Supplementary Materials

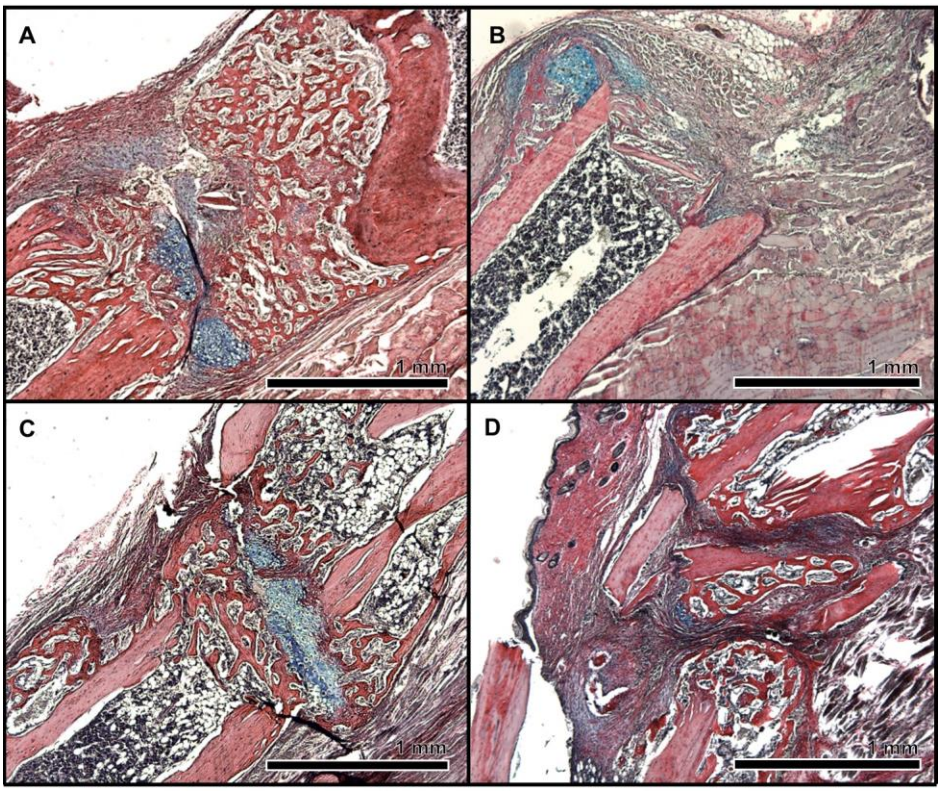

Fig. S1 - Original histology images of external fixator model samples (Fig. 2A-B,D-E).
Histology sections are stained with HBQ (blue = cartilage, red = bone). **(A)** Original image of the histology section in Fig. 2A of an externally-fixed 0.5 mm defect at 14 days post-fracture. **(B)** Original image of the histology section in Fig. 2B of an externally-fixed 2 mm defect at 14 days post-fracture. **(C)** Original image of the histology section in Fig. 2D of an externally-fixed well-healed mouse at day 28. **(D)** Original image of the histology section in Fig. 2E of an externally-fixed poorly-healed mouse at day 28.

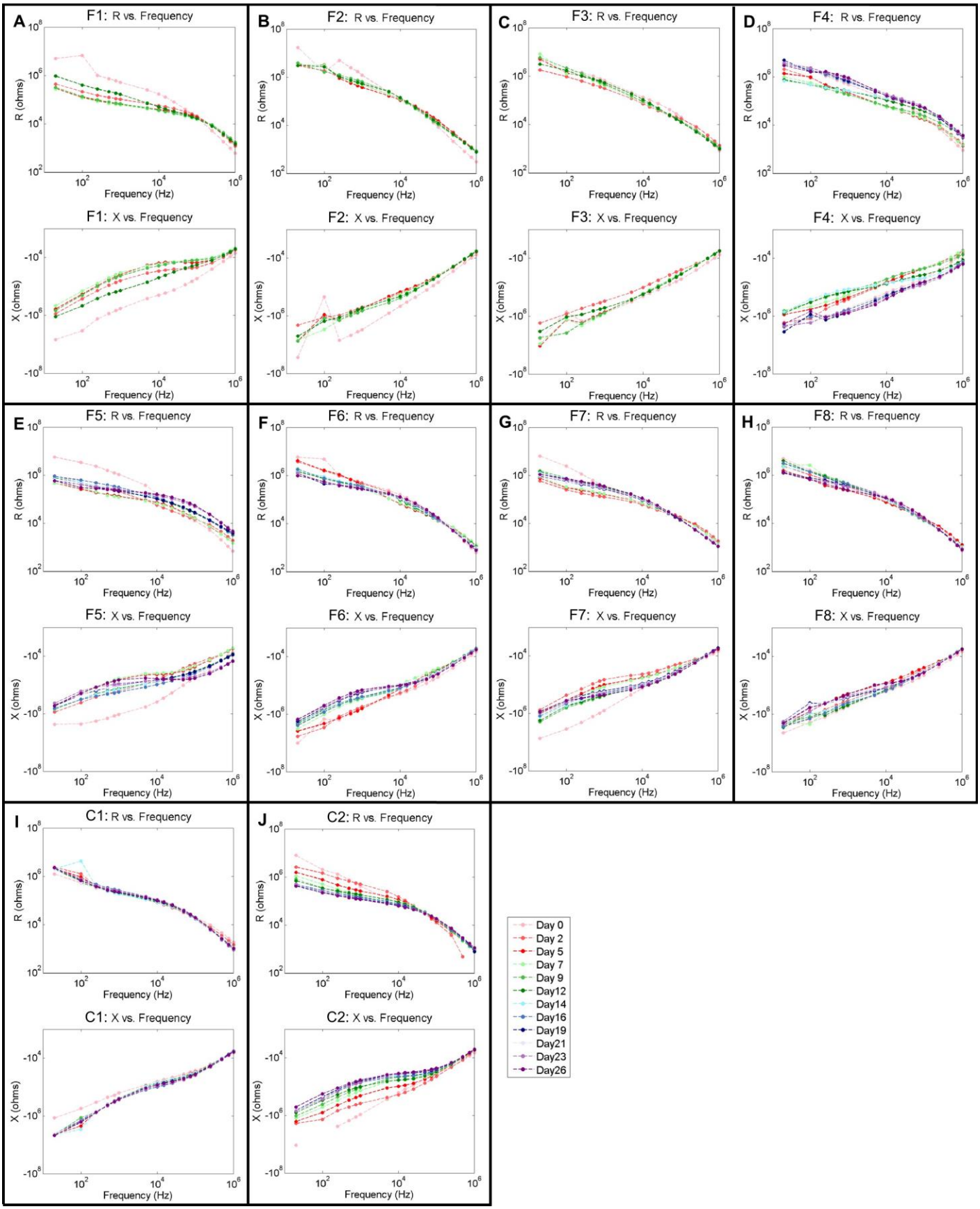
A
F1: R vs. Frequency
F1: X vs. Frequency
B
F2: R vs. Frequency
F2: X vs. Frequency
C
F3: R vs. Frequency
F3: X vs. Frequency
D
F4: R vs. Frequency
F4: X vs. Frequency
E
F5: R vs. Frequency
F5: X vs. Frequency
F
F6: R vs. Frequency
F6: X vs. Frequency
G
F7: R vs. Frequency
F7: X vs. Frequency
H
F8: R vs. Frequency
F8: X vs. Frequency
I
C1: R vs. Frequency
C1: X vs. Frequency
J
C2: R vs. Frequency
C2: X vs. Frequency
R (ohms)
X (ohms)
Frequency (Hz)
Day 0
Day 2
Day 5
Day 7
Day 9
Day12
Day14
Day16
Day19
Day21
Day23
Day26

Fig. S2 - Frequency response over time in all bone plate model mice.
(A-C) Electrical resistance (R) and reactance (X) plotted as a function of frequency for each measurement day in mice sacrificed on day 12. **(D-F)** R and X plotted as a function of frequency for each measurement day in mice sacrificed on day 26 with calluses composed nearly completely of new trabecular bone. **(G-H)** R and X plotted as a function of frequency for each measurement day in mice sacrificed on day 26 that experienced mixed healing. **(I-J)** R and X plotted as a function of frequency for each measurement day for control mice.

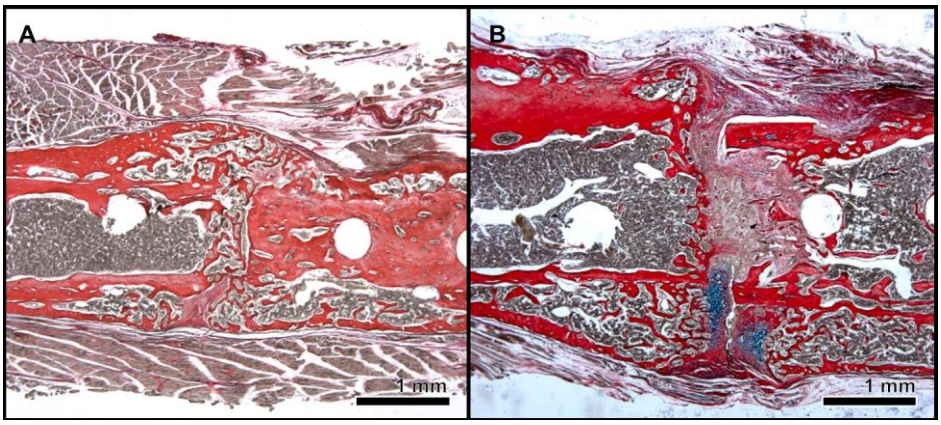

Fig. S3 - Original histology images of healing and non-healing bone plate model samples (Fig. 4A,E).
Histology sections are stained with HBQ (blue = cartilage, red = bone). **(A)** Original image of the histology section in Fig. 4A of a fracture fixed with a bone plate at 26 days post-fracture that was well-healed. **(B)** Original image of the histology section in Fig. 4E of a fracture fixed with a bone plate at 26 days post-fracture that had a mixed healing response.

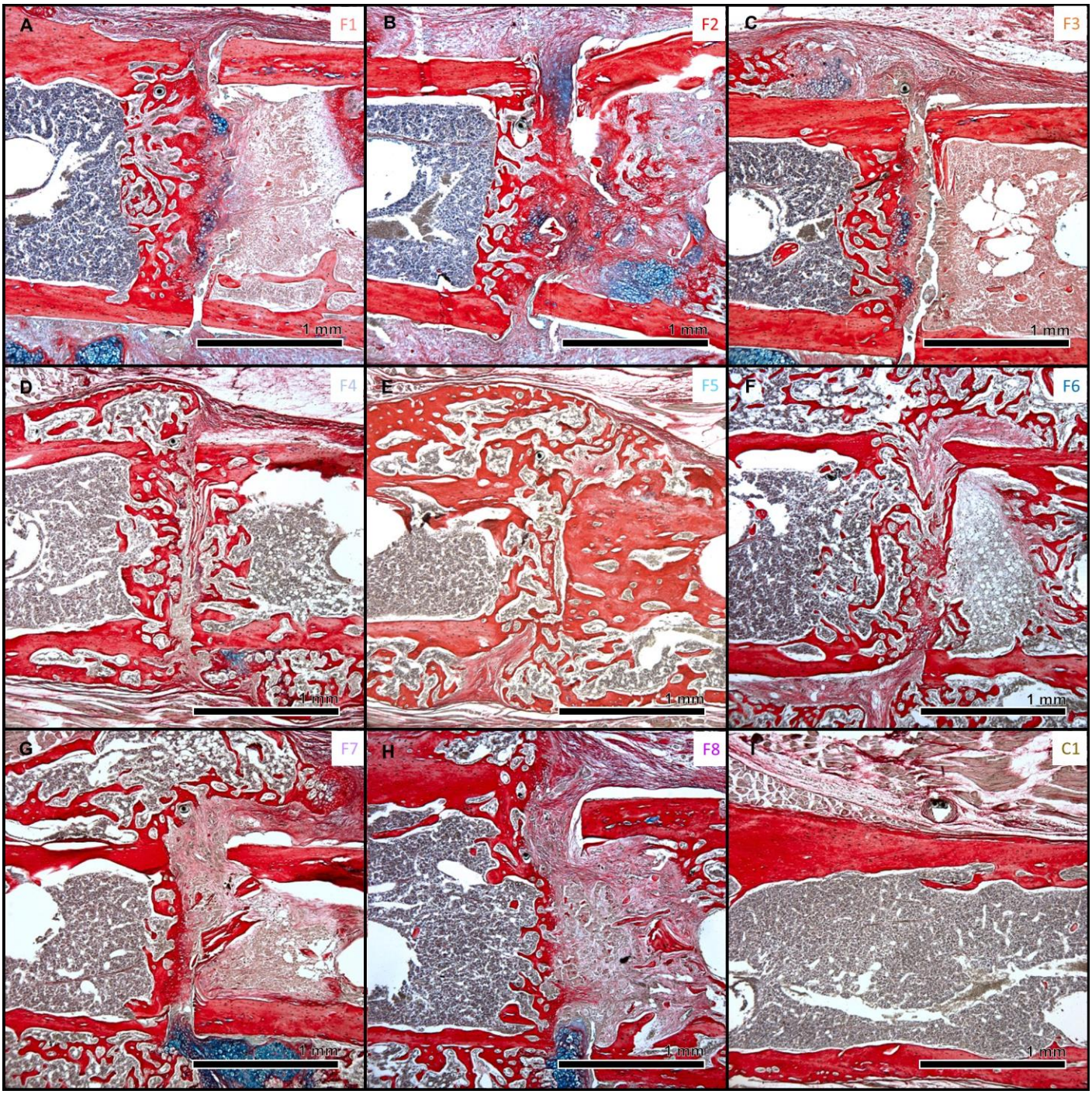

Fig. S4 - Original histology images of all bone plate model samples (Fig. 5).
Histology sections in this figure are stained with HBQ (blue = cartilage, red = bone). **(A-C)** Original images of the histology sections in Fig. 5A-C of mice sacrificed on day 12. **(D-F)** Original images of the histology sections in Fig. 5D-F of mice sacrificed on day 26 with calluses composed nearly completely of new trabecular bone. **(G-H)** Original images of the histology sections in Fig. 5G-H of mice sacrificed on day 26 that experienced mixed healing. **(I)** Original image of the histology section in Fig. 5I of a control mouse on day 26.

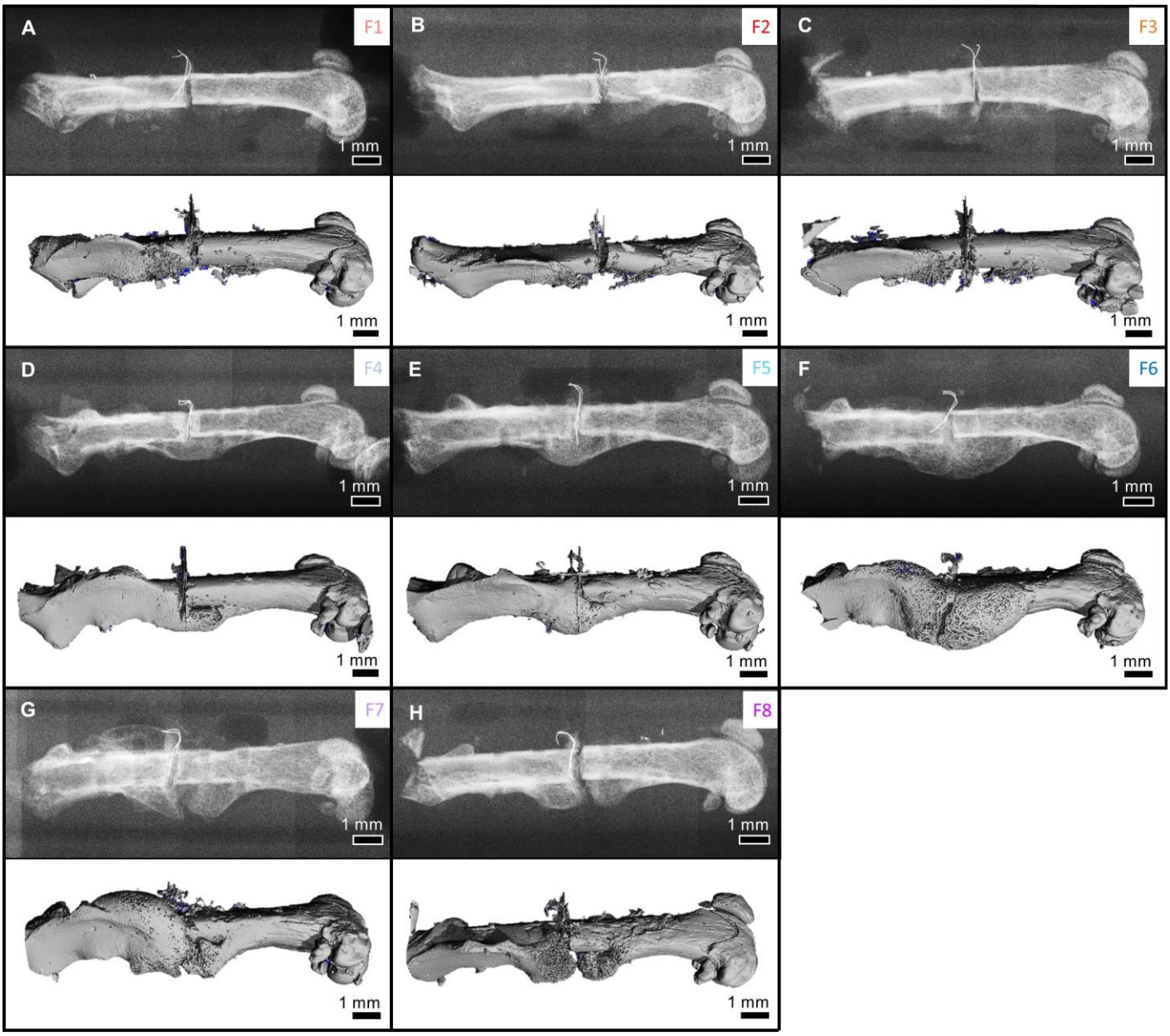

Fig. S5 - X-ray and µCT images of all bone plate model fracture samples.
(A-C) X-ray and µCT images of femurs from mice sacrificed on day 12. **(D-F)** X-ray and µCT images of femurs from mice sacrificed on day 26 with calluses composed nearly completely of new trabecular bone. **(G-H)** X-ray and µCT images of femurs from mice sacrificed on day 26 that experienced mixed healing.

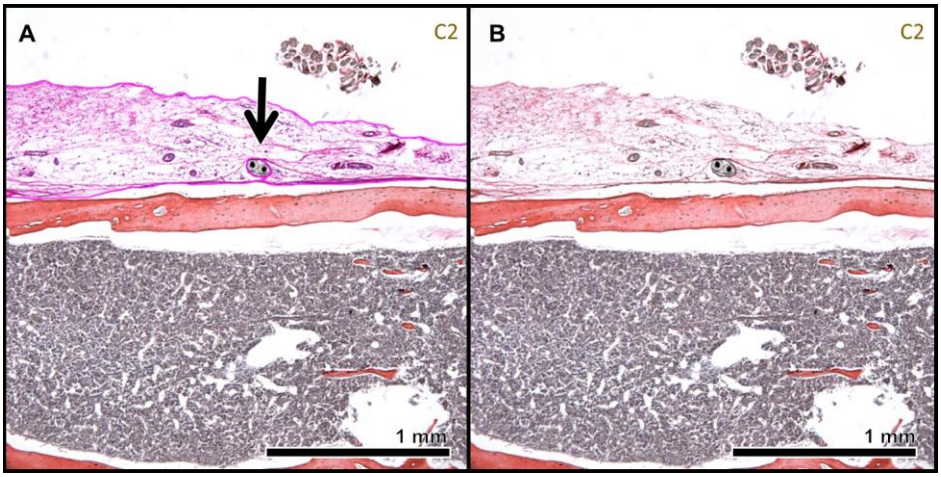

Fig. S6 - Histology image for control mouse.
Histology sections in this figure are stained with HBQ (blue = cartilage, red = bone). **(A)** Histology section is false-colored to aid interpretation of tissue composition. Purple = fibrous/amorphous tissue. Original red color = cortical bone, black/white area = bone marrow. Black arrow points to sensors embedded in fibrous tissue next to the unfractured bone. **(B)** Original histology section from (A).

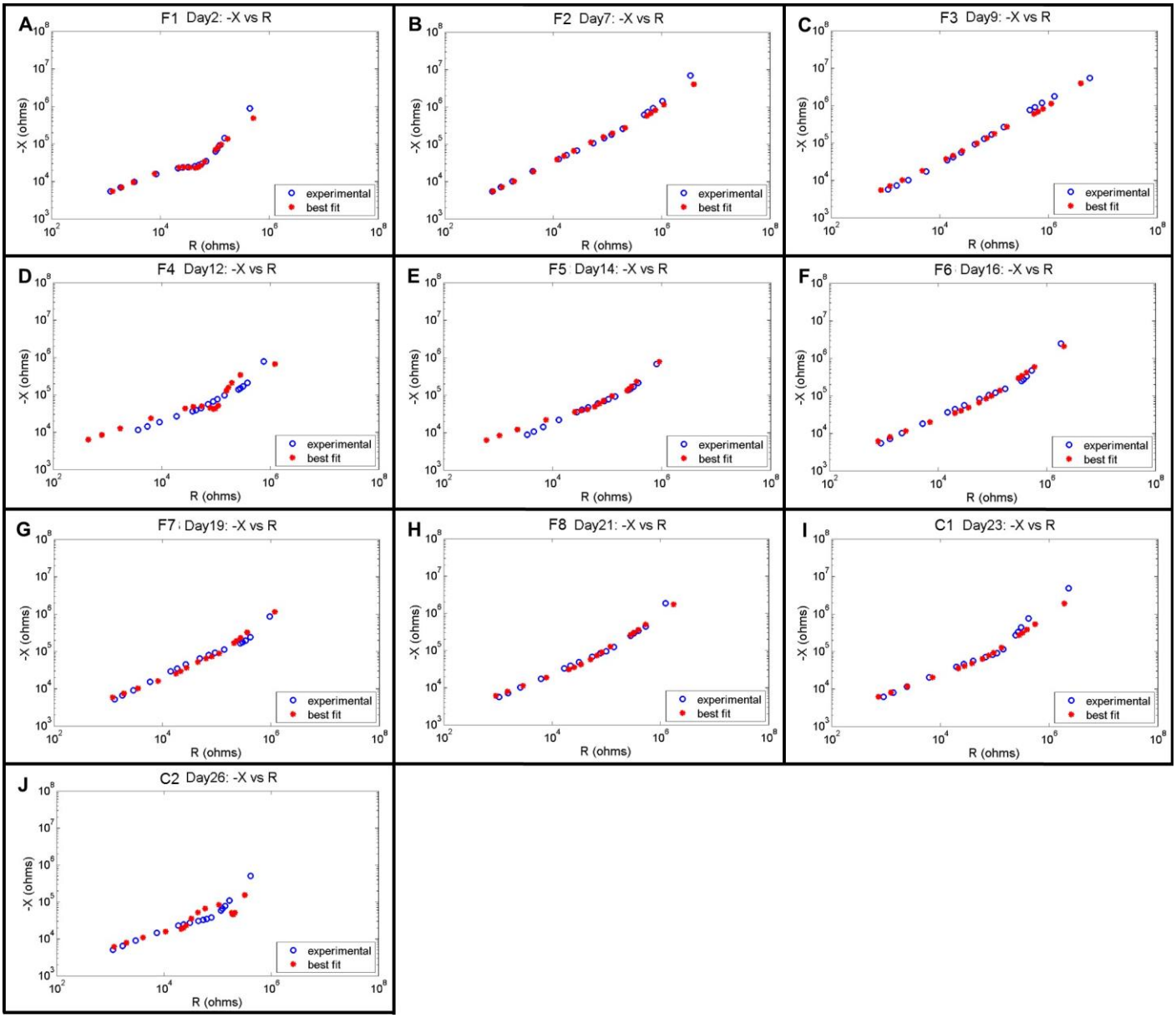

Fig. S7 - Goodness of fits for data fit to equivalent circuit model.
Representative set of graphs depicting the experimental values and best fit values derived from the equivalent circuit model of electrical reactance plotted over electrical resistance.

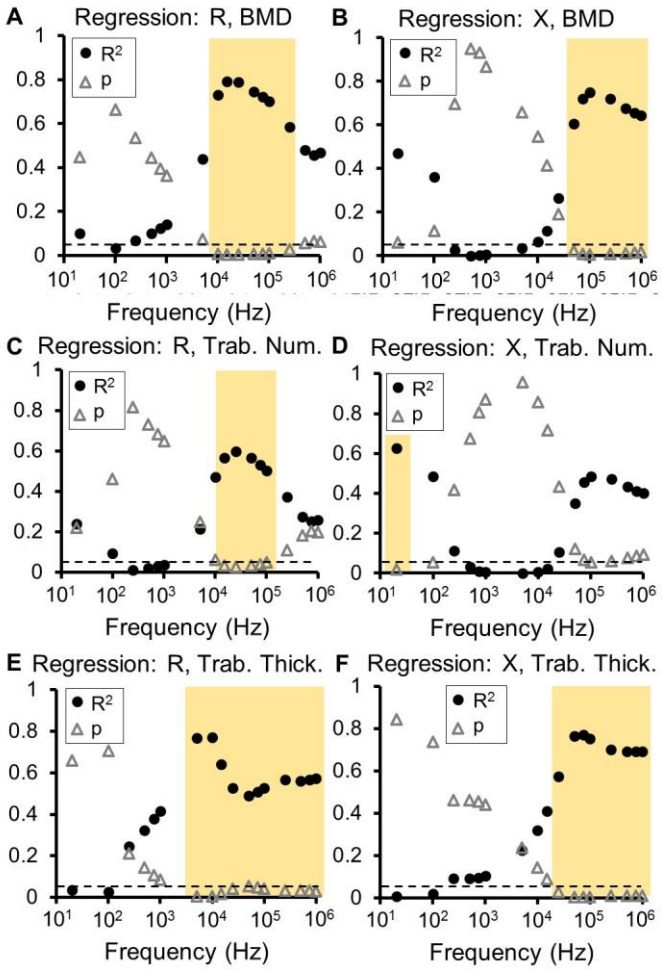

Fig. S8 - Clinically-relevant frequencies of operation with significant correlation between impedance data and µCT.

Resultant R^2 and p values from regression analyses comparing normalized R and X with bone mineral density (BMD), trabecular number, and trabecular thickness. Significance is set at $p < 0.05$ (below dashed line).

	Surgeon 1					Surgeon 2				
Sample	**Cortex 1**	**Cortex 2**	**Cortex 3**	**Total**	**Category**	**Cortex 1**	**Cortex 2**	**Cortex 3**	**Total**	**Category**
F1	1	2	2	5	NU	2	1	2	5	SNU
F2	2	2	2	6	NU	2	1	2	5	SNU
F3	3	2	2	7	SNU	2	1	2	5	SNU
F4	3	2	3	8	U	3	3	3	9	U
F5	3	2	3	8	U	3	3	3	9	U
F6	3	3	3	9	SNU	3	3	3	9	SNU
F7	2	2	2	6	NU	2	2	2	6	NU
F8	3	3	3	9	U	3	3	3	9	U

	Surgeon 3					Surgeon 4				
Sample	**Cortex 1**	**Cortex 2**	**Cortex 3**	**Total**	**Category**	**Cortex 1**	**Cortex 2**	**Cortex 3**	**Total**	**Category**
F1	1	1	1	3	NU	1	2	2	5	SNU
F2	1	1	1	3	NU	2	1	2	5	SNU
F3	2	1	2	5	NU	2	2	2	6	SNU
F4	3	2	3	8	U	3	3	3	9	U
F5	3	2	3	8	U	3	3	3	9	U
F6	3	3	3	9	U	3	3	3	9	SNU
F7	3	3	2	8	NU	2	3	2	7	SNU
F8	3	3	3	9	U	3	3	3	9	U

	Surgeon 5				
Sample	**Cortex 1**	**Cortex 2**	**Cortex 3**	**Total**	**Category**
F1	2	2	2	6	SNU
F2	2	1	2	5	SNU
F3	2	3	2	7	SNU
F4	3	2	3	8	U
F5	3	4	3	10	U
F6	3	3	3	9	U
F7	3	2	3	8	U
F8	3	3	3	9	U

Table S1 – Modified RUST scores of bone plate model samples.
Five surgeons scored each cortex (excluding the anterior cortex) from 1 to 4: 1 = no callus, 2 = callus present, 3 = bridging callus, 4 = remodeled with no visible fracture line. Scores from the three cortices for each sample were added to generate a total score between 3 and 12. Each surgeon also clinically categorized each sample as union (U), nonunion (NU), or suspected nonunion (SNU).

Mouse	**Day**	**Bone Volume (BV)**	**Total Volume (TV)**	**BV/TV**	**Bone Mineral Density (BMD)**	**Trabecular Number**	**Trabecular Thickness**	**Trabecular Separation**
F1	12	0.2129	2.4666	0.0863	135.8959	3.3514	0.0489	0.3197
F2	12	0.1029	2.3747	0.0433	99.1292	2.9957	0.0504	0.3456
F3	12	0.1831	2.6416	0.0693	116.7744	2.2935	0.0607	0.4634
F4	26	1.7574	4.6154	0.3808	335.406	8.2039	0.069	0.1146
F5	26	2.38	5.9458	0.4003	355.0899	9.0805	0.0645	0.1023
F6	26	3.8163	16.4001	0.2327	219.9742	7.226	0.045	0.134
F7	26	2.6295	9.2405	0.2846	260.3964	7.3311	0.0528	0.1405
F8	26	1.8757	7.4606	0.2514	237.9708	7.302	0.0489	0.1401

Table S2 – Quantified µCT indices for bone plate model samples.
The cortical surface and bone morphology for each sample was assessed from µCT scans in the region between the central surgical screws, and a number of three-dimensional microstructural indices are reported here.

Normalized Resistance (R)																		
	Freq (Hz)	**20**	**100**	**250**	**500**	**750**	**1k**	**5k**	**10k**	**15k**	**25k**	**50k**	**75k**	**100k**	**250k**	**500k**	**750k**	**1M**
BV/TV	R^2	0.12	0.04	0.06	0.09	0.12	0.13	0.41	0.69	0.76	0.75	0.70	0.68	0.65	0.53	0.43	0.40	0.41
	p	0.41	0.65	0.55	0.46	0.41	0.38	0.09	0.01	0.01	0.01	0.01	0.01	0.02	0.04	0.08	0.09	0.09
BMD	R^2	0.10	0.03	0.07	0.10	0.12	0.14	0.44	0.73	0.79	0.79	0.75	0.72	0.70	0.58	0.48	0.46	0.47
	p	0.45	0.66	0.53	0.45	0.39	0.36	0.07	0.01	0.00	0.00	0.01	0.01	0.01	0.03	0.06	0.07	0.06
Trab. Num.	R^2	0.24	0.09	0.01	0.02	0.03	0.04	0.21	0.47	0.56	0.60	0.56	0.53	0.50	0.37	0.27	0.25	0.26
	p	0.22	0.46	0.82	0.73	0.68	0.65	0.25	0.06	0.03	0.02	0.03	0.04	0.05	0.11	0.18	0.21	0.20
Trab. Thick.	R^2	0.03	0.03	0.25	0.32	0.38	0.41	0.77	0.77	0.64	0.53	0.49	0.51	0.53	0.57	0.56	0.57	0.57
	p	0.66	0.71	0.21	0.14	0.10	0.09	0.00	0.00	0.02	0.04	0.05	0.05	0.04	0.03	0.03	0.03	0.03
Trab. Sep.	R^2	0.24	0.09	0.01	0.01	0.02	0.02	0.13	0.29	0.36	0.40	0.39	0.37	0.35	0.27	0.20	0.18	0.18
	p	0.22	0.48	0.84	0.78	0.74	0.71	0.39	0.17	0.12	0.09	0.10	0.11	0.12	0.19	0.27	0.30	0.29
Normalized Reactance (X)																		
	Freq (Hz)	**20**	**100**	**250**	**500**	**750**	**1k**	**5k**	**10k**	**15k**	**25k**	**50k**	**75k**	**100k**	**250k**	**500k**	**750k**	**1M**
BV/TV	R^2	0.50	0.39	0.03	0.00	0.00	0.00	0.03	0.06	0.11	0.25	0.58	0.69	0.71	0.67	0.63	0.60	0.59
	p	0.05	0.10	0.67	0.93	0.94	0.88	0.68	0.56	0.43	0.20	0.03	0.01	0.01	0.01	0.02	0.02	0.03
BMD	R^2	0.47	0.36	0.03	0.00	0.00	0.01	0.03	0.06	0.11	0.26	0.60	0.72	0.75	0.72	0.68	0.65	0.64
	p	0.06	0.11	0.70	0.95	0.93	0.87	0.66	0.55	0.41	0.19	0.02	0.01	0.01	0.01	0.01	0.02	0.02
Trab. Num.	R^2	0.63	0.49	0.11	0.03	0.01	0.00	0.00	0.01	0.02	0.11	0.35	0.46	0.49	0.47	0.43	0.41	0.40
	p	0.02	0.06	0.42	0.68	0.81	0.87	0.96	0.86	0.72	0.43	0.12	0.07	0.05	0.06	0.08	0.09	0.09
Trab. Thick.	R^2	0.01	0.02	0.09	0.09	0.10	0.10	0.22	0.32	0.41	0.57	0.76	0.77	0.75	0.70	0.69	0.69	0.69
	p	0.84	0.74	0.46	0.46	0.46	0.44	0.24	0.14	0.09	0.03	0.00	0.00	0.01	0.01	0.01	0.01	0.01
Trab. Sep.	R^2	0.64	0.42	0.11	0.03	0.01	0.00	0.00	0.00	0.01	0.06	0.21	0.28	0.30	0.31	0.28	0.27	0.27
	p	0.02	0.08	0.43	0.70	0.83	0.89	0.96	0.90	0.80	0.57	0.25	0.18	0.16	0.16	0.17	0.18	0.19

Table S3 – Resulting R^2 and p values from regression analyses comparing impedance to quantified µCT indices.
Regression analyses was performed to compare normalized electrical resistance (R) and reactance (X) to each of the reported µCT indices. The resultant R^2 and p values associated with each relationship are provided with 2 significant digits. If the p-value is listed as 0.00, this indicates a value less than 0.01. Significance is set as $p < 0.05$, with significant p-values underlined.