

A Biomechanical Comparison Between 2.7mm versus 3.5mm LC-DCP in The Treatment of Diaphyseal Both-Bone Forearm Fractures: Is Mini-Fragment All We Need?

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INTRODUCTION:

The purpose of this study is to investigate whether 2.7mm plates, or a combination of 2.7mm and 3.5mm plates, demonstrate adequate biomechanical strength for use in adult both bone forearm fractures.

METHODS: Midshaft volar to dorsal osteotomies at the distal third diaphysis of both the radius and ulna were created using an electric saw on sawbones models (AO/OTA classification: 2RA/2U2A). Ten sawbone models were randomly assigned to the following constructs: (1) 3.5mm and 3.5mm, (2) 3.5mm and 2.7mm, (3) 2.7mm and 3.5mm, (4) 2.7mm and 2.7mm LCDCP across the radius and ulna, respectively. Electronic inclinometers were attached to each fragment 1cm proximal and 1 cm distal to the osteotomy site. Mechanical testing was conducted using an electrodynamic Acumen 3 AT axial torsion testing system to apply bending, torsional, and axial loading.

RESULTS:

The constructs were significantly different across compression, bending and torsion (ANOVA $p=0.029$, $p=0.041$, $p=0.006$, respectively). Differences in Torsion were statistically significant across both Levene's test $p=0.002$ and Welch's $p=0.015$. Post Hoc Tukey for compression resulted in a significant mean force difference of 0.402 (Nm) between 2.7R 2.7U vs 3.5R 2.5U ($p=0.017$). Post Hoc Tukey for bending resulted in a significant mean force difference of 8325.06 (Nm) between 3.5R 2.7U vs 3.5R 3.5U. Lastly, Post Hoc Tukey for torsion resulted in significant mean force differences of 0.999 (Nm) for 2.7R 2.7U vs 3.5R 3.5U ($p=0.004$) and 0.761 (Nm) for 2.7R 3.5U vs 3.5R 3.5U $p=0.039$.

DISCUSSION AND CONCLUSION:

As expected, 3.5mm plate constructs resulted in significantly increased stiffness and stability across compression, bending, and torsion forces. However, when 2.7mm plates were used in conjunction with 3.5mm plates, parameters were very similar to that of 3.5mm constructs alone. All 2.7mm constructs, while weaker compared to 3.5mm constructs, were still significantly higher than native bone parameters reported in the literature. While 3.5mm LC-DCP remains the standard in the treatment of diaphyseal forearm fractures, utilizing 2.7mm LC-DCP, especially in smaller stature patients, may also offer enough biomechanical stability for clinical success.

Table 1A. Compression Stiffness Analysis								
Group	Mean Nm	SD	Levene Stat	Levene Sig.	ANOVA Sum of Squares	ANOVA Sig.	Welch Stat.	Welch Sig.
2.7R 2.7U	0.356	0.153	2.319	0.092	0.826	0.029	-	-
2.7R 3.5U	0.504	0.251						
3.5R 2.7U	0.533	0.227						
3.5R 3.5U	0.758	0.434						
Table 1B. Compression Post Hoc Tukey Honestly Significant Difference								
Group A	Group B	Mean Difference (A - B)	Std. Error	Sig.	Lower Bound	Upper Bound	95% CI	
2.7R 2.7U	2.7R 3.5U	-0.148	0.127	0.657	-0.492	0.196		
	3.5R 2.7U	-0.177	0.127	0.518	-0.521	0.167		
	3.5R 3.5U	-0.402	0.127	0.017	-0.746	-0.058		
2.7R 3.5U	2.7R 2.7U	0.148	0.127	0.657	-0.196	0.492		
	3.5R 2.7U	-0.029	0.127	0.996	-0.373	0.315		
	3.5R 3.5U	-0.254	0.127	0.211	-0.598	0.090		
3.5R 2.7U	2.7R 2.7U	0.177	0.127	0.518	-0.167	0.521		
	2.7R 3.5U	0.029	0.127	0.996	-0.315	0.373		
	3.5R 3.5U	-0.225	0.127	0.308	-0.569	0.119		
3.5R 3.5U	2.7R 2.7U	0.402	0.127	0.017	0.058	0.746		
	2.7R 3.5U	0.254	0.127	0.211	-0.090	0.598		
	3.5R 2.7U	0.225	0.127	0.308	-0.119	0.569		
Table 1C. Bending Stiffness Analysis								
Group	Mean Nm	SD	Levene Stat	Levene Sig.	ANOVA Sum of Squares	ANOVA Sig.	Welch Stat.	Welch Sig.
2.7R 2.7U	21783.2	13835.66	1.167	0.328	795458433.17	0.041	-	-
2.7R 3.5U	23716.4	7021.48						
3.5R 2.7U	20390.3	9581.63						
3.5R 3.5U	28715.4	5966.79						

Table 1D. Bending Post Hoc Tukey Honestly Significant Difference								
Group A	Group B	Mean Difference (A - B)	Std. Error	Sig.	Lower Bound	Upper Bound	95% CI	
2.7R 2.7U	2.7R 3.5U	-1933.11	3033.71	0.920	-9902.1	6035.84		
	3.5R 2.7U	1392.83	3033.71	0.968	-6576.1	9361.84		
	3.5R 3.5U	-6932.17	3033.71	0.111	-14901.1	1036.78		
2.7R 3.5U	2.7R 2.7U	1933.11	3033.71	0.920	-6035.84	9902.06		
	3.5R 2.7U	3245.01	3033.71	0.693	-4642.94	11294.96		
	3.5R 3.5U	-4999.06	3033.71	0.358	-12968.0	2969.89		
3.5R 2.7U	2.7R 2.7U	-1392.89	3033.71	0.968	-9361.84	6576.06		
	2.7R 3.5U	-3326.01	3033.71	0.693	-11295.0	4642.94		
	3.5R 3.5U	-8325.06	3033.71	0.037	-16294.0	-356.115		
3.5R 3.5U	2.7R 2.7U	6932.17	3033.71	0.111	-1036.78	14901.12		
	2.7R 3.5U	4999.06	3033.71	0.358	-2969.9	12968.01		
	3.5R 2.7U	8325.06	3033.71	0.037	356.115	16294.01		
Table 1E. Torsion Stiffness Analysis								
Group	Mean Nm	SD	Levene Stat	Levene Sig.	ANOVA Sum of Squares	ANOVA Sig.	Welch Stat.	Welch Sig.
2.7R 2.7U	1.7499	0.2296	6.158	0.002	5.454	0.006	4.585	0.015
2.7R 3.5U	1.9884	0.5522						
3.5R 2.7U	2.1205	0.4722						
3.5R 3.5U	2.7490	0.9475						
Table 1F. Torsion Post Hoc Tukey Honestly Significant Difference								
Group A	Group B	Mean Difference (A - B)	Std. Error	Sig.	Lower Bound	Upper Bound	95% CI	
2.7R 2.7U	2.7R 3.5U	-0.238	0.272	0.817	-0.971	0.494		
	3.5R 2.7U	-0.379	0.272	0.512	-1.111	0.354		
	3.5R 3.5U	-0.999	0.272	0.004	-1.731	-0.267		
2.7R 3.5U	2.7R 2.7U	0.238	0.272	0.817	-0.493	0.971		
	3.5R 2.7U	-0.140	0.272	0.955	-0.872	0.592		
	3.5R 3.5U	-0.761	0.272	0.039	-1.493	-0.028		
3.5R 2.7U	2.7R 2.7U	0.379	0.272	0.512	-0.354	1.111		
	2.7R 3.5U	0.140	0.272	0.955	-0.592	0.872		
	3.5R 3.5U	-0.620	0.272	0.121	-1.353	0.112		
3.5R 3.5U	2.7R 2.7U	0.999	0.272	0.004	0.267	1.731		
	2.7R 3.5U	0.761	0.272	0.039	0.028	1.493		
	3.5R 2.7U	0.621	0.272	0.121	-0.112	1.353		