams-Berger reconstruction [34]. This finding aligns with our results, where the double-suture button construct demonstrated enhanced stability and potential for early mobilization, highlighting the advantages of modern fixation techniques in restoring DRUJ function [34].

Additionally, the inclusion of effect sizes (Partial Eta Squared) provides a deeper understanding of the practical significance of our findings. While statistical significance confirms the existence of differences between groups, effect sizes quantify the magnitude of these differences, offering insights into their real-world relevance. The large effect sizes observed across all positions (neutral, pronation, and supination) suggest that the differences in dorsal translation between the double and single suture button constructs are not only statistically significant but also clinically meaningful. This highlights the potential of the double-suture button construct to offer more robust stability in clinical practice, contributing to better functional outcomes for patients with DRUJ instability. Future studies involving live subjects are needed to validate the practical benefits observed in this biomechanical model.

As de Vries et al. noted, while reconstructing an unstable DRUJ with a double suture button construct is minimally invasive, it can lead to complications [16]. Over-tightening the suture buttons may restrict wrist movement and increase pressure on the sigmoid notch. In addition, bone tunnel creation carries a risk of damaging the sensory branches of the ulnar and radial nerves, as well as causing fractures of the radial and ulnar. The risk of fracture is particularly high when using a double-suture button construct due to the proximity of the bone tunnels in the distal radius. Therefore, careful use of fluoroscopy during tunnel creation is critical to maintain at least a 1 cm distance between the tunnels in the distal radius. Furthermore, there is a theoretical risk of radioulnar synostosis as the tunnels pass between the radius and ulna [16]. Moreover, wear and tear over time may cause the buttons to break, necessitating their removal through minimally invasive incisions. Prominent knots on the ulnar side may also cause pain, which can be mitigated by using a knotless suture button construct.

The increased surface area of the double suture button construct may elevate the risk of implant irritation, which is a common concern in clinical practice. This tradeoff between enhanced stability and the risk of irritation should be carefully considered when selecting the appropriate construct for each patient. While using a single construct may reduce irritation, further clinical studies are needed to confirm this without compromising joint stability [16].

In contrast to suture button constructs, tendon allograft techniques, such as those using the extensor carpi radialis longus (ECRL) or extensor carpi radialis brevis (ECRB) tendons, have been introduced as viable alternatives for DRUJ stabilization, particularly in cases where TFCC repair is not feasible or has failed [3, 8, 35]. The Adams procedure, which focuses on distal radioulnar ligament reconstruction using palmaris longus or ECRB tendon grafts, is another commonly employed technique with comparable functional outcomes [3, 8]. Although tendon allograft techniques offer the advantage of preserving soft tissue integrity and minimizing the risk of implant irritation, they are generally more invasive compared to suture button constructs. The suture button technique, being minimally invasive, provides the benefit of fewer complications related to soft tissue dissection [3, 8, 16]. Spies et al. demonstrated the long-term effectiveness of tendon grafts in the Adams procedure but also highlighted the associated complications [36]. In contrast, our study achieved similar stability using the double-suture button construct without the need for tendon harvesting, thereby reducing procedural invasiveness. Similarly, Tathe et al. described a novel technique for DRUJ reconstruction that avoided tendon graft morbidity, offering faster recovery and shorter operative times compared to traditional methods [37]. Nevertheless, further comparative studies between suture button constructs and tendon allograft methods, including the Adams procedure and DOB reconstructions, are necessary to fully evaluate their long-term efficacy in terms of stability, patient comfort, and minimizing complications.

While this study provides valuable biomechanical insights into the stabilization of the DRUJ using double suture button constructs, it is important to acknowledge the limitations of using cadaveric specimens. Cadaveric models allow for controlled testing environments but do not fully replicate the dynamic properties of living tissues, including muscle tone, healing capacity, and patient-specific variability. As such, the results presented here should be interpreted with caution when translating to clinical practice. Future studies should focus on validating these findings through in vivo models and clinical trials, where long-term stability, functional outcomes, and patient-reported pain levels can be assessed. These steps will be crucial for determining the true clinical efficacy of double suture button constructs in treating DRUJ instability.

This study has several limitations. First, as a cadaveric study, it lacks clinical data correlating the reduction in dorsal translation with patients' clinical outcomes. Although the double-suture button construct significantly reduced dorsal translation in all three positions compared to the single-suture button construct, clinical studies are needed to determine the clinical relevance of these findings. Existing literature reports successful outcomes with the single-suture button construct in both acute and chronic DRUJ instability [27, 30–33]. Only one case report indicates that a second suture button was necessary to achieve sufficient stability [17]. It is essential to assess the adequacy of stability during surgery, and if needed, a second suture button may be a logical addition. Our study demonstrates that the double-suture button construct provides optimal stability, forming a basis for future clinical studies.

Another limitation is the relatively small sample size, which is often a constraint in cadaveric studies due to limited specimen availability. However, despite this limitation, our study was able to achieve statistically significant results that support the validity of our findings. Future studies with larger sample sizes would be beneficial in further confirming these results and enhancing the generalizability of the conclusions. Additionally, the advanced age of the cadaveric specimens and the use of both limbs in four of the five cadavers may have reduced variability in the results. However, this can be seen as a strength, as it eliminated anatomical differences and potentially increased the study's power.

In our study, standardizing the force applied to the radius to measure dorsal translation and repeating each measurement three times minimized the potential for error, thereby strengthening our findings.

Conclusions

In conclusion, our study demonstrates the superiority of the double-suture button construct over the single-suture button construct in achieving optimal DRUJ stability. Although the cadaveric study has limitations, such as the absence of clinical data and a small sample size, it provides a strong foundation for future clinical research. Our findings contribute to the development of more effective and reliable treatment methods for patients with DRUJ instability.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13018-024-05151-7.

Supplementary Material 1

Author contributions

S.Ç. contributed to manuscript preparation, data analysis, and interpretation, was involved in the design of the study, provided critical revisions, and approved the final manuscript. A.I.K. assisted in manuscript preparation, contributed to data analysis and interpretation, played a role in study design, provided critical revisions, and approved the final manuscript. R.B.H. participated in manuscript preparation and data analysis, was responsible for final approval of the manuscript, and contributed to study design and data interpretation. G.Z. was involved in critical revisions of the manuscript, provided final approval, and contributed to study design and data interpretation. A.K. provided critical revisions, gave final approval of the manuscript, and contributed to study design and data interpretation.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethical approval

Approval from the ethics committee was obtained (Approval number: 1607).

Conflict of interest

None of the authors received any financial support that could be perceived as a potential conflict of interest related to the manuscript or its submission.

Competing interests

The authors declare no competing interests.

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