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Supplementary information

Optimizing mechanical properties of braided nitinol stents through geometric parameter engineering: Insights from experiments and finite element analysis

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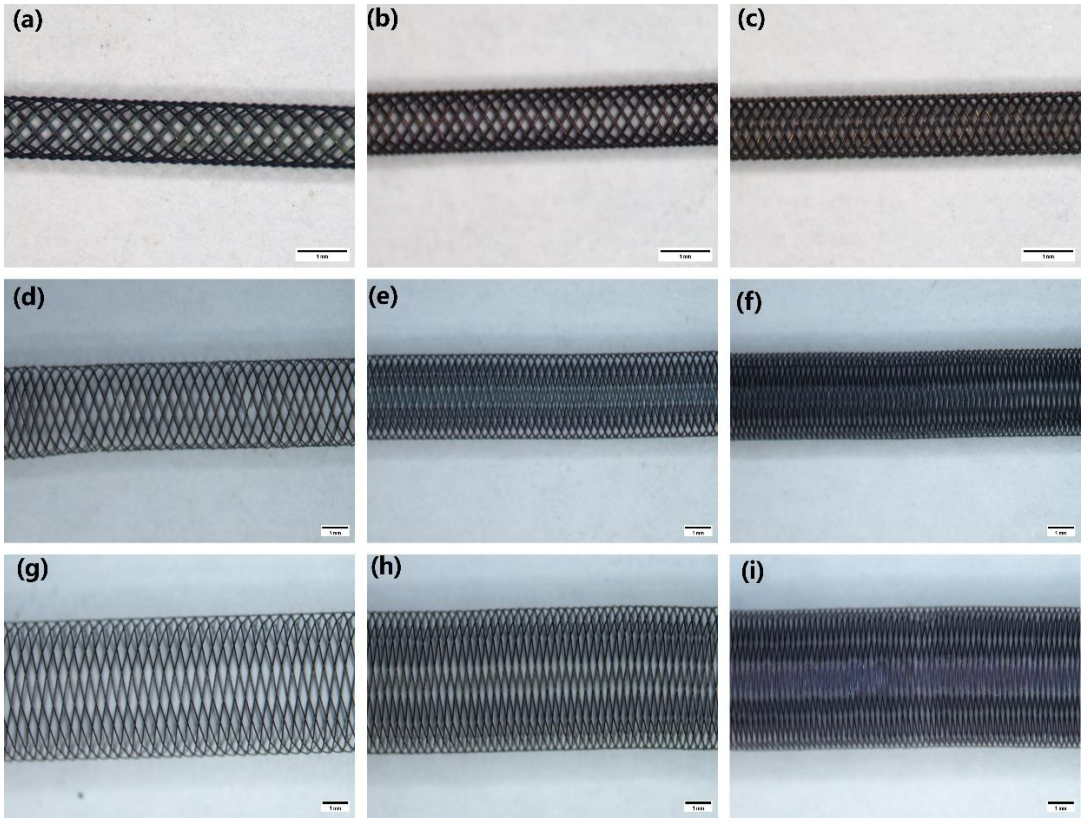

Figure S1. Photographs of 16/1-1 catheters. (a) 1 mm 60PPI; (b) 1 mm 90PPI; (c) 1 mm 120PPI; (d) 3 mm 60PPI; (e) 3 mm 90PPI; (f) 3 mm 120PPI; (g) 5 mm 60PPI; (h) 5 mm 90PPI; (i) 5 mm 120PPI.

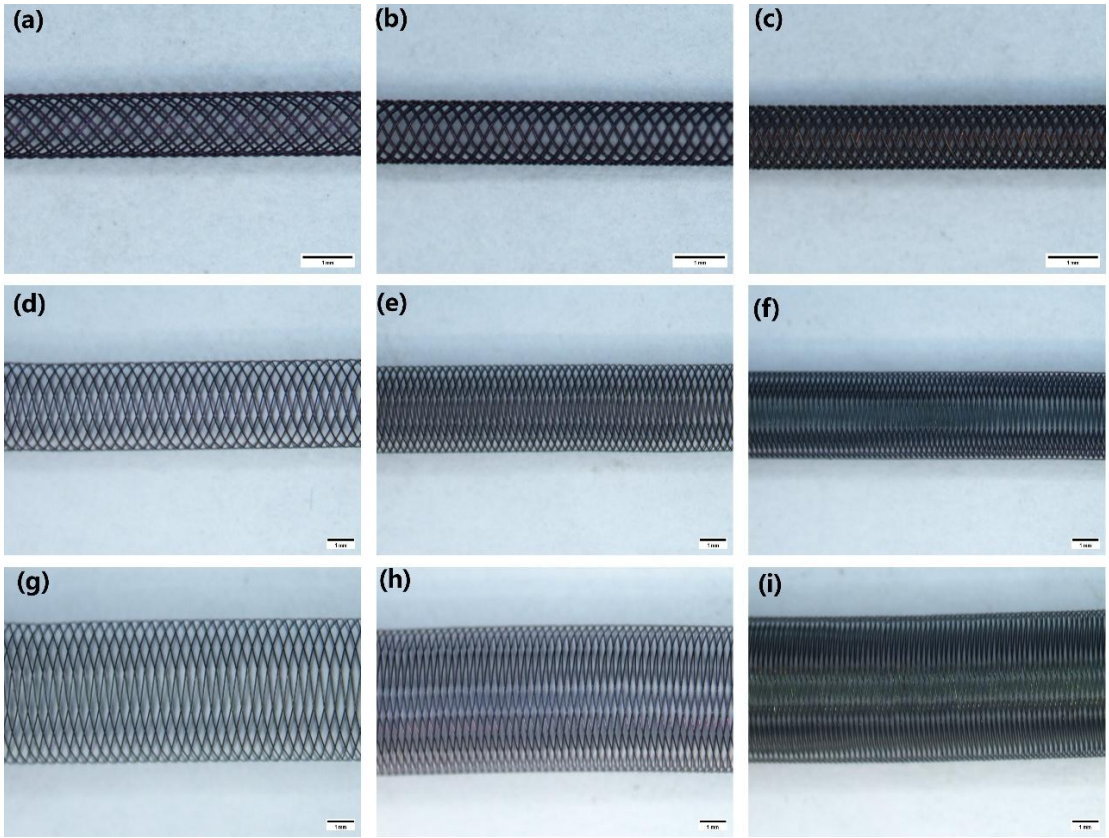

Figure S2. Photographs of 16/1-2 catheters. (a) 1 mm 60PPI; (b) 1 mm 90PPI; (c) 1 mm 120PPI; (d) 3 mm 60PPI; (e) 3 mm 90PPI; (f) 3 mm 120PPI; (g) 5 mm 60PPI; (h) 5 mm 90PPI; (i) 5 mm 120PPI.

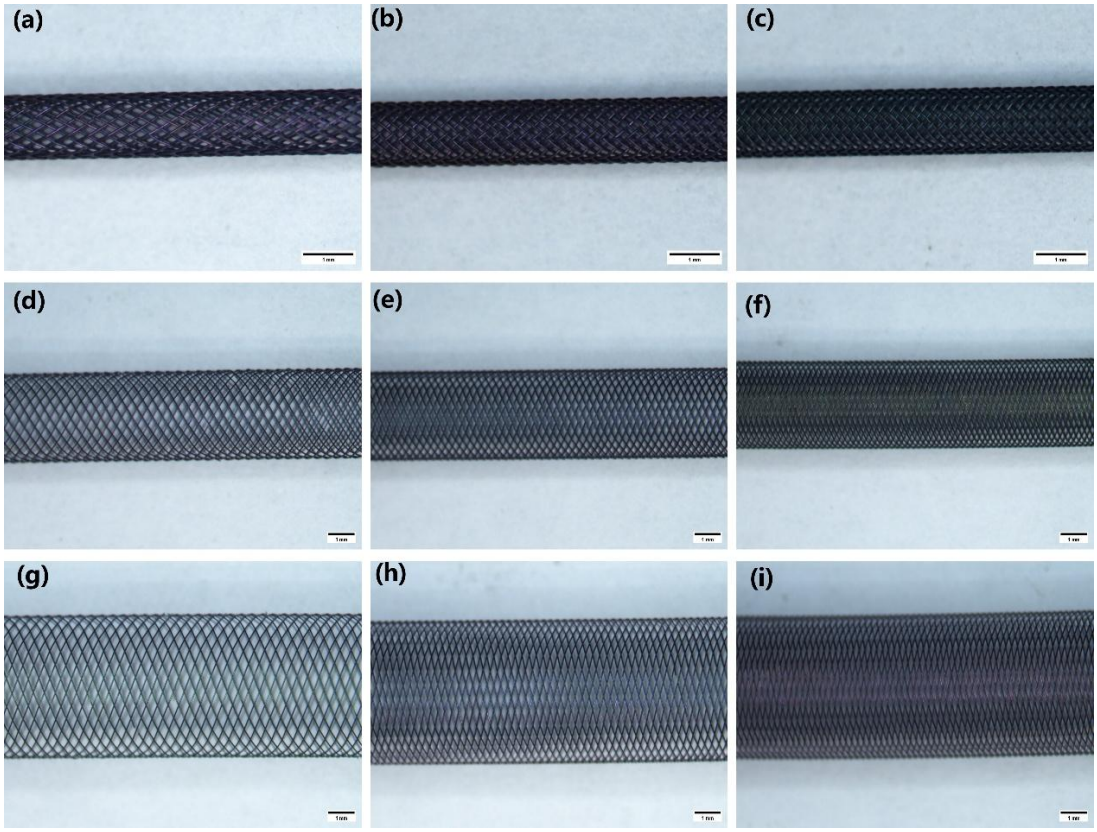

Figure S3. Photographs of 32/1-2 catheters. (a) 1 mm 60PPI; (b) 1 mm 90PPI; (c) 1 mm 120PPI; (d) 3 mm 60PPI; (e) 3 mm 90PPI; (f) 3 mm 120PPI; (g) 5 mm 60PPI; (h) 5 mm 90PPI; (i) 5 mm 120PPI.

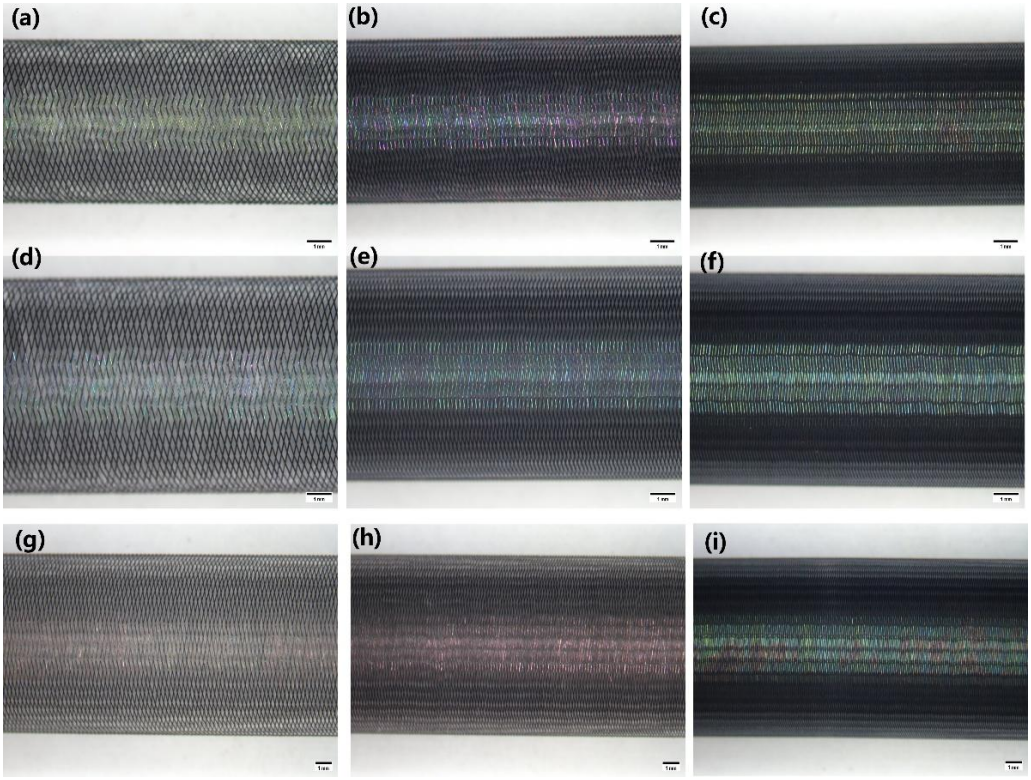

Figure S4. Photographs of 48/1-1 stents. (a) 6 mm 100PPI; (b) 6 mm 150PPI; (c) 6 mm 200PPI; (d) 8 mm 100PPI; (e) 8 mm 150PPI; (f) 8 mm 200PPI; (g) 10 mm 100PPI; (h) 10 mm 150PPI; (i) 10 mm 200PPI.

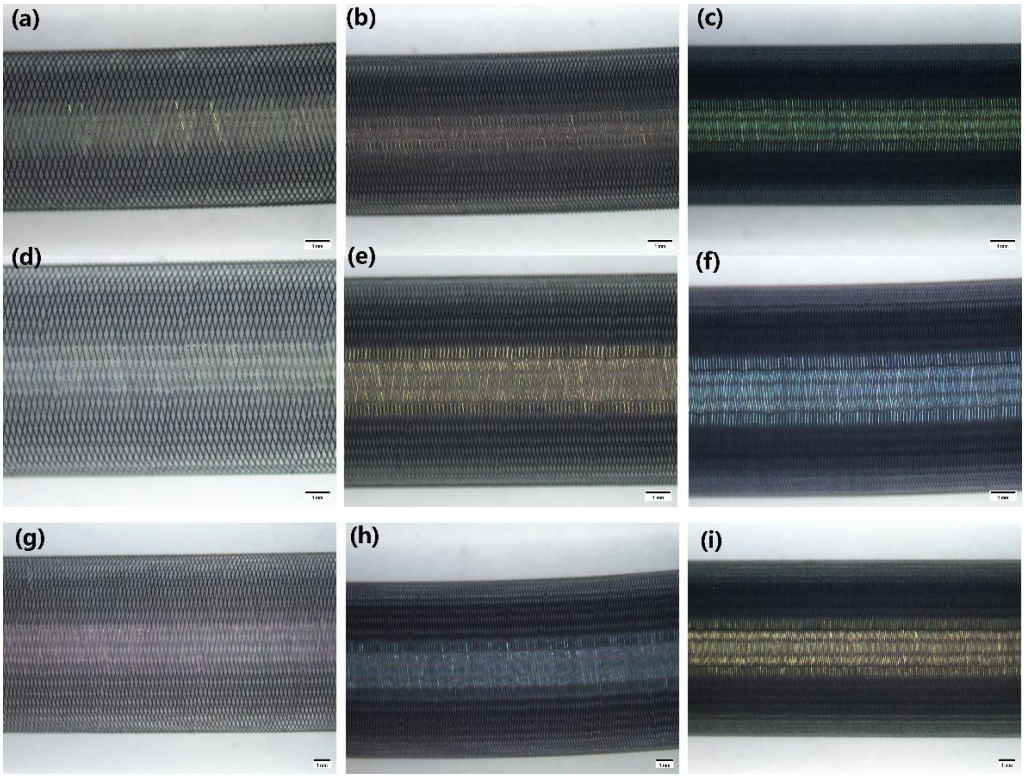

Figure S5. Photographs of 48/1-2 stents. (a) 6 mm 100PPI; (b) 6 mm 150PPI; (c) 6 mm 200PPI; (d) 8 mm 100PPI; (e) 8 mm 150PPI; (f) 8 mm 200PPI; (g) 10 mm 100PPI; (h) 10 mm 150PPI; (i) 10 mm 200PPI.

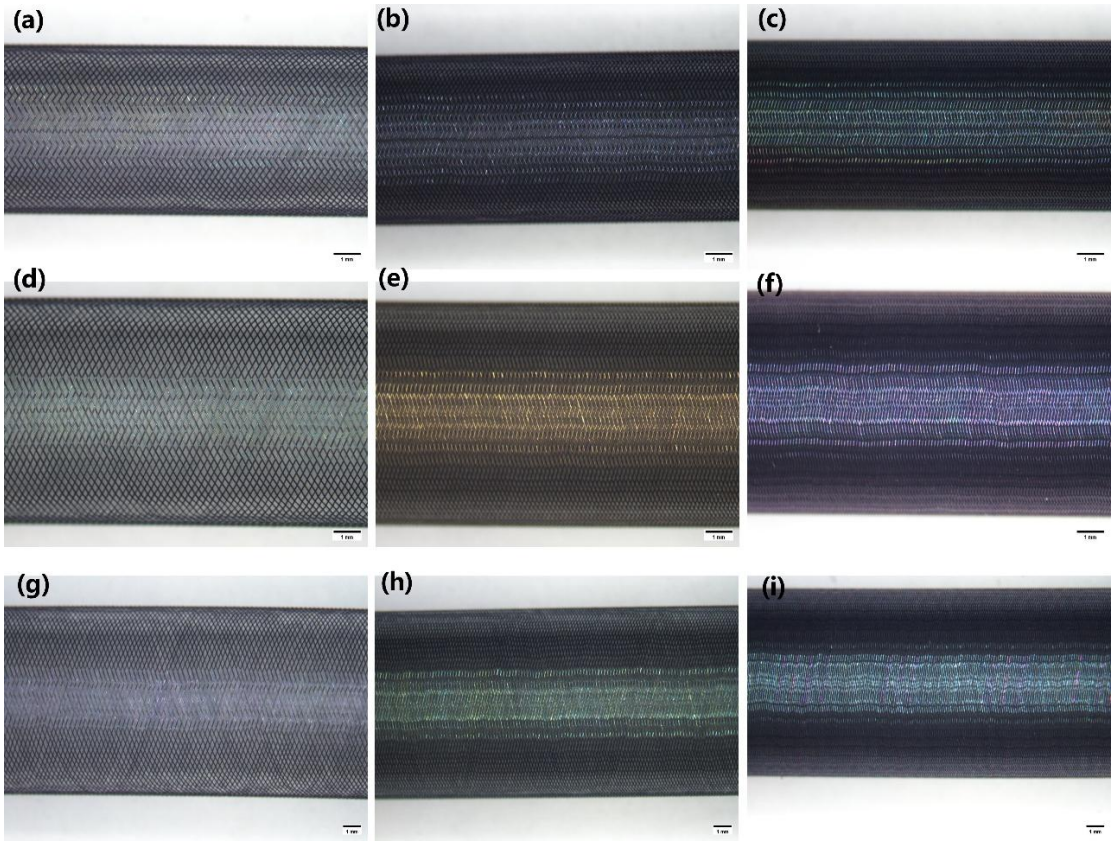

Figure S6. Photographs of 96/1-2 stents. (a) 6 mm 100PPI; (b) 6 mm 150PPI; (c) 6 mm 200PPI; (d) 8 mm 100PPI; (e) 8 mm 150PPI; (f) 8 mm 200PPI; (g) 10 mm 100PPI; (h) 10 mm 150PPI; (i) 10 mm 200PPI.

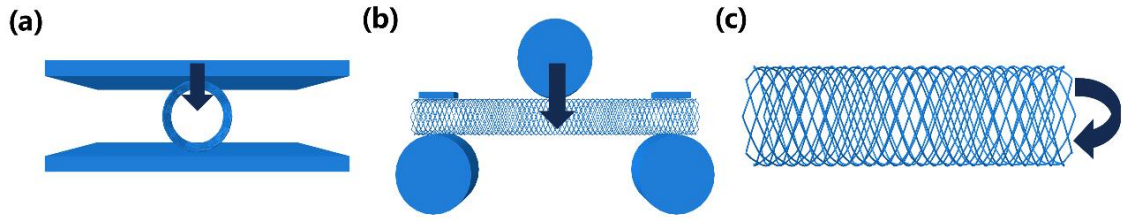

Figure S7. Finite element simulation configurations: (a) Plate compression: Stationary lower plate with displacement-controlled vertical motion of the upper plate; (b) Three-point bending: Vertical displacement applied solely to the upper indenter; (c) Torsional testing: Fixed proximal segment with rotational displacement imposed on the distal end.

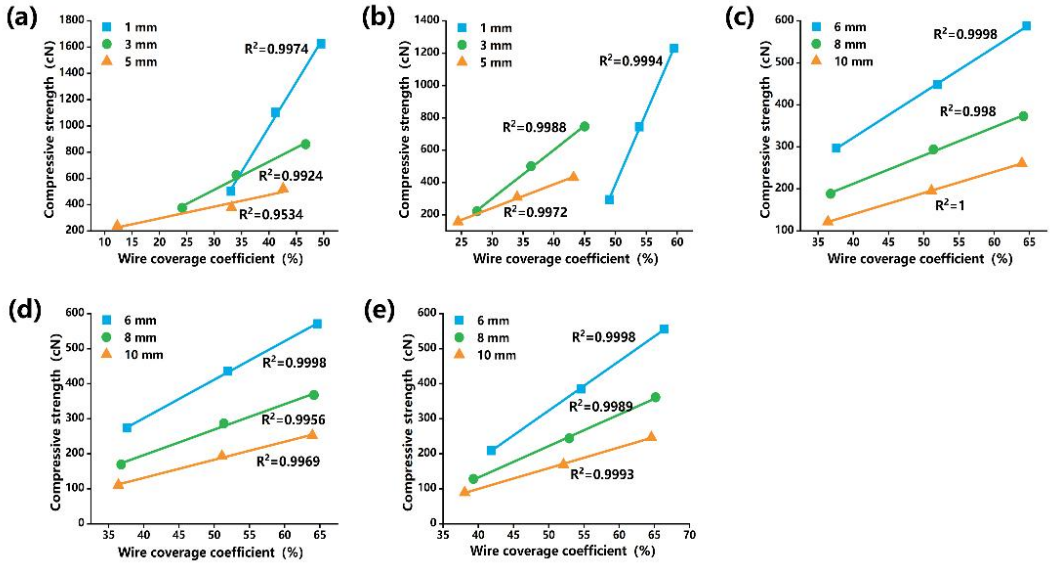

Figure S8. Linear relationship between compressive strength and WCC: (a) 16/1-2; (b) 32/1-2; (c) 48/1-1; (d) 48/1-2; (e) 96/1-2.

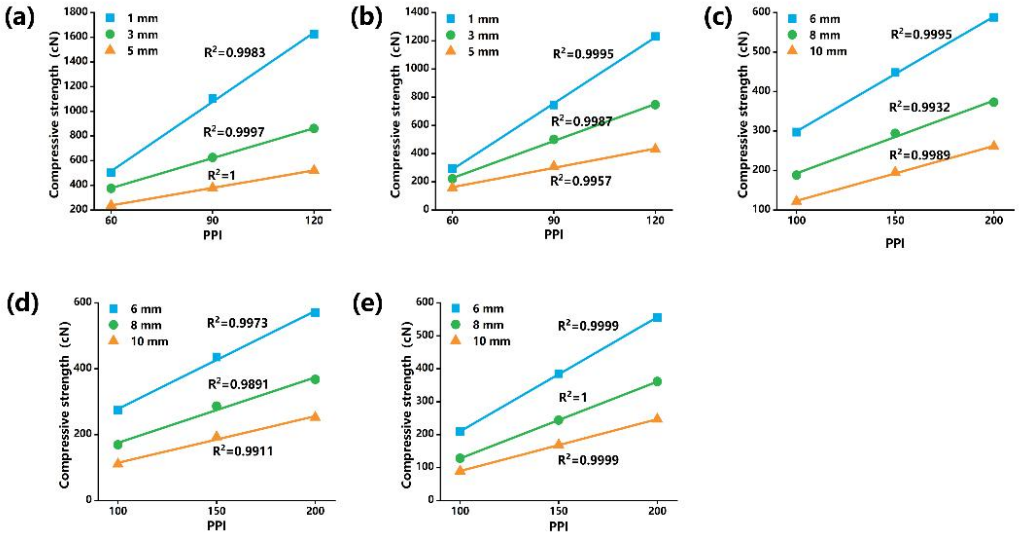

Figure S9. Linear relationship between compressive strength and PPI: (a) 16/1-2; (b) 32/1-2; (c) 48/1-1; (d) 48/1-2; (e) 96/1-2.

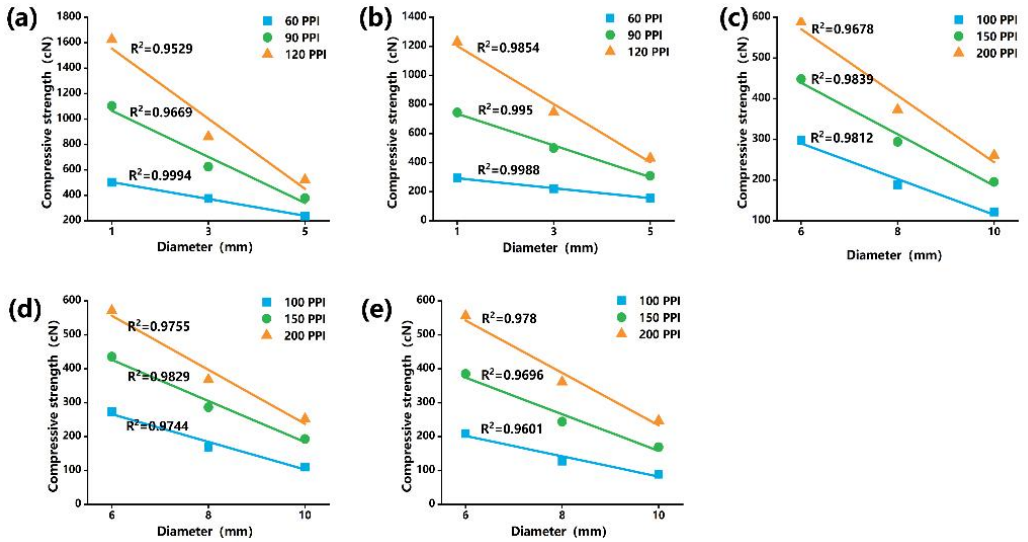

Figure S10. Linear relationship between compressive strength and PPI: (a) 16/1-2; (b) 32/1-2; (c) 48/1-1; (d) 48/1-2; (e) 96/1-2.

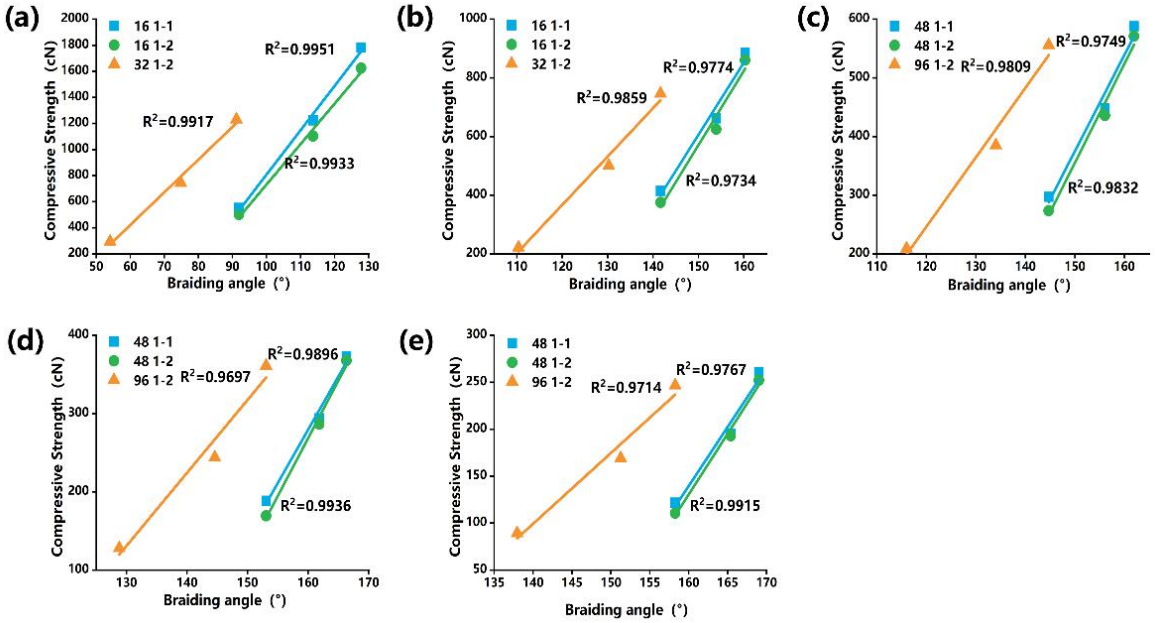

Figure S11. Linear relationship between compressive strength and braiding angle: (a) 1 mm; (b) 3 mm; (c) 6 mm; (d) 8 mm; (e) 10 mm.

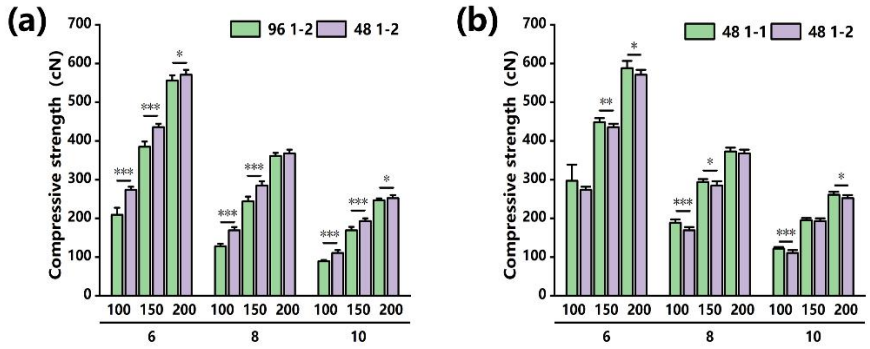

Figure S12. (a) Effect of the number of wires on compressive strength; (b) Effect of the braiding structure on compressive strength.

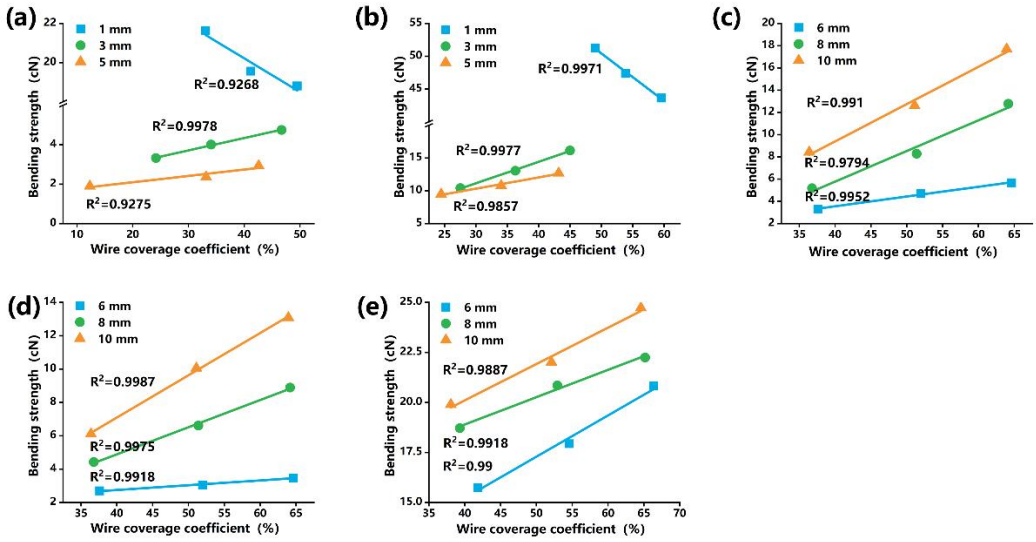

Figure S13. Linear relationship between bending strength and WCC: (a) 16/1-2; (b) 32/1-2; (c) 48/1-1; (d) 48/1-2; (e) 96/1-2.

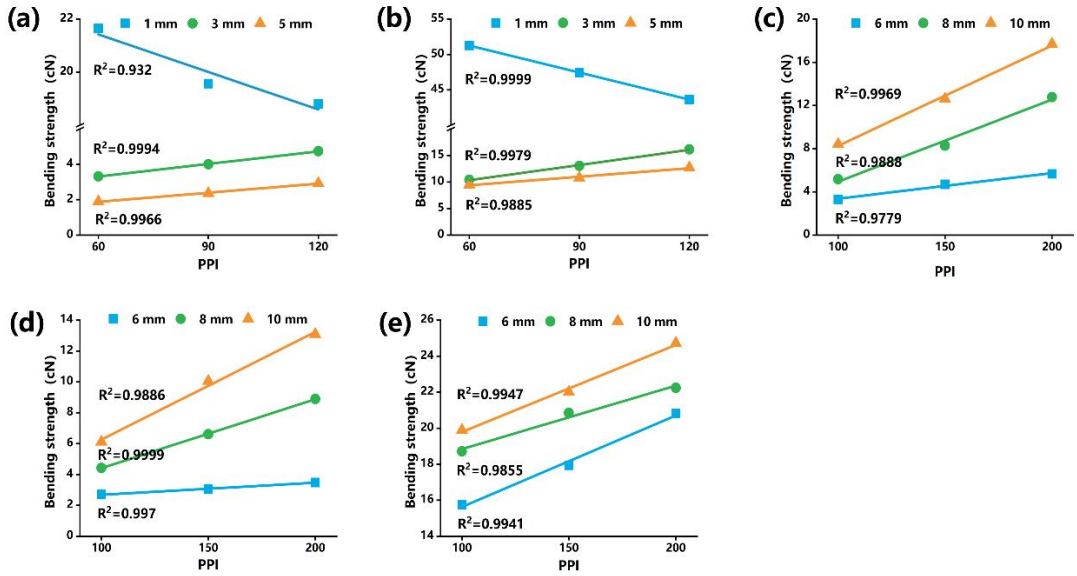

Figure S14. Linear relationship between bending strength and PPI: (a) 16/1-2; (b) 32/1-2; (c) 48/1-1; (d) 48/1-2; (e) 96/1-2.

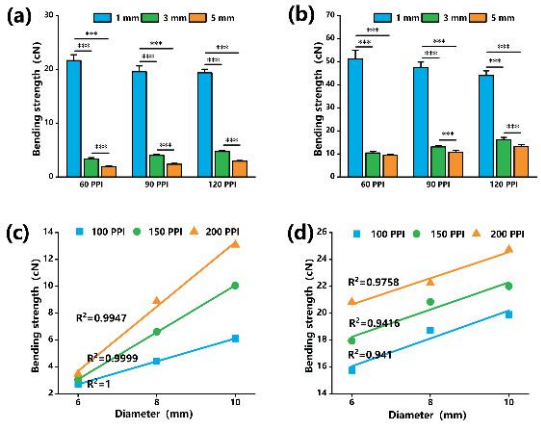

Figure S15. Relationship between bending strength and braiding diameter: (a) 16/1-2; (b) 32/1-2; (c) 48/1-2; (d) 96/1-2.

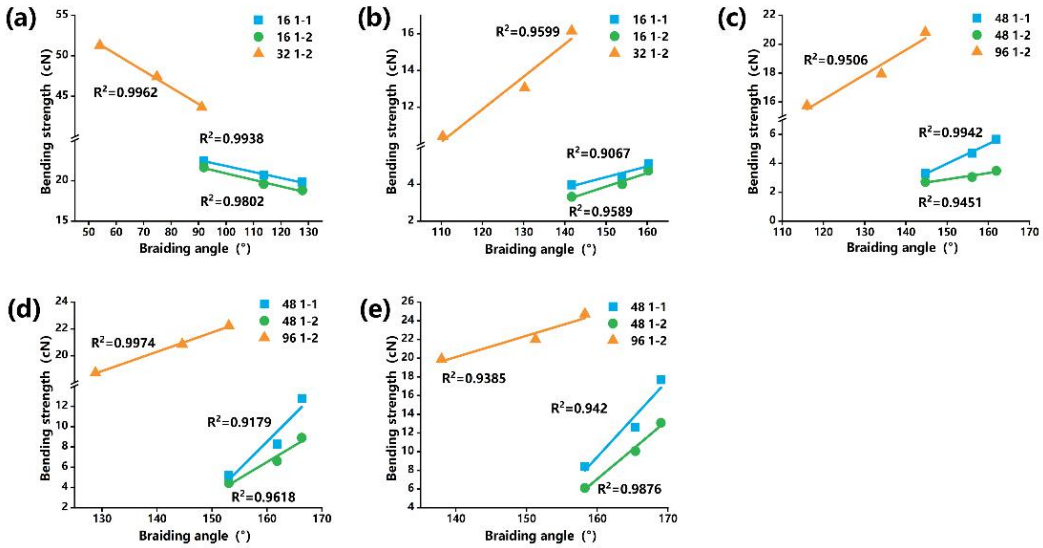

Figure S16. Linear relationship between bending strength and braiding angle: (a) 1 mm; (b) 3 mm; (c) 6 mm; (d) 8 mm; (e) 10 mm.

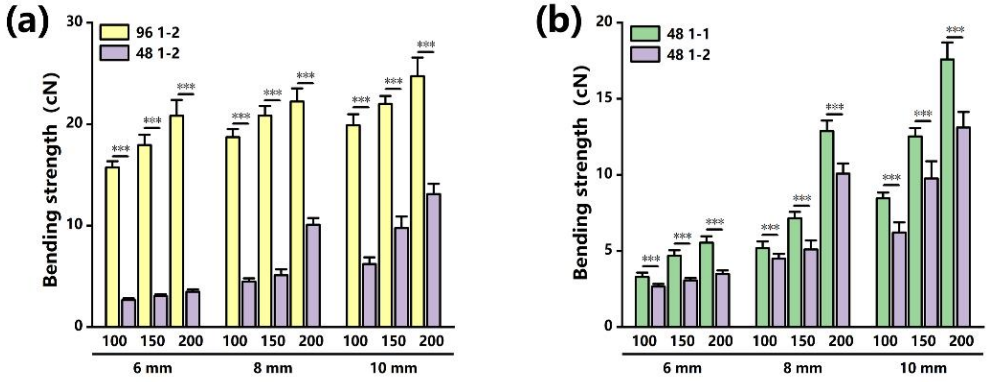

Figure S17. (a) Effect of the number of wires on bending strength; (b) Effect of the braiding structure on bending strength.

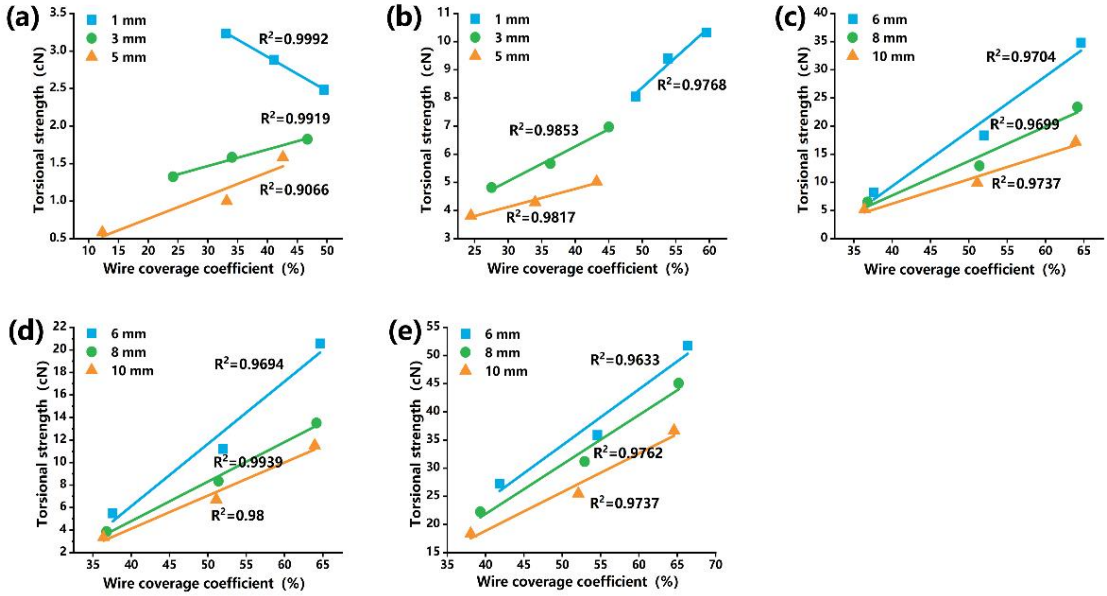

Figure S18. Linear relationship between torsional strength and WCC: (a) 16/1-2; (b) 32/1-2; (c) 48/1-1; (d) 48/1-2; (e) 96/1-2.

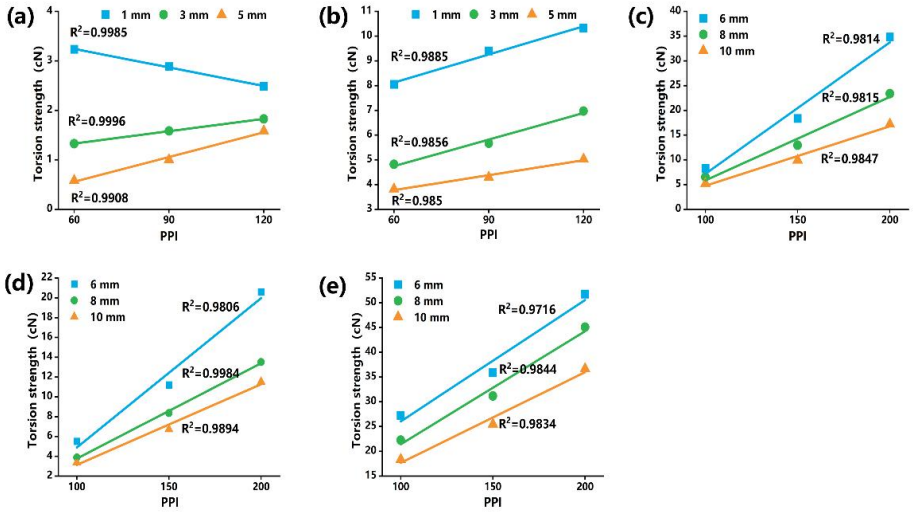

Figure S19. Linear relationship between torsional strength and PPI: (a) 16/1-2; (b) 32/1-2; (c) 48/1-1; (d) 48/1-2; (e) 96/1-2.

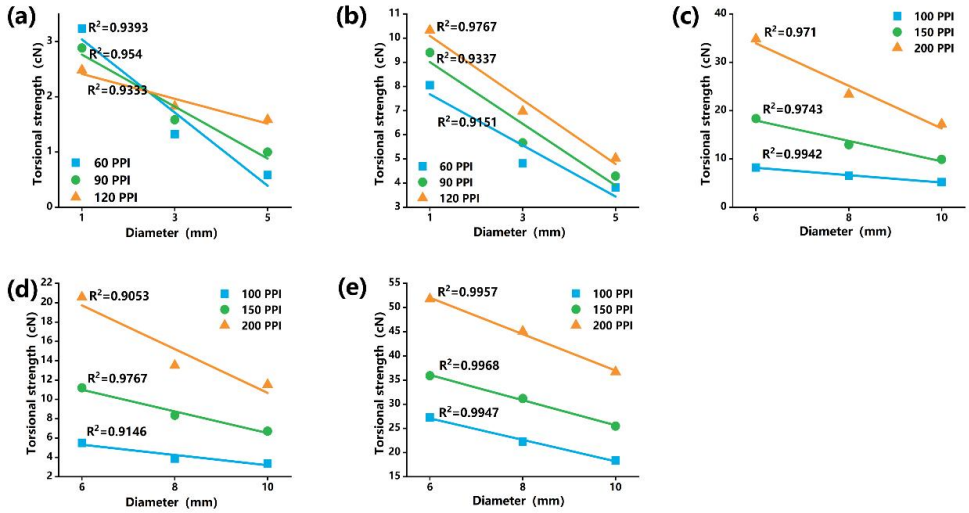

Figure S20. Linear relationship between torsional strength and braiding diameter: (a) 16/1-2; (b) 32/1-2; (c) 48/1-1; (d) 48/1-2; (e) 96/1-2.

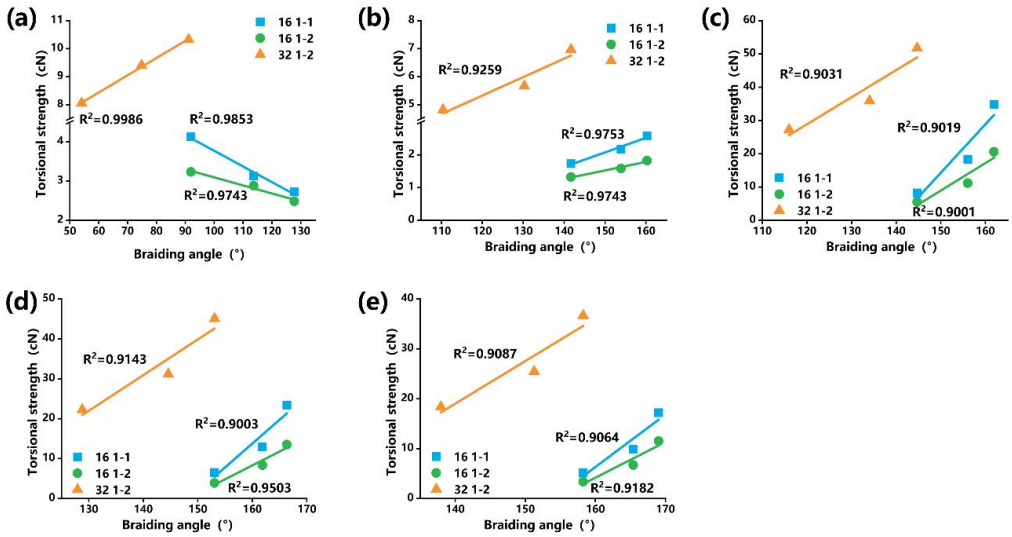

Figure S21. Linear relationship between torsional strength and braiding angle: (a) 1 mm; (b) 3 mm; (c) 6 mm; (d) 8 mm; (e) 10 mm.

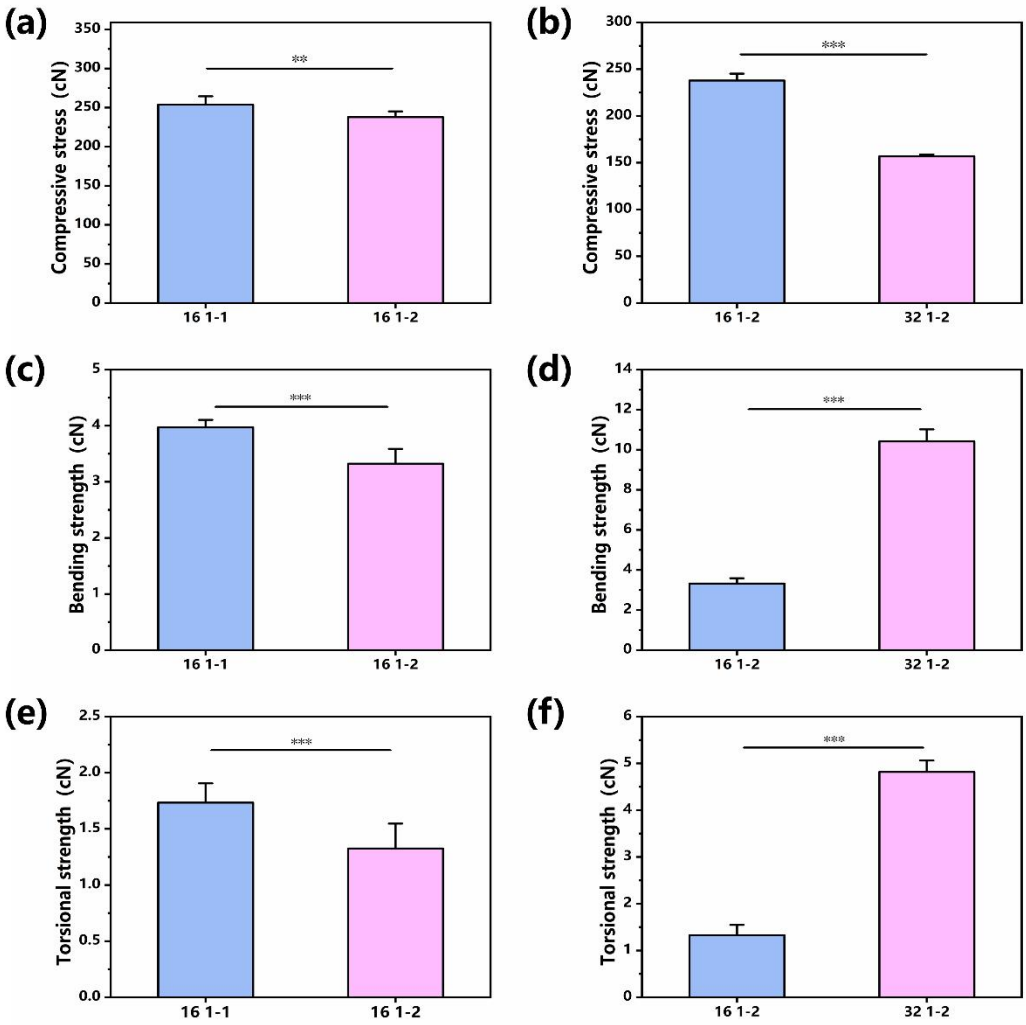

Figure S22. Comparison of test data for braids with different braiding structures and wire counts: (a) Compression strength of different structures at 5 mm, 60 PPI; (b) Compression strength of different wire counts at 5 mm, 60 PPI; (c) Three-point bending strength of different structures at 3 mm, 60 PPI; (d) Three-point bending strength of different wire counts at 3 mm, 60 PPI; (e) Torsional strength of different structures at 3 mm, 60 PPI; (f) Torsional strength of different wire counts at 3 mm, 60 PPI.

Table S1. Actual braiding angle and PPI of braided tubes with different parameters.

16/1-1			
	1 mm 60 PPI	1 mm 90 PPI	1 mm 120 PPI
PPI	61.72±0.67	90.57±0.97	119.01±1.41
Braiding Angle (°)	91.53±1.97	110.54±3.11	124.47±2.45
	3 mm 60 PPI	3 mm 90 PPI	3 mm 120 PPI
PPI	60.24±0.76	89.68±0.76	119.3±1.29
Braiding Angle (°)	138.26±2.06	147.72±2.10	154.96±2.74
	5 mm 60 PPI	5 mm 90 PPI	5 mm 120 PPI
PPI	59.47±1.07	90.28±1.58	119.55±1.66
Braiding Angle (°)	150.78±1.65	158.02±2.34	162.90±2.41
16/1-2			
	1 mm 60 PPI	1 mm 90 PPI	1 mm 120 PPI
PPI	63.24±0.25	93.33±1.13	121.27±2.25

Braiding Angle (°)	86.96±2.61	112.56±4.26	123.34±3.09
	3 mm 60 PPI	3 mm 90 PPI	3 mm 120 PPI
PPI	60.36±1.11	90.61±2.24	122.24±1.18
Braiding Angle (°)	138.07±3.65	145.69±2.46	155.41±2.66
	5 mm 60 PPI	5 mm 90 PPI	5 mm 120 PPI
PPI	61.51±0.55	91.136±1.44	122.97±1.23
Braiding Angle (°)	152.39±3.86	155.48±2.55	160.16±1.93
	32/1-2		
	1 mm 60 PPI	1 mm 90 PPI	1 mm 120 PPI
PPI	63.15±0.75	92.96±0.55	123.32±0.41
Braiding Angle (°)	58.51±3.64	74.53±2.81	89.74±5.16
	3 mm 60 PPI	3 mm 90 PPI	3 mm 120 PPI
PPI	61.86±1.51	90.11±0.86	120.77±2.76
Braiding Angle (°)	108.32±3.01	127.28±1.81	134.77±2.13
	5 mm 60 PPI	5 mm 90 PPI	5 mm 120 PPI
PPI	59.7±0.44	91.31±1.1	120.08±1.38
Braiding Angle (°)	129.10±1.82	144.84±2.04	152.02±2.21
	48/1-1		
	6 mm 100 PPI	6 mm 150 PPI	6 mm 200 PPI
PPI	102.89±2.05	152.57±3.06	201.14±2.7
Braiding Angle (°)	144.12±1.83	157.25±2.01	161.97±1.60
	8 mm 100 PPI	8 mm 150 PPI	8 mm 200 PPI
PPI	103.74±1.27	152.92±2.37	203.52±1.72
Braiding Angle (°)	150.90±2.00	160.49±1.13	164.81±1.26
	10 mm 100 PPI	10 mm 150 PPI	10 mm 200 PPI
PPI	102.39±1.55	143.6±1.33	197.08±4.37
Braiding Angle (°)	156.59±1.24	163.21±1.56	166.26±1.41
	48/1-2		
	6 mm 100 PPI	6 mm 150 PPI	6 mm 200 PPI
PPI	103.38±1.39	149.11±1.70	201.17±4.32
Braiding Angle (°)	145.08±1.77	155.44±2.39	161.44±1.92
	8 mm 100 PPI	8 mm 150 PPI	8 mm 200 PPI
PPI	103.62±1.55	154.84±2.44	201.23±3.27
Braiding Angle (°)	151.63±1.64	161.48±1.55	165.35±1.52
	10 mm 100 PPI	10 mm 150 PPI	10 mm 200 PPI
PPI	101.33±2.07	152.12±1.64	202.96±2.67
Braiding Angle (°)	156.84±1.32	164.17±1.49	168.40±1.68
	96/1-2		
	6 mm 100 PPI	6 mm 150 PPI	6 mm 200 PPI
PPI	103.63±3.13	147.89±3.13	200.32±3.29
Braiding Angle (°)	114.04±2.55	130.00±3.14	139.43±3.57
	8 mm 100 PPI	8 mm 150 PPI	8 mm 200 PPI
PPI	99.64±1.93	156.58±1.74	208.28±3.98
Braiding Angle (°)	125.12±2.35	143.06±2.09	150.35±2.70

	10 mm 100 PPI	10 mm 150 PPI	10 mm 200 PPI
PPI	103.83±4.6	149.76±3.19	203.47±3.39
Braiding Angle (°)	135.87±2.62	149.23±1.15	156.69±2.13

Table S2. Magnitude of compressive strength variation induced by braided structural changes

16 1-1 compared with 16 1-2									
	1mm60	1mm90	1mm120	3mm60	3mm90	3mm120	5mm60	5mm90	5mm120
Increment Rate (%)	10.14	10.94	9.68	10.46	5.93	2.9	6.71	4.88	5.16
48 1-1 compared with 48 1-2									
	6mm100	6mm150	6mm200	8mm100	8mm150	8mm200	10mm100	10mm150	10mm200
Increment Rate (%)	8.6	2.91	2.99	11.36	3.14	1.38	10.11	1.27	3.49

Table S3. Magnitude of compressive strength variation resulting from changes in braiding wire count.

16 1-2 compared with 32 1-2									
	1mm60	1mm90	1mm120	3mm60	3mm90	3mm120	5mm60	5mm90	5mm120
Increment Rate (%)	70.71	48.11	32.07	69.62	24.88	15.31	51.69	22.45	21.01
48 1-2 compared with 96 1-2									
	6mm100	6mm150	6mm200	8mm100	8mm150	8mm200	10mm100	10mm150	10mm200
Increment Rate (%)	30.89	13.16	2.73	32.26	16.82	1.87	23.97	14.2	2.22

Table S4. Magnitude of bending strength variation induced by braided structural changes.

16 1-1 compared with 16 1-2									
	1mm60	1mm90	1mm120	3mm60	3mm90	3mm120	5mm60	5mm90	5mm120
Increment Rate (%)	3.79	5.73	5.42	19.58	10.5	8.02	21.05	16.53	4.78
48 1-1 compared with 48 1-2									
	6mm100	6mm150	6mm200	8mm100	8mm150	8mm200	10mm100	10mm150	10mm200
Increment Rate (%)	24.06	53.27	59.03	15.59	39.92	27.78	36.17	28.25	34.1

Table S5. Magnitude of bending strength variation resulting from changes in braiding wire count.

16 1-2 compared with 32 1-2									
	1mm60	1mm90	1mm120	3mm60	3mm90	3mm120	5mm60	5mm90	5mm120
Increment Rate (%)	136.32	143.43	127.32	213.86	226	241.95	398.42	355.08	350.85
48 1-2 compared with 96 1-2									
	6mm100	6mm150	6mm200	8mm100	8mm150	8mm200	10mm100	10mm150	10mm200

Increment Rate (%)	491.73	486.27	496.56	316.93	308.02	120.63	219.77	125.18	88.63

Table S6. Magnitude of bending strength variation induced by braided structural changes.

16 1-1 compared with 16 1-2									
	1mm60	1mm90	1mm120	3mm60	3mm90	3mm120	5mm60	5mm90	5mm120
Increment Rate (%)	27.86	8.68	10.08	30.08	37.97	40.98	82.76	52	32.91
48 1-1 compared with 48 1-2									
	6mm100	6mm150	6mm200	8mm100	8mm150	8mm200	10mm100	10mm150	10mm200
Increment Rate (%)	49.64	63.75	69.1	67.78	54.67	72.98	53.55	47.32	49.31

Table S7. Magnitude of bending strength variation resulting from changes in braiding wire count.

16 1-2 compared with 32 1-2									
	1mm60	1mm90	1mm120	3mm60	3mm90	3mm120	5mm60	5mm90	5mm120
Increment Rate (%)	149.23	226.39	316.53	262.41	258.86	280.87	558.62	329	218.35
48 1-2 compared with 96 1-2									
	6mm100	6mm150	6mm200	8mm100	8mm150	8mm200	10mm100	10mm150	10mm200
Increment Rate (%)	395.64	220.36	151.46	473.45	272.97	233.68	443.49	278.87	218.4