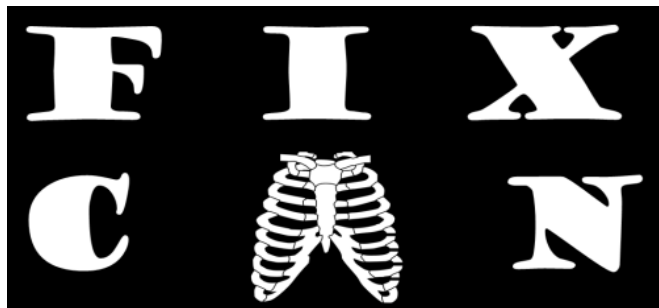


PREVALENCE OF RIB FRACTURE NONUNION AND ASSOCIATION WITH FRACTURE CHARACTERISTICS

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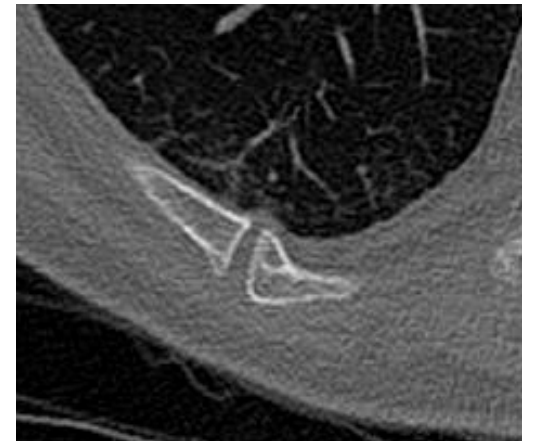
Disclosures

Funding FixCon trial

- ZonMw (Dutch Ministry of Health, Welfare and Sport)
- OTC foundation
- Stichting Coolsingel
- Johnson & Johnson DePuy Synthes

Rib fractures and chronic pain

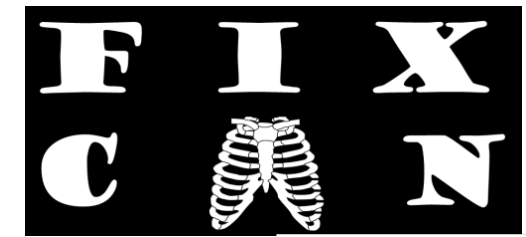
- 40% of patients with rib fractures report pain after 1 year¹
- Normal fracture healing → biological and mechanical factors
- SSRF increasingly popular, but reserved for a selected group
- Possible high prevalence of bone healing problems in non-operative group
- Abnormal rib healing may explain chronic complaints → pain, clicking, dyspnea



Aims

- Determine **prevalence** of nonunion in patients with multiple rib fractures after 6 months
- Investigate **association** between fracture characteristics (total number, rib number, CWIS taxonomy classification) and nonunion
- All patients treated conservatively for rib fractures in FixCon trial

FixCon: multicenter RCT



Inclusion criteria:

- ≥ 18 years
- ≥ 3 rib fractures after blunt trauma
- Shaft width dislocation or severe pain (NRS >6)
- No flail chest or flail segment



Methods

2 chest CT scans:

- 1st: <72 hours after trauma → number of fractures + characteristics
- 2nd: after 6 months → fracture healing versus nonunion (fracture line fully visible)

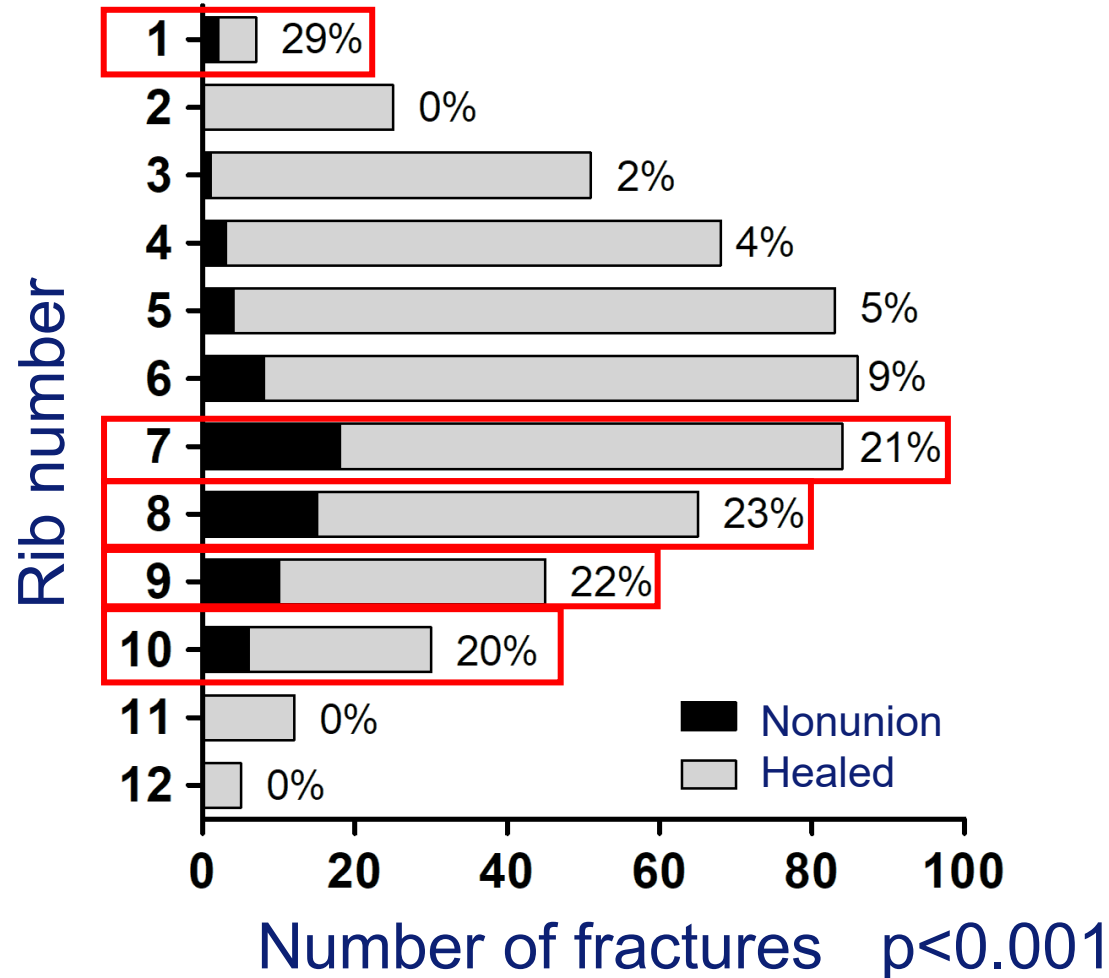
Patients with and without symptoms indicative of nonunion had 6 month CT scan

Patient and injury characteristics

68 patients with 561 fractures: 29 patients (**43%**) and 67 fractures (**12%**) showed nonunion, with median 2 (P_{25} - P_{75} 1-3) nonunions per patient

	≥1 nonunion (N=29)	All fractures healed (N=39)	p-value
Age	67 (59-75)	65 (53-77)	0.660
Male sex	19 (66%)	25 (64%)	1.000
Nr. of broken ribs	7 (5-8)	6 (5-7)	0.710
Nr. of rib fractures	7 (5-11)	8 (6-11)	0.690
Bilateral rib fractures	4 (14%)	4 (10%)	0.715

Nonunion percentage differs per rib



Location of rib fractures and nonunions

Acute rib fractures

Σ	Left side					Rib	Right side					Σ
	PV	P	L	A	CC		CC	A	L	P	PV	
2	0	1	0	1	0	1	0	3	0	1	1	5
13	2	3	5	3	0	2	0	6	1	4	1	12
30	3	6	11	9	1	3	0	5	8	8	0	21
39	3	12	18	6	0	4	0	7	12	8	2	29
49	2	18	24	4	1	5	0	8	14	9	3	34
55	6	17	23	7	2	6	1	4	14	10	2	31
50	7	20	17	3	3	7	1	4	17	9	3	34
36	3	18	10	4	1	8	0	2	17	9	1	29
24	1	13	9	1	0	9	0	2	7	11	1	21
14	1	10	3	0		10		0	5	10	1	16
6	1	3	2			11			0	6	0	6
1	0	1				12				4	0	4
Σ	319	29	122	122	38	8	2	41	95	89	15	242

Nonunions

Σ	Left side					Rib	Right side					Σ
	PV	P	L	A	CC		CC	A	L	P	PV	
1	0	0	0	1	0	1	0	1	0	0	0	1
0	0	0	0	0	0	2	0	0	0	0	0	0
1	0	0	1	0	0	3	0	0	0	0	0	0
3	0	1	1	1	0	4	0	0	0	0	0	0
4	0	2	2	0	0	5	0	0	0	0	0	0
7	0	5	1	0	1	6	1	0	0	0	0	1
13	0	7	3	0	3	7	1	0	3	1	0	5
13	0	7	5	0	1	8	0	0	1	1	0	2
8	0	3	5	0	0	9	0	0	1	1	0	2
6	0	4	2	0		10		0	0	0	0	0
0	0	0	0			11			0	0	0	0
0	0	0	0			12			0	0	0	0
Σ	56	0	29	20	2	5	2	1	5	3	0	11

Nonunion differs per anatomic location

Anatomic location	Nonunion (%)
Costochondral	7/10 (70%)
Anterior	3/79 (4%)
Lateral	25/217 (12%)
Posterior	32/211 (15%)
Paravertebral	0/44 (0%)

p<0.001

Nonunions

Σ	Left side					Rib	Right side					Σ
	PV	P	L	A	CC		CC	A	L	P	PV	
1	0	0	0	1	0	1	0	1	0	0	0	1
0	0	0	0	0	0	2	0	0	0	0	0	0
1	0	0	1	0	0	3	0	0	0	0	0	0
3	0	1	1	1	0	4	0	0	0	0	0	0
4	0	2	2	0	0	5	0	0	0	0	0	0
7	0	5	1	0	1	6	1	0	0	0	0	1
13	0	7	3	0	3	7	1	0	3	1	0	5
13	0	7	5	0	1	8	0	0	1	1	0	2
8	0	3	5	0	0	9	0	0	1	1	0	2
6	0	4	2	0		10		0	0	0	0	0
0	0	0	0			11			0	0	0	0
0	0	0				12			0	0	0	0
Σ	56	0	29	20	2	5	2	1	5	3	0	11

Fracture type is not associated with nonunion

Simple
42 (11%)



Wedge
19 (17%)



Complex
6 (13%)

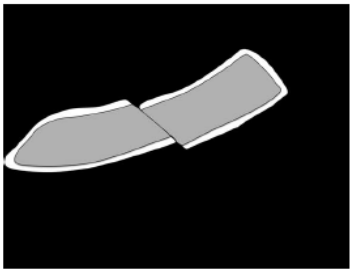


p=0.176

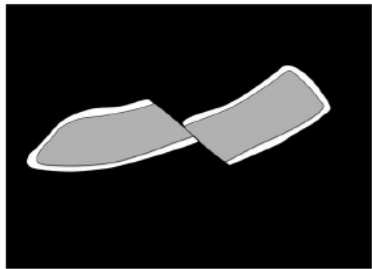
Σ	Left side			Rib	Right side			Σ
	C	W	S		S	W	C	
1	0	1	0	1	1	0	0	1
0	0	0	0	2	0	0	0	0
1	0	0	1	3	0	0	0	0
3	1	1	1	4	0	0	0	0
4	0	3	1	5	0	0	0	0
7	1	4	2	6	1	0	0	1
13	0	5	8	7	5	0	0	5
13	2	2	9	8	1	1	0	2
8	0	2	6	9	1	0	1	2
6	1	0	5	10	0	0	0	0
0	0	0	0	11	0	0	0	0
0	0	0	0	12	0	0	0	0
Σ	56	5	18	33	9	1	1	11

Nonunion rate increases with more dislocation

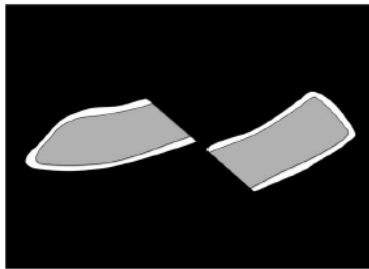
Undisplaced
14 (5%)



Offset
33 (19%)



Displaced
20 (23%)



$p < 0.001$

Σ

	Left side				Right side			
Σ	D	O	U	Rib	U	O	D	Σ
1	0	0	1	1	1	0	0	1
0	0	0	0	2	0	0	0	0
1	0	0	1	3	0	0	0	0
3	1	2	0	4	0	0	0	0
4	2	1	1	5	0	0	0	0
7	3	3	1	6	0	1	0	1
13	3	8	2	7	1	2	2	5
13	5	6	2	8	0	2	0	2
8	2	3	3	9	0	2	0	2
6	2	3	1	10	0	0	0	0
0	0	0	0	11	0	0	0	0
0	0	0	0	12	0	0	0	0
Σ	18	26	12		2	7	2	11

Conclusions

Nonunion occurs in:

- 43% of patients with multiple rib fractures
- 12% of rib fractures

Development of nonunion is associated with:

- Rib number (1, and 7–10)
- Anatomic sector (costochondral)
- Fracture displacement (offset and displaced)

Clinical relevance → not all radiological nonunion are symptomatic, FixCon study results for association radiology and symptoms