Impact Of Tonic-Clonic Seizure Frequency On Glenoid Retroversion In Epileptic Patients

Davide Cucchi, MD, Tobias Baumgartner, MD, Jan Pukropski, MD,
Filippo Maria Piana Jacquot, MD, Amadeo Touet, MD,
Alessandra Menon, PhD, Pietro S. Randelli, MD

Department of Orthopaedics and Trauma Surgery, University Hospital Bonn

ISAKOS CONGRESS 2025 | MUNICH GERMANY June 8–11

UNIVERSITÄT BONN

ukb universitätsklinikumbonn

Financial disclosures:

Lima, Exatech (travel/accommodation reimbursement) outside the presented work

Journal of Experimental Orthopaedics (associate editor)

Epilepsy and musculoskeletal injuries

Epilepsy patients VS general population: ↑ accidental injuries and fractures
(Beghi et al., 2002; Persson et al., 2002; Téllez-Zenteno et al., 2008; Kwon et al., 2010)

Fracture risk: 1.91 - 2.45
(Vestergaard et al., 1999; Persson et al., 2002; Vestergaard, 2005; Asadi-Pooya et al., 2012)

↑ access to emergency department, hospitalization

↑ fracture sequelae and injury-related disabilities

↓ quality of life (Friedman et al., 2012)

General risk factors for sustaining fractures in patients with epilepsy and seizures
1st tonic-clonic seizure
seizure frequency
type of seizure (tonic-clonic >> atonic, tonic, myoclonic)
generalized onset
inappropriate patient positioning during seizure
psychiatric comorbidities
less independent living situation
number & type of ASMs
response to therapy
patients' compliance with ASMs

Mechanisms of injury

Uncontrolled powerful muscular contraction
(tonic-clonic seizures)

Unprotected fall
(tonic, atonic, tonic-clonic or myoclonic seizures)

Loss of consciousness during other activities (motor vehicle accidents, falls…)

Aboukasm, 1997; Kristiansen & Christensen, 1984; Vestergaard et al., 1999

AEDs

- reduction of bone mineral density
- sedation, gait insecurity: ↑ increasing risk of falling

Stephen et al., 1999; Pack et al., 2003; Souverein et al., 2005; Carbone et al., 2009; Tan & D'Souza, 2013; Petty et al., 2016

Mechanisms of injury

Uncontrolled powerful muscular contraction
(tonic-clonic seizures)

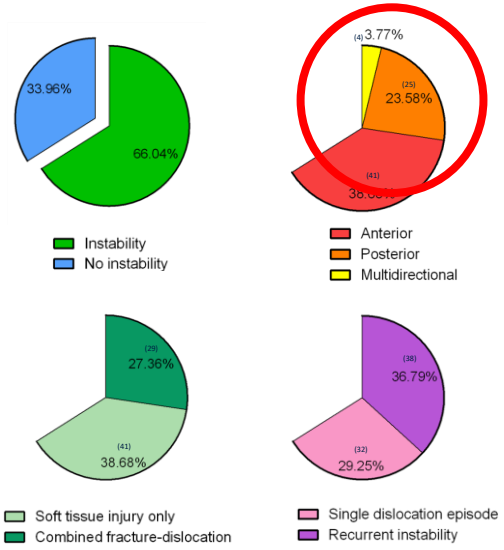
"Figure-of-four" position during seizure = adduction, internal rotation, and flexion
+ contraction of the infraspinatus, teres minor, deltoid, latissimus dorsi, teres major

Alternative: "fencing position" = one arm in abducted and externally rotated position

Atwan et al., 2023; DeToledo et al., 1999; Goudie et al., 2012

Just like all other injuries?

Dislocations



Cucchi et al., AOTS 2022

Predominantly anterior....	.... but ↑ % posterior (compared to general population)	
50% (Bühler & Gerber, JSES 2002)	**50%** posterior	
73% (Thangarajah & Lambert, JSES 2015)	**18%** posterior	9% multidirectional
58.6% (Cucchi et al., AOTS 2022)	**35.7**% posterior	5.7% multidirectional

Trauma dynamics?

Muscular activation important but not exclusive!

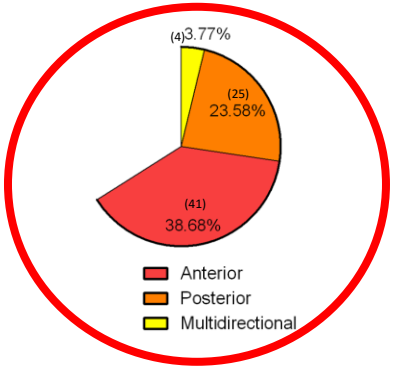
Uncontrolled muscle activation → both anterior and posterior dislocations

Posterior dislocations also after direct fall on the arm/shoulder

Muscle activation timing and pattern?

Patient's anatomy?

Open questions:



Does epilepsy alter the anatomy of the shoulder?

of the glenoid

of the acromion

How do exactly these lesions occurr?

How does the underliying neurological pathology affect results?

Study design

Prospective radiological investigation

Ethic committee approval: Ethikkommission an der Medizinischen Fakultät der Rheinischen Friedrich-Wilhelms-Universität Bonn, No. ID 534/20).

Primary goal:

Measure the **glenoid version** in epileptic patients

relate its value to the tonic-clonic seizure burden

Axial MRI scans (Chest MRI Scans)

Materials and methods

Inclusion criteria:

clinically diagnosed epilepsy

patient willing to undergo an additional MRI investigation

Exclusion criteria:

underlying kidney insufficiency, cardiac disease,

pregnancy, use of intrauterine devices for contraception

not or only partially MRI-safe cardiac pacemaker or other medical implants

(e.g. cochlear implants, aneurysm clips)

Materials and methods

Power analysis:

"no BuRST" group VS "high BuRST" group

BuRST = cumulative Burden of Recurring Seizure over Time

= duration of epilepsy * n. of yearly tonic-clonic seizures

physiological angle of 3° retroversion considered for "no BuRST"

effect size of 2 was postulated for "high BuRST" group

power >80% with a significance level set at 5% (two-tailed).

28 patients per group

Materials and methods

Outcome measures:

Epilepsy-related:

BuRST = $n_{\text{tonic-clonic seizures/year}} \cdot t_{\text{epilepsy (years)}}$

approximates the number of tonic-clonic episodes over the lifetime of the patient

<u>Grouping:</u>

TCSB = 0 (no BuRST)

TCSB < 40 (low BuRST)

TCSB ≥ 40 (high BuRST)

Shoulder-related:

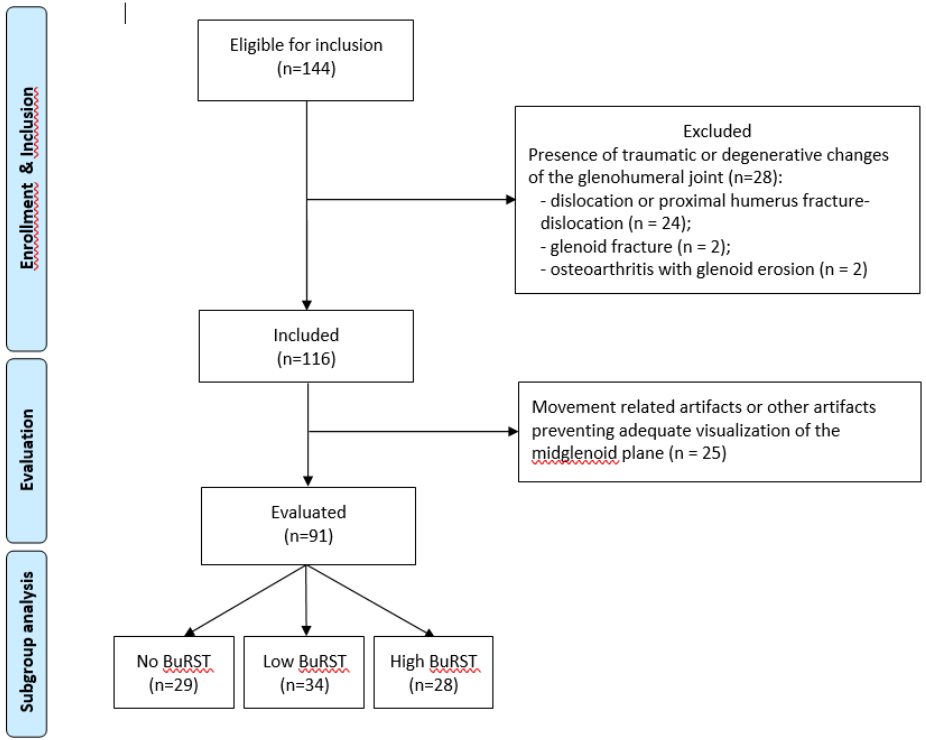
Glenoid version

Glenoid vault angle

Scapulohumeral subluxation index

Two independent observers, duplicate

Results



Patient Characteristics	
Sex (M/F)	42/49 (46,2%/53,8%)
Age (years)	
Mean ± SD	38.49 ± 14.31
Median [Q1-Q3]	37.43 [27.92-46.03]
BMI (kg/m²)	
Mean ± SD	25.74 ± 5.21
Median [Q1-Q3]	24.93 [22.21-28.83]
Duration of epilepsy (years)	
Mean ± SD	13.07 ± 11.81
Median [Q1-Q3]	11 [3.00-19.50]
Age at epilepsy onset (years)	
Mean ± SD	21.05 ± 12
Median [Q1-Q3]	19.1 [12.95- 27.05]
BuRST	
Mean ± SD	67.71 ± 148.17
Median [Q1-Q3]	10 [1.0- 54.0]

Results: demographics and radiological variables

Variable		No BuRST (N=29)	Low BuRST (N=34)	High BuRST (N=28)	Total (N=-1)	p-value
Sex	M/F (%)	14/15 (48,3%/51,7%)	16/18 (47,1%/52,9%)	12/16 (42,9%/57,1%)	42/49 (46,2%/53,8%)	n.s.
Age (years)	Mean ± SD	40.19 ± 16.29	37.16 ± 13.44	38.36 ± 13.46	38.49 ± 14.31	n.s.
	Median [Q1-Q3]	37.23 [31.33-48.06]	37.41 [26.18-45.09]	38.55 [29.77-44.76]	37.43 [27.92-46.03]	
BMI (kg/m^2)	Mean ± SD	24.00 ± 4.09	27.07 ± 5.82	25.93 ± 5.12	25.74 ± 5.21	n.s.
	Median [Q1-Q3]	23.55 [21.22-25.62]	27.50 [23.33-29.30]	24.93 [21.77-29.44]	24.93 [22.21-28.83]	
Duration of epilepsy (years)	Mean ± SD	9.69 ± 10.85	9.16 ± 8.45	21.32 ± 12.39	13.07 ± 11.81	<0.001
	Median [Q1-Q3]	8.00 [1.00-15.00]	6.50 [3.00-13.00]	22.00 [12.75-29.50]	11.00 [3.00-19.50]	
Age at epilepsy onset (years)	Mean ± SD	19.68 ± 12.90	25.78 ± 12.60	17.04 ± 9.13	21.05 ± 12.00	0.031
	Median [Q1-Q3]	19.29 [11.78-22.98]	20.68 [15.72-34.29]	16.70 [10.10-20.47]	19.10 [12.95-27.05]	
Glenoid version angle (°)	Mean ± SD	-1.93 ± 4.02	-3.80 ± 4.34	-6.67 ± 4.73	-4.09 ± 4.71	<0.001
	Median [Q1-Q3]	-1.37 [0.86- -4.27]	-3.81 [-1.03- -7.51]	-5.83 [-2.98- -9.78]	-3.83 [-0.70- -7.36]	
Glenoid vault angle (°)	Mean ± SD	-12.78 ± 3.81	-16.58 ± 4.02	-20.66 ± 4.35	-16.54 ± 5.08	<0.001
	Median [Q1-Q3]	-12.84 [-9.97- -14.52]	-16.10 [-13.73- -19.60]	-19.95 [-18.24- -23.51]	-15.62 [13.18- -19.97]	
Subluxation index (%)	Mean ± SD	51.2 ± 4.7	54.6 ± 5.2	55.9 ± 5.1	53.9 ± 5.4	<0.001
	Median [Q1-Q3]	50.5 [48.1-54.0]	53.5 [51.5-57.7]	55.6 [51.4-58.8]	53.0 [49.3-57.0]	

Results: multiple comparisons

Pairwise comparison: ANOVA results computed for simultaneous tests for general linear hypotheses, multiple comparisons of means. Adjusted p values are reported, with Bonferroni method of correction.

	Comparison			Estimate	Std, Error	t value	Pr(>|t|)	p-value
Glenoid version angle (°)	Low BuRST	-	No BuRST	1,873	1,103	1,699	0,278729	n.s.
	High BuRST	-	No BuRST	4,744	1,156	4,104	0,000271	***
	High BuRST	-	Low BuRST	2,871	1,113	2,578	0,034771	*
Glenoid vault angle (°)	Low BuRST	-	No BuRST	3,795	1,031	3,680	0,001225	**
	High BuRST	-	No BuRST	7,879	1,094	7,200	6,7e-10	***
	High BuRST	-	Low BuRST	4,084	1,062	3,844	0,000699	***
Subluxation index (%)	Low BuRST	-	No BuRST	0,03390	0,01069	3,170	0,006313	**
	High BuRST	-	No BuRST	0,04678	0,01113	4,202	0,000191	***
	High BuRST	-	Low BuRST	0,01288	0,01080	1,193	0,708397	n.s.

Results

Reproducibility of measurements assessed by single score intraclass correlation Pairwise comparison

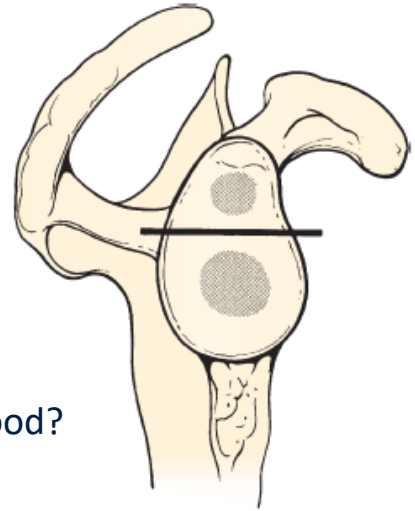
	Intra-rater				Inter-rater			
	ICC(1)	F-Test (df1, df2)	p-value	95% Confidence Interval	ICC(1,2)	F-Test (df1, df2)	p-value	95% Confidence Interval
Glenoid version angle, right	0,864	F(73,74) = 13,7	5,59e-24	0,792 < ICC < 0,912	0,652	F(78,78,7) = 4,73	2,68e-11	0,505 < ICC < 0,763
Glenoid version angle, left	0,806	F(68,69) = 9,31	1,26e-17	0,705 < ICC < 0,875	0,688	F(70,48,8) = 5,89	7,68e-10	0,524 < ICC < 0,799
Glenoid vault angle, right	0,913	F(82,83) = 22	2,46e-34	0,869 < ICC < 0,943	0,742	F(83,50,9) = 7,41	2,18e-12	0,606 < ICC < 0,832
Glenoid vault angle, left	0,845	F(75,76) = 11,9	1,36e-22	0,766 < ICC < 0,899	0,696	F(77,66,1) = 5,87	2,91e-12	0,555 < ICC < 0,796
Subluxation index, right	0,719	F(72,73) = 6,13	1,95e-13	0,588 < ICC < 0,814	0,590	F(77,78) = 3,9	3,92e-09	0,425 < ICC < 0,717
Subluxation index, left	0,611	F(68,69) = 4,14	8,31e-09	0,439 < ICC < 0,739	0,492	F(69,69,6) = 2,93	6,61e-06	0,292 < ICC < 0,651

Good to excellent reproducibility for angular measurements and moderate to good for subluxation measurements

Results (summary)

Patients with a higher cumulative burden of recurring tonic-clonic seizure and still without episodes of shoulder instability show a higher glenoid retroversion and posterior scapulohumeral subluxation as compared to patients with no or rare tonic-clonic episodes

Discussion



Plasticity of the glenoid during development

2 ossification centres of the glenoid: fusion with the scapula at 15-17 years

→ altered version of the glenoid after tonic clonic seizures in childhood?

Limitations

Only axial MRI reconstruction; Measurement of the shape of the acromion not possible

References

- Atwan Y, Wang A, Labrum JT, Sanchez-Sotelo J, Barlow JD, Dines JS, et al. Management of Shoulder Instability in Patients with Seizure Disorders. Curr Rev Musculoskelet Med. 2023 May;16(5):201–10.
- Thangarajah T, Lambert SM. Management of recurrent shoulder instability in patients with epilepsy. J Shoulder Elbow Surg. 2016 Aug 20;25(8):1376–84
- Cucchi D, Walter SG, Baumgartner T, Menon A, Egger L, Randelli PS, et al. Poor midterm clinical outcomes and a high percentage of unsatisfying results are reported after seizure-related shoulder injuries, especially after posterior proximal humerus fracture-dislocations. J Shoulder Elbow Surg. 2024 Jun;33(6):1340–51.
- Bühler M, Gerber C. Shoulder instability related to epileptic seizures. J Shoulder Elbow Surg. 2002 Jul;11(4):339–44.
- Cucchi D, Baumgartner T, Walter SG, Menon A, Ossendorff R, Surges R, et al. Epidemiology and specific features of shoulder injuries in patients affected by epileptic seizures. Arch Orthop Trauma Surg. 2023 Apr;143(4):1999–2009.

Team

Tobias Baumgartner, MD
Jan Pukropski, MD
Arthur Jordan, MD
Rainer Surges, MD
Pietro S. Randelli, MD
Alessandra Menon, PhD
Richard J. Freytag, BPt
Filippo M. P. Jacquot, MD
Lisa Egger
Sofia Fragedakis
Jan Petersen

d.cucchi@gmail.com