

Titel:

PIP joint contact incongruity in different grip positions as a trigger for epiphyseal fatigue fracture in adolescent climbers

Introduction:

Epiphyseal fatigue fractures through the growth plate of the middle phalanx at PIP joint of the middle and ring finger have been observed and described by Hochholzer and Schöffl in 2002 and 2005 and are among the most common climbing specific injuries of the hand in adolescents. Symptoms are subtle and climbers present to medical advice often late with joint surface incongruency, which might lead to early joint degeneration. The object of the study was to evaluate the amount of translation of the middle versus the proximal phalanx of different grip hold positions as an indicator for joint surface incongruity and hence increased pressure and load on the dorsal aspect of the PIP joint, a risk factor of epiphyseal fatigue fractures.

Material and Methods:

31 adolescent elite sport climbers (13 females) with an average age of 13y (range 9-16y) were evaluated ultrasonographically. The climbers were recruited at the Swiss national sportclimbing testing day, a performance test for competition sport climbers in Switzerland. Ethical committee approval and informed consent of the participants and their parents was obtained. Open grip, half-open grip and crimp grip position of the middle and ring finger of both sides was investigated in unloaded and maximally loaded situations on standard campus board ledge of 2cm depth. Left and right hand was measured separately. A special fixation device for the ultrasonographic probe to the dorsal aspect of the middle phalanx and the head of the proximal phalanx (PIP joint) was built (3d print) to be able for positioning the probe at the same place for all measurements (Fig 1). All finger positions were depicted in loaded and unloaded situation. The ultrasonographic pictures were uploaded to the PACS system and measurements were conducted with common PACS measuring tools. A line was set along/parallel to the dorsal aspect of the middle phalanx and a second line parallel to the first line as a tangent to the head of the proximal phalanx. The distance between the two lines was measured. The difference of the distance of the two lines in loaded and unloaded position of the finger is the amount of dorso-palmar translation of the middle versus the proximal phalanx (Figure 2). Measurements were conducted by one of the author N.B. Statistical evaluation was performed with paired students t- test, differences were assumed to be significant if $p < 0.05$.

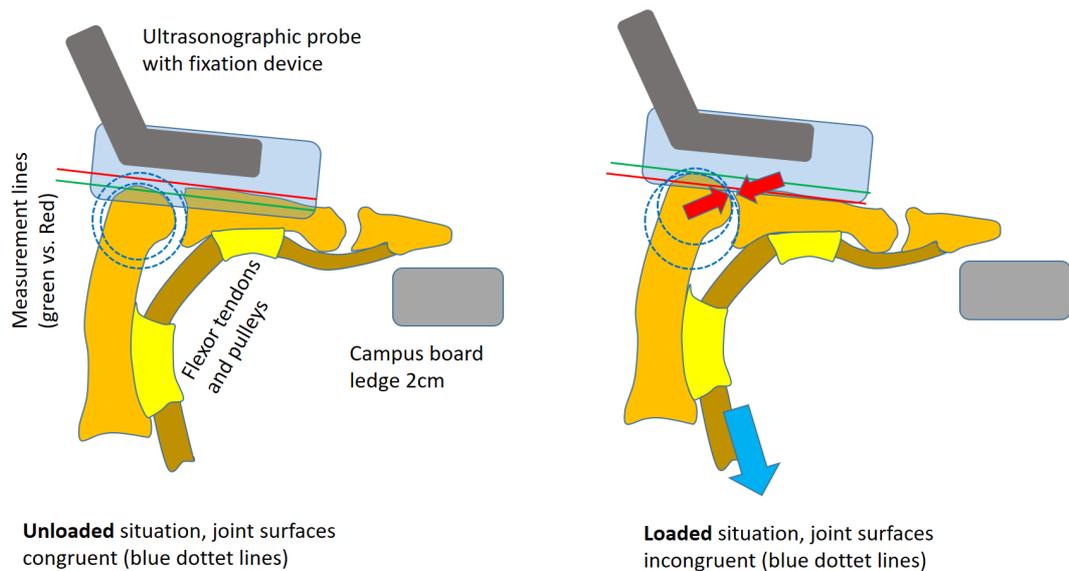


Fig. 1: Arrangement of measurements for crimp grip position in unloaded and unloaded position. Distance between of red and green lines were measured, if red line crossed green line, value was recorded as negative. Joint contact surface incongruity made visible with blue dotted circles (congruent in unloaded, incongruent in loaded position) resulting in punctual peak forces only at the dorsal area of the PIP joint (red arrows).

Results:

The palmar translation of the middle phalanx was significantly greater in the crimp grip positions compared to the open and half-open positions. There were no significant differences between the half-open and the open finger positions. Average palmar translation distances after application of load for crimp grip / half-open / open position was 0.86mm / 0.13mm / 0.02mm (Dig. III L), 0.64mm / 0.21mm / 0.26mm (Dig. IV L), 0.52mm / 0.06mm / 0.4mm (Dig. III R) and 0.62mm / 0.19mm / 0.07mm (Dig. IV R) as shown in Table 1, 2.

	open		half-open		crimp	
values in mm	mean	SD	mean	SD	mean	SD
Dig III Left	0.019	0.191	0.131	0.265	0.858	0.417
Dig IV Left	0.257	0.215	0.212	0.326	0.639	0.354
Dig III Right	0.403	0.367	0.056	0.258	0.519	0.364
Dig IV Right	0.073	0.367	0.193	0.303	0.619	0.338

Table 1: Translation of the middle versus the proximal phalanx between unloaded and loaded situation for 3 different finger positions.

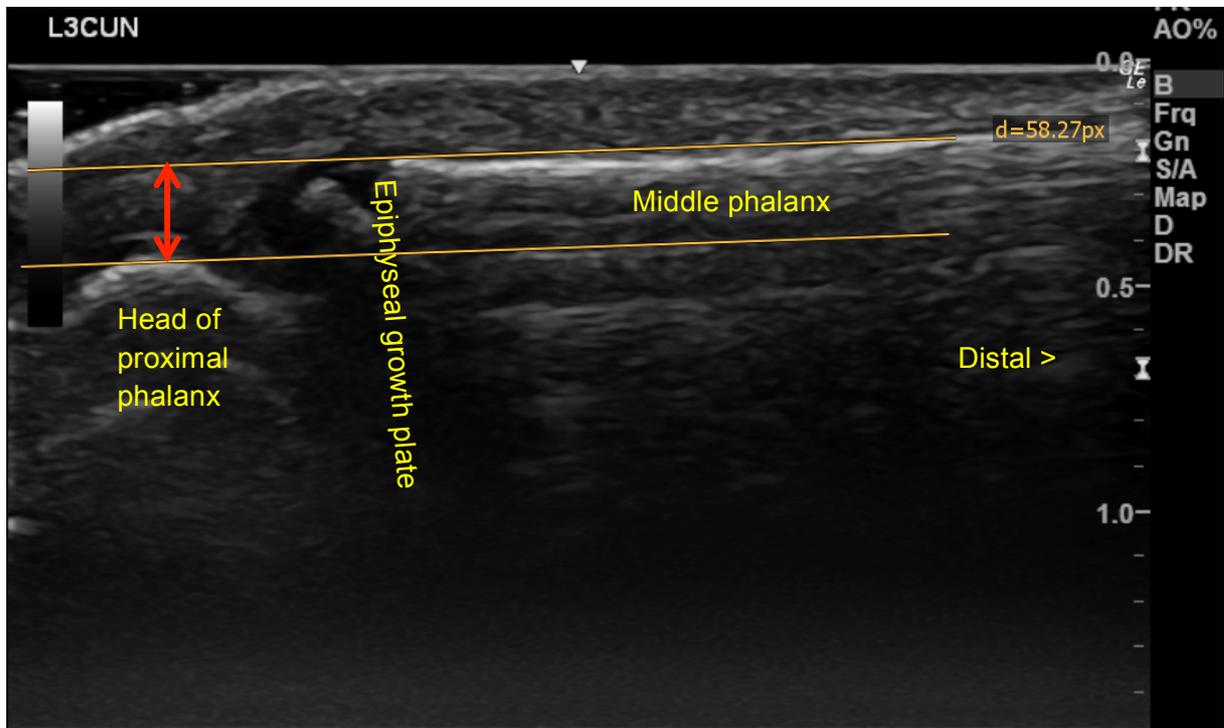
p-value	open vs. crimp	half open vs. crimp	open vs. half open
Dig III Left	<0.001	<0.001	0.077
Dig IV Left	<0.001	<0.001	0.213
Dig III Right	<0.001	<0.001	0.430
Dig IV Right	<0.001	<0.001	0.120

Table 2: Significant differences between crimp and open or half open grip could be shown, no significant differences between open and half open was apparent.

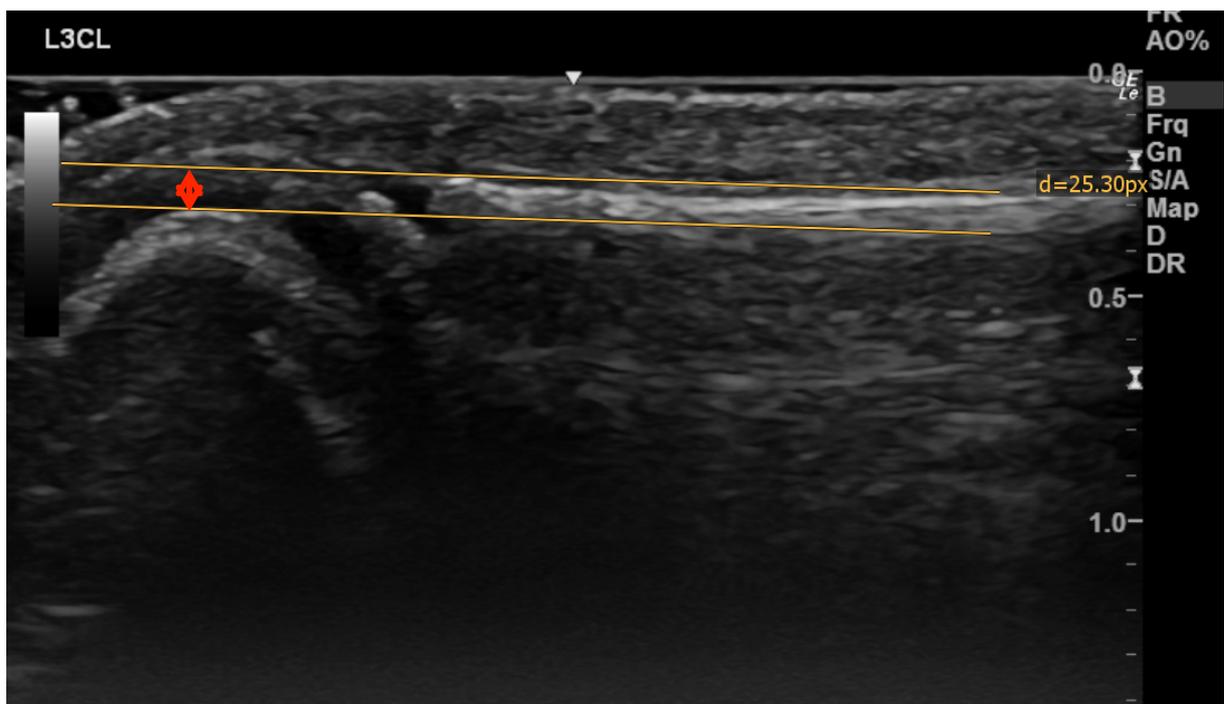
Discussion:

Crimp grip position is assumed to be a risk factor for epiphyseal fatigue fracture (Hochholzer et al. 2002) in adolescent competitive sport climbers and may lead to joint surface incongruity (step, gap) if treatment is neglected. Later degenerative changes and arthritis may follow. The mechanism of injury is supposed to be an increase of pressure at the dorsal part of the PIP joint as the fragment is found always at dorsal part of base of the middle phalanx (Bayer et al. 2013). We evaluated the translation or shift of the middle versus the proximal phalanx in PIP joint during the 3 most commonly used finger position in sport climbing, crimp grip, half-open grip and open grip. We found the greatest translation in crimp grip position which was up to almost 0.9mm during maximal load. There was no difference between the open and half-open grip position where the translation was much less, between 0.02 and 0.4mm. These two positions can probably be applied with similar much lower risk for overload at the PIP joint (Fig. 2).

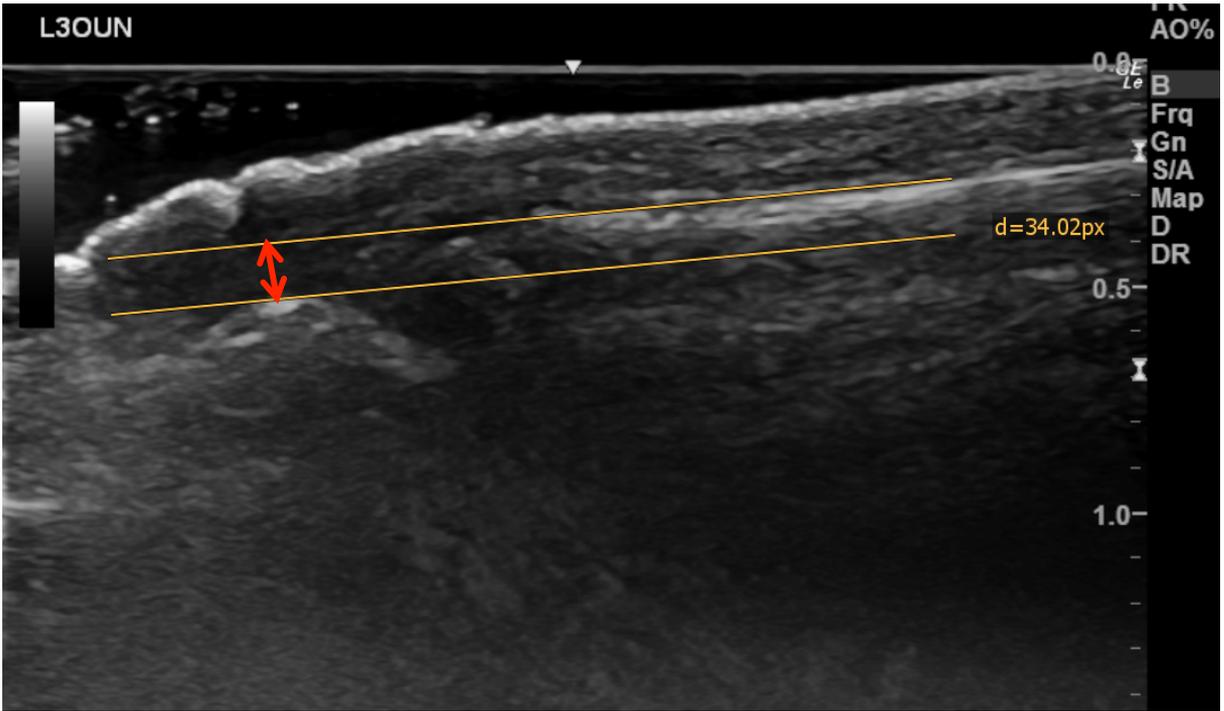
Fig. 2: Example of a loaded and unloaded situation in crimp grip and open position, measurement lines in yellow, distance measured in red arrow



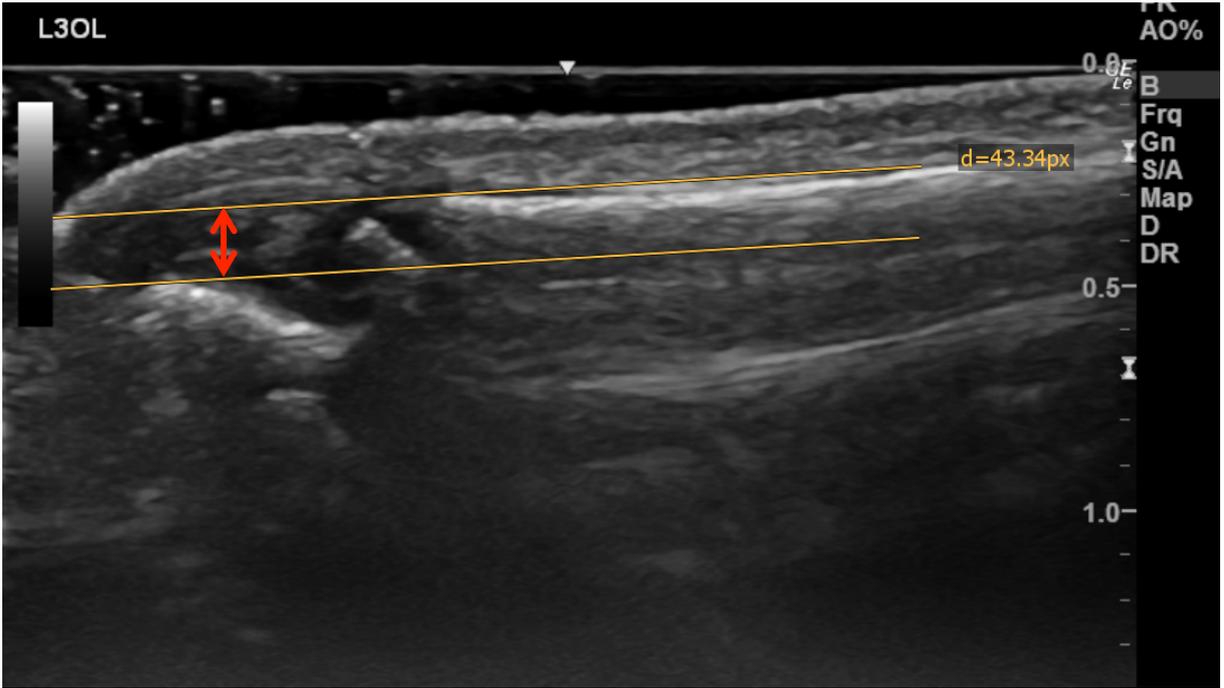
PIP joint in crimp grip position unloaded



PIP joint in crimp grip position loaded



PIP joint in open grip position unloaded



PIP joint in open grip position loaded

In conclusion palmar translation of the middle phalanx in the PIP joint results in greater joint surface contact incongruity compared to open and half-open grip position and increased load at the dorsal area of the PIP joint which may provoke epiphyseal fatigue fracture. Use of crimp grip position in adolescent climbers should therefore be applied with great care until growth plates at the middle phalanges are closed.

References:

Hochholzer T, Schöffl VR. Epiphyseal fractures of the finger middle joints in young sport climbers. *Wilderness Environ Med.* 2005 Fall;16(3):139-42.

Hochholzer TH, Schöffl V, Bischof B. Epiphysenfrakturen der Fingermittelgelenke bei Sportkletterern. *Sport Orthop Traumatol.* 2002;18:87–92.

Bayer T, Schöffl VR, Lenhart M, Herold T. Epiphyseal stress fractures of finger phalanges in adolescent climbing athletes: a 3.0-Tesla magnetic resonance imaging evaluation. *Skeletal Radiol.* 2013 Nov;42(11):1521-5.