S. Gumina

My current conceptions on surgical treatment of complex humeral head fractures.

Full Professor, Sapienza, University of Rome – Italy

Past President Italian Society for the Shoulder and Elbow Surgery

President 15° International ICSES, Rome 2023)

President International Society for Technology in Arthroplasty (ISTA – Rome) 2025)

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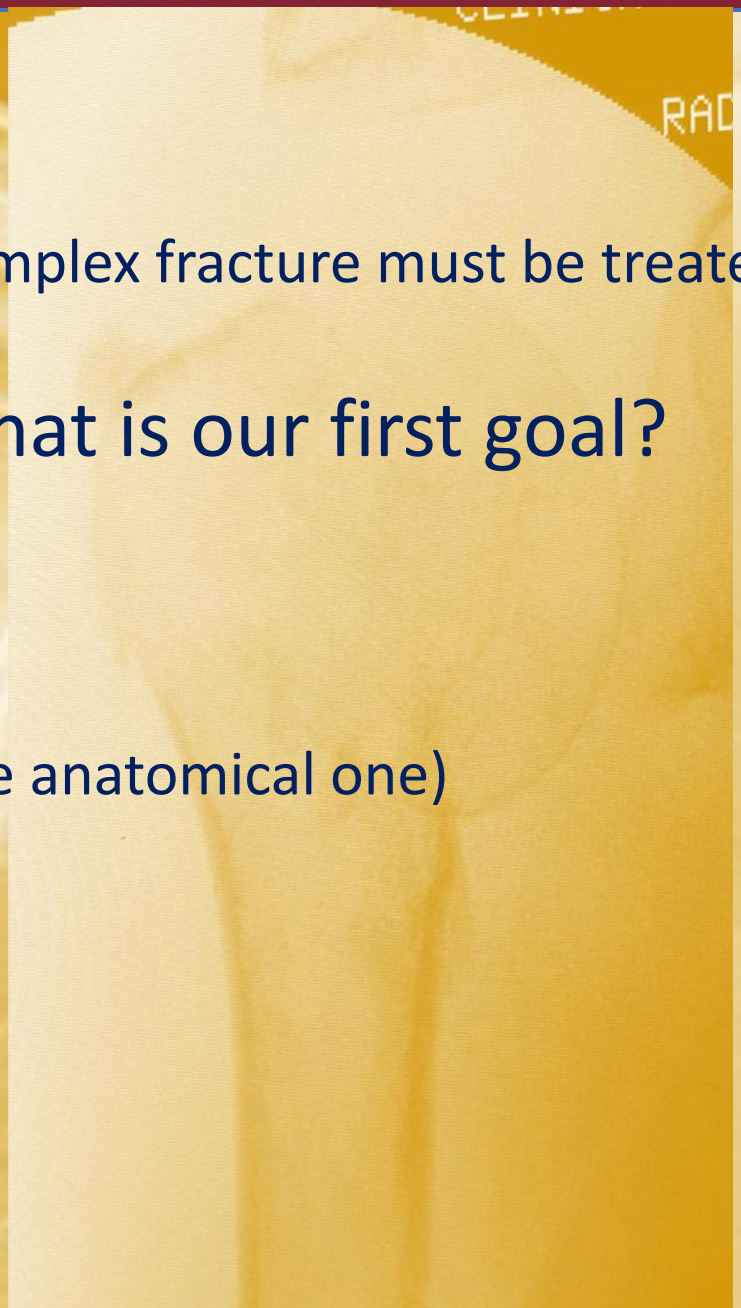

If we exclude that the complex fracture must be treated with a prosthesis

what is our first goal?

- Reduction

(as close as possible to the anatomical one)

(Primary healing)

- Everyone performs it according to:
  - tradition
  - experience
  - ability

tradition – experience - ability

My current conceptions on surgical treatment of complex humeral head fractures

- Everyone performs it according to:
  - tradition
  - experience
  - ability

Once the reduction is obtained, and temporarily stabilized

Which are our second third and fourth goals?

2nd goal:

stable fixation

which prevents, in post-op period, rotation and translation of the HH

3rd goal:

fixation that does not hinder healing

(Secondary healing)

hematoma: (activation of coagulation cascade; release inflammatory mediators)
internal callus (bone marrow, mesenchymal stem cells)
external callus: muscles and periosteum

4th goal:

fixation that reduces the major complication rate

avascular necrosis
infections
non union
sintering

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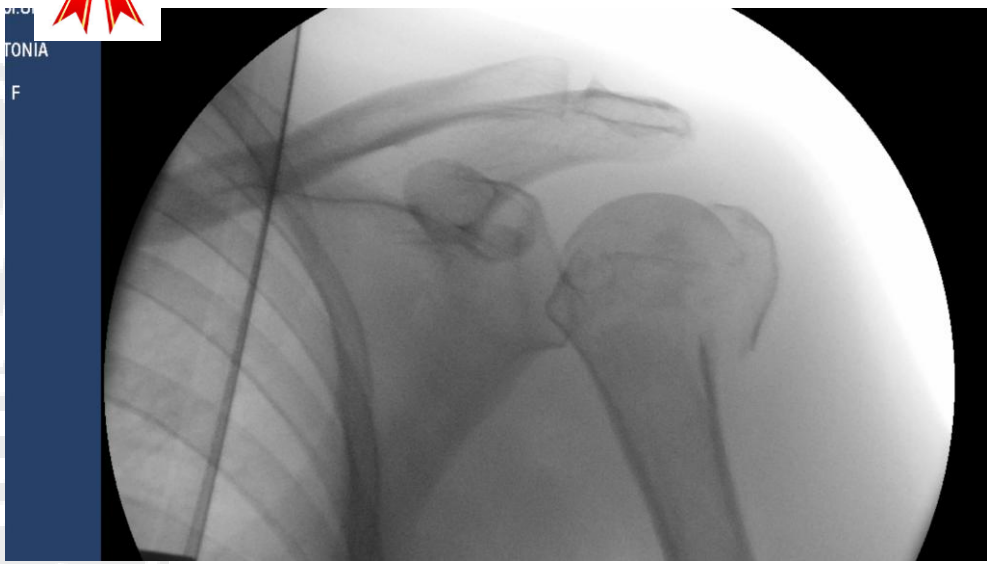

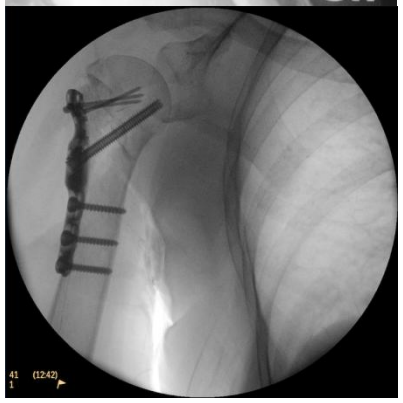

Our cases, plates with different shapes, profiles and radiolucent

Complication%.....

2016

Hertel 7 fracture of the humeral head. Can two different fixation systems (Diphos/PHP) lead to different outcomes? A retrospective study

S. Gumina, PhD MD, Prof.[a,*], P. Baudi, MD[b], V. Candela, MD[a], G. Campochiaro, MD[b]

[a] Section of Orthopaedics and Traumatology, Shoulder and Elbow Unit, Sapienza University, Rome, Italy
[b] Section of Orthopaedics and Traumatology, University of Modena, Italy

Complications: 9.6%

- Avascular necrosis
- Non union
- Sintering

My current conceptions on surgical treatment of complex humeral head fractures

Laux et al. Journal of Orthopaedic Surgery and Research (2017) 12:137
DOI 10.1186/s13018-017-0639-3

Journal of Orthopaedic Surgery and Research

2017

REVIEW Open Access

Current concepts in locking plate fixation of proximal humerus fractures

Christoph J. Laux[1*], Florian Grubhofer[2], Clément M. L. Werner[1], Hans-Peter Simmen[1] and Georg Osterhoff[1]

Abstract: Despite numerous available treatment strategies, the management of complex proximal humeral fractures remains demanding. Impaired bone quality and considerable comorbidities pose special challenges in the growing aging population. Complications after operative treatment are frequent, in particular loss of reduction with varus malalignment and subsequent screw cutout. Locking plate fixation has become a standard in stabilizing these fractures, but surgical revision rates of up to 25% stagnate at high levels. Therefore, it seems of utmost importance to select the right treatment for the right patient. This article provides an overview of available classification systems, indications for operative treatment, important pathoanatomic principles, and latest surgical strategies in locking plate fixation. The importance of correct reduction of the medial cortices, the use of calcar screws, augmentation with bone cement, double-plate fixation, and auxiliary intramedullary bone graft stabilization are discussed in detail.

major complications affect 25% pts (re-operation)

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My current conceptions on surgical treatment of complex humeral head fractures

J Shoulder Elbow Surg (2020) ■, 1–6

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2020

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

Locking plate fixation of proximal humerus fractures in patients older than 60 years continues to be associated with a high complication rate

Jonathan D. Barlow, MD*, Anthony L. Logli, MD, Scott P. Steinmann, MD, Stephen A. Sems, MD, William W. Cross, MD, Brandon J. Yuan, MD, Michael E. Torchia, MD, Joaquin Sanchez-Sotelo, MD, PhD

Table I Failure rate based on patient age

Failure by age	Failures, n	Total patients (n)	%
60-64	7	26	27
65-69	8	31	26
70-74	7	23	30
75-79	10	20	50
80-84	6	13	46
85-89	6	12	50
≥90	0	6	0
	44	131	34

- Complication rate: 44%
- Failure rate: 34%
- Reoperation rate: 11%

- AVN with severe head collapse (52% of failures),
- delayed intra-articular screw penetration (14% of failures)

Failure increases with increasing age and fracture complexity

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Role??!!

SYSTEMATIC REVIEW Open Access

Effect of intramedullary nail and locking plate in the treatment of proximal humerus fracture: an update systematic review and meta-analysis

Xiaoqing Shi, Hao Liu, Runlin Xing, Wei Mei, Li Zhang, Liang Ding, Zhengquan Huang and Peimin Wang*

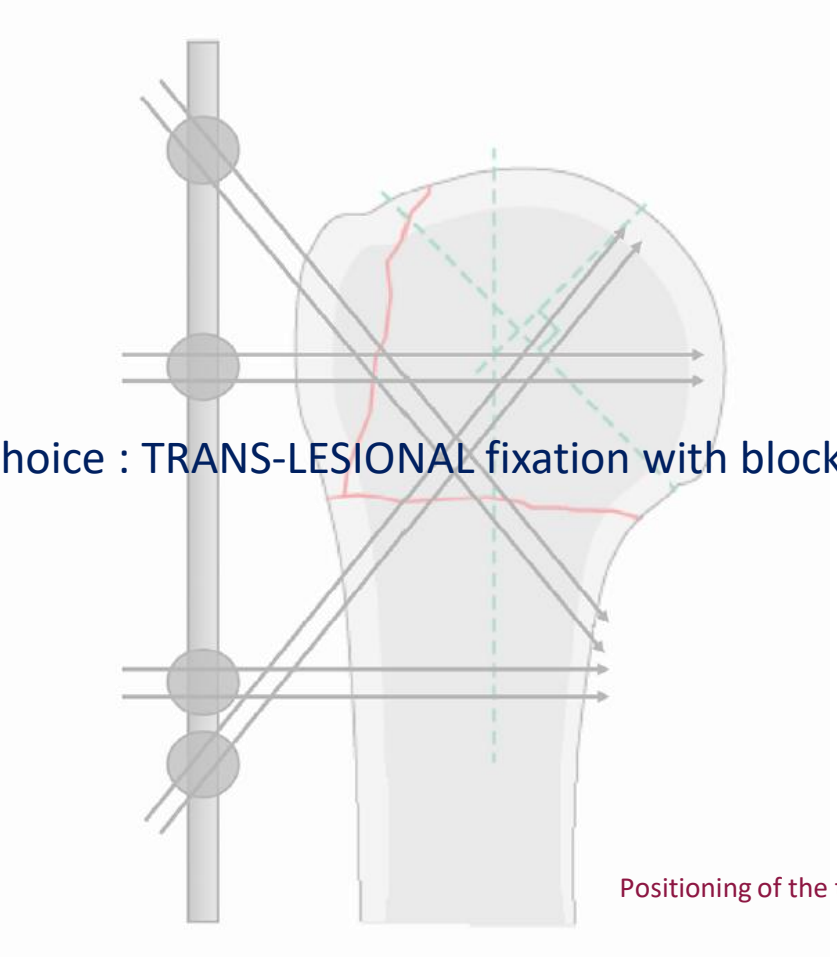
Conclusions:

The intramedullary nail is superior to locking plate in:

- reducing the total complication
- intraoperative blood loss
- operative time
- postoperative fracture healing time
- postoperative humeral head necrosis rate

2019

My current conceptions on surgical treatment of complex humeral head fractures



My current choice : TRANS-LESIONAL fixation with blocked threaded wires

Positioning of the threaded wires: no random!!!!!

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«Trans-lesional»: suggested term by (my friend) Marco Massobrio

My current conceptions on surgical treatment of complex humeral head fractures

J Shoulder Elbow Surg (2018) ■■, ■■–■■

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JOURNAL OF SHOULDER AND ELBOW SURGERY

www.elsevier.com/locate/ymse

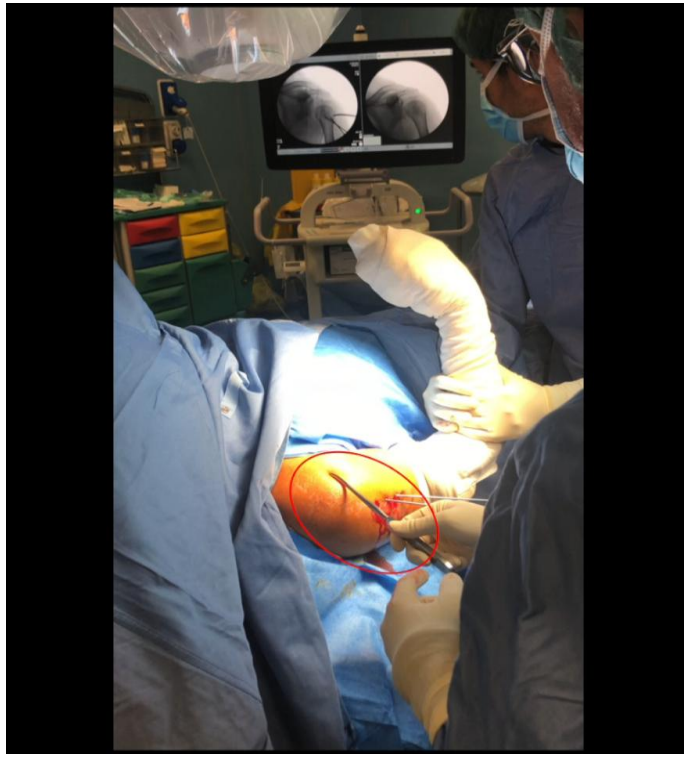
ORIGINAL ARTICLE

Complex humeral head fractures treated with blocked threaded wires: maintenance of the reduction and clinical results with two different fixation constructs

Stefano Gumina, PhD, MD[a], Vittorio Candela, MD[a,*], Giuseppe Giannicola, MD[b], Luigi Orsina, PhD[c], Daniele Passaretti, MD[b], Ciro Villani, PhD, MD[b]

our series of three-part (Hertel 7) humeral head fracture treated with
deltopect approach and trans-lesional fixation
(ISOSTATIC CONSTRUCT)
with blocked threaded wires

2019



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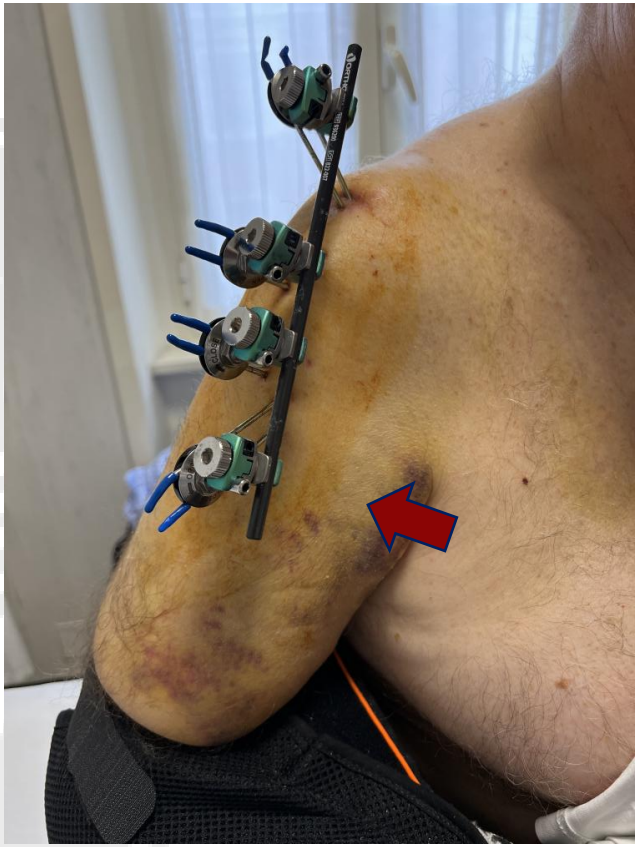
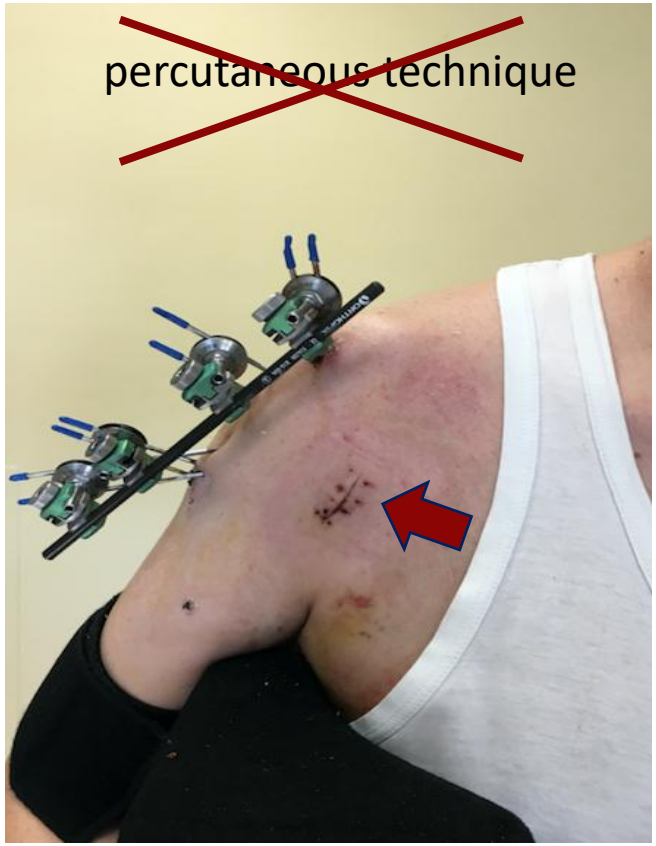
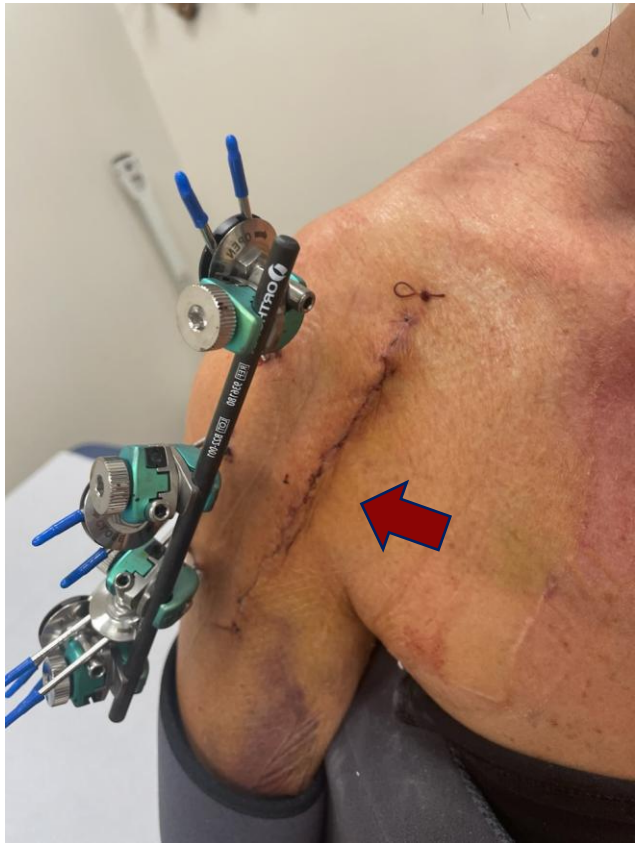
My current conceptions on surgical treatment of complex humeral head fractures







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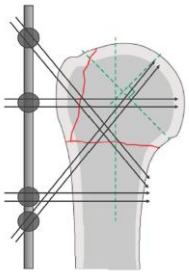
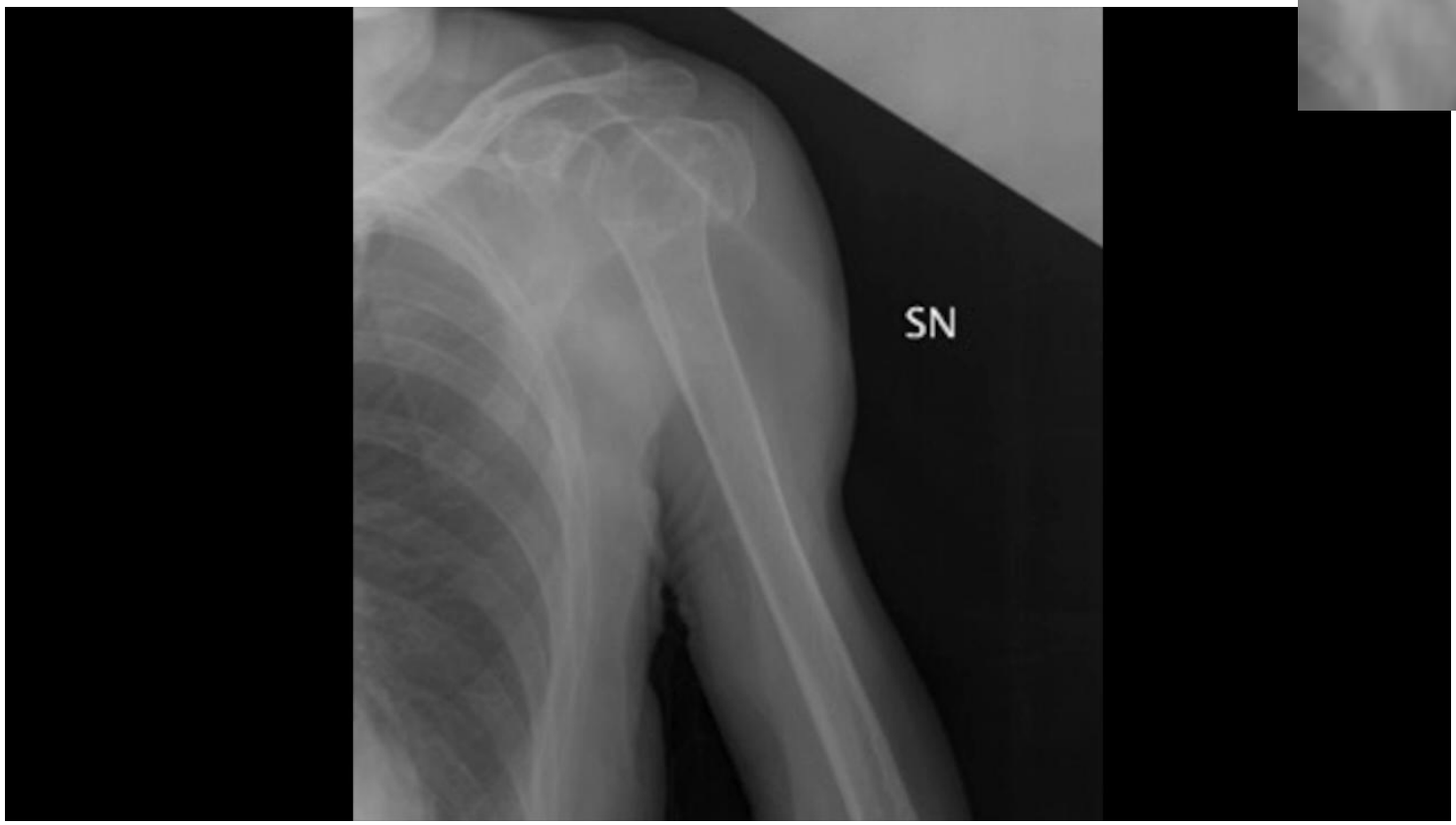
My current conceptions on surgical treatment of complex humeral head fractures



Consecutive series of complex proximal humeral fractures treated with blocked threaded wires
In a NEW CONFIGURATION

Hertel 7 fracture



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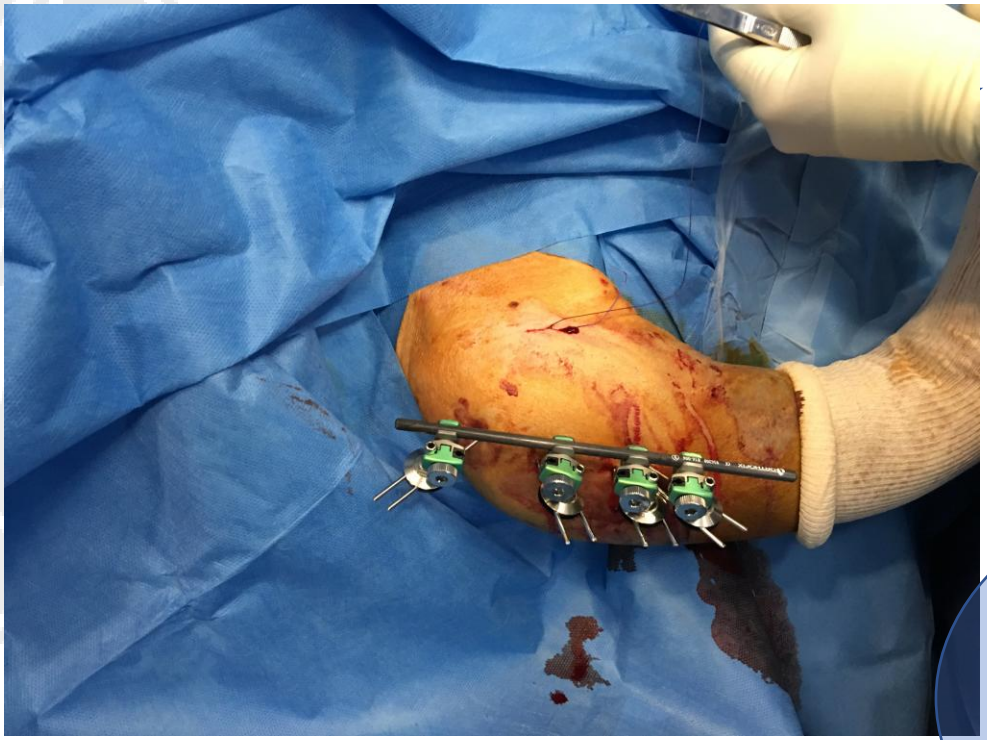
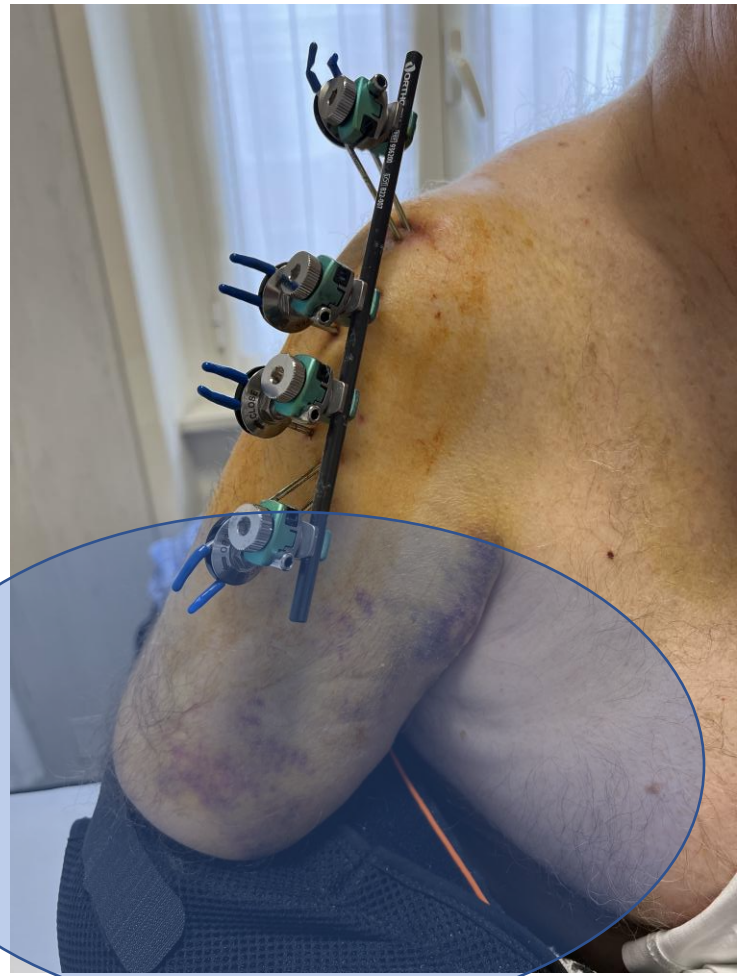
Post-op protocol

Immobilization for **30 days**

- Arm in neutral position
- Elbow mobilization: after 15 days





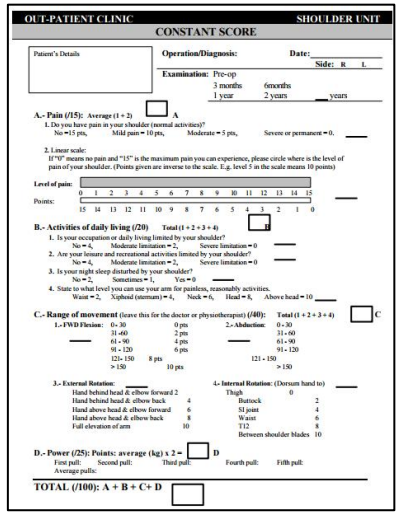
Post-op protocol ⇩

after 30 days we remove the brace

passive and assisted active mobilization
(limited to 100° flex and abd)


45 days: Blocked threaded wires removal
Passive and active assisted Rehabilitation

Results



OUT-PATIENT CLINIC — SHOULDER UNIT

CONSTANT SCORE

Patient's Details

Operation/Diagnosis: Date:

Side: R L

Examination: Pre-op

3 months 6months

1 year 2 years years

A.- Pain (/15): Average (1 + 2) A

1. Do you have pain in your shoulder (normal activities)?

No = 15 pts, Mild pain = 10 pts, Moderate = 5 pts, Severe or permanent = 0,

2. Linear scale:

If "0" means no pain and "15" is the maximum pain you can experience, please circle where is the level of pain of your shoulder. (Points given are inverse to the scale. E.g. level 5 in the scale means 10 points)

Level of pain:

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Points:

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0

B.- Activities of daily living (/20) Total (1 + 2 + 3 + 4) B

1. Is your occupation or daily living limited by your shoulder?

No = 4, Moderate limitation = 2, Severe limitation = 0

2. Are your leisure and recreational activities limited by your shoulder?

No = 4, Moderate limitation = 2, Severe limitation = 0

3. Is your night sleep disturbed by your shoulder?

No = 2, Sometimes = 1, Yes = 0

4. State to what level you can use your arm for painless, reasonably activities.

Waist = 2, Xiphoid (sternum) = 4, Neck = 6, Head = 8, Above head = 10

C.- Range of movement (leave this for the doctor or physiotherapist) (/40): Total (1 + 2 + 3 + 4) C

1.- FWD Flexion:	0 pts	2.- Abduction:	0 pts
0 - 30	2 pts	0 - 30	2 pts
31 -60	4 pts	31 - 60	4 pts
61 - 90	6 pts	61 - 90	6 pts
91 - 120	8 pts	91 - 120	8 pts
121- 150	10 pts	121 - 150	10 pts
> 150		> 150	

3.- External Rotation:		4.- Internal Rotation: (Dorsum hand to)	
Hand behind head & elbow forward	2	Thigh	0
Hand behind head & elbow back	4	Buttock	2
Hand above head & elbow forward	6	SI joint	4
Hand above head & elbow back	8	Waist	6
Full elevation of arm	10	T12	8
		Between shoulder blades	10

D.- Power (/25): Points: average (kg) x 2 = D

First pull: Second pull: Third pull: Fourth pull: Fifth pull:

Average pulls:

TOTAL (/100): A + B + C+ D

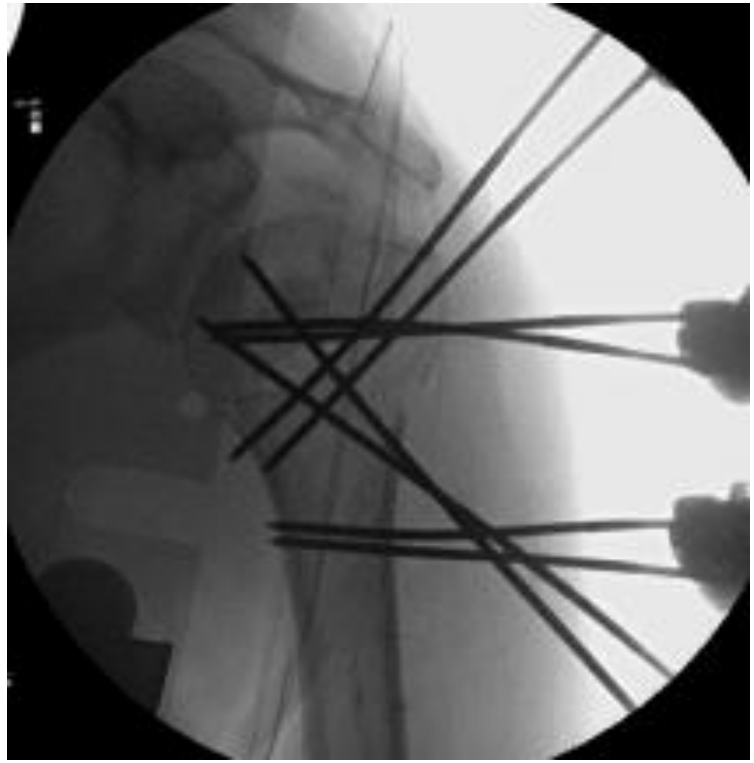
With respect to our LP :

1) **lower incidence of major complications** (2.5% vs 9.6% plate)

-no periosteal or fracture hematoma removal
-no multiple perforation of the HH (as we do when plate is used)
-no permanent metallic devices that may hinder the healing

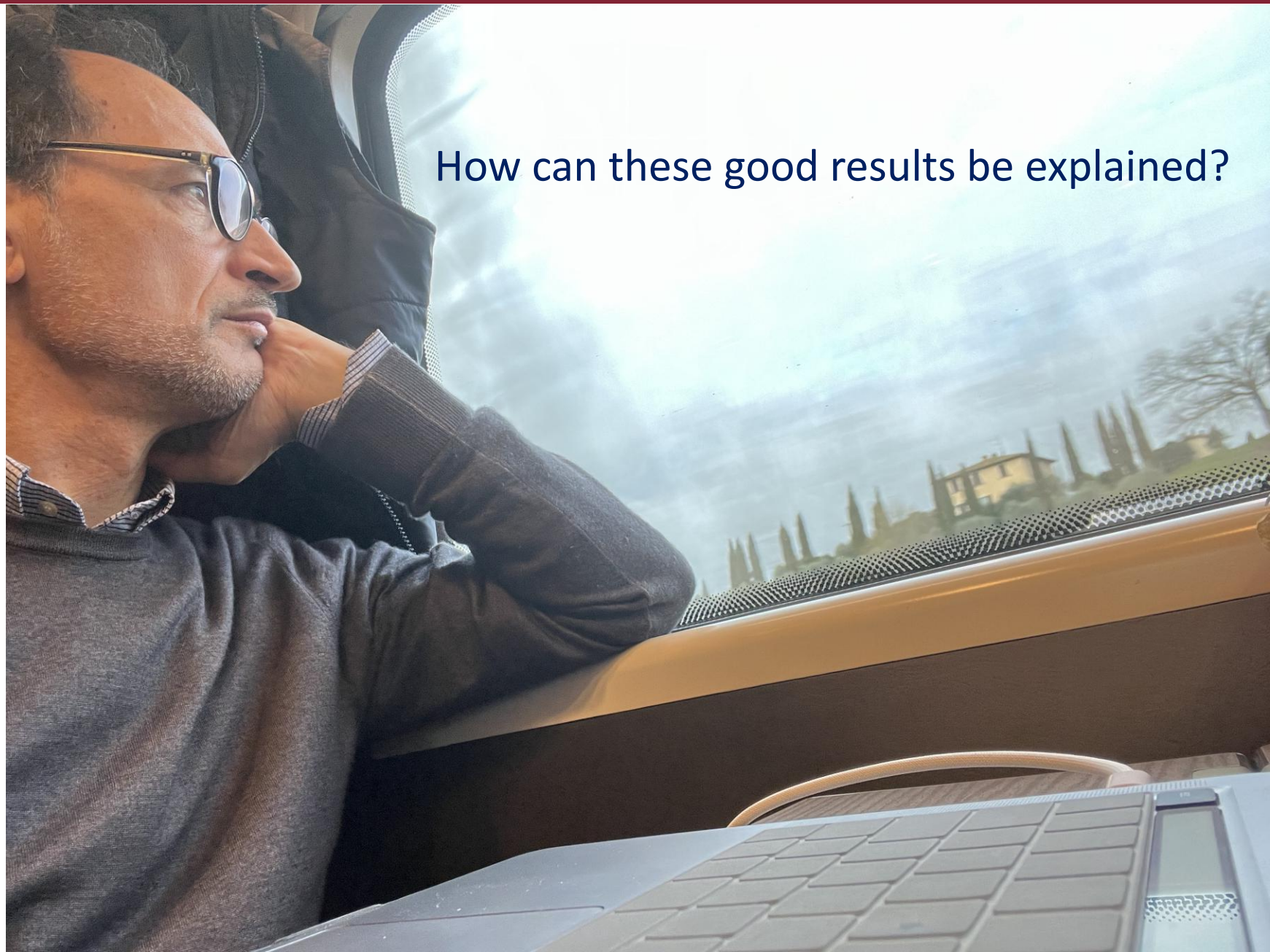
2) **lower rate of infection**: 4.5% (all superficial) vs 6%

-weekly antiseptic treatment of the inlet holes
-short surgical time
-small surgical approach



3) **similar clinical and radiological outcomes**

-Mean individual relative CS: 91%


How can these good results be explained?

1. Biomechanical validation

2. Postoperative stability

3. Postoperative interference with fracture healing

My current conceptions on surgical treatment of complex humeral head fractures

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Three-part humeral head fractures treated with a definite construct of blocked threaded wires: finite element and parametric optimization analysis

Stefano Gumina, MD, PhD[a], Vittorio Candela, MD[a,*], Arianna Cacciarelli, BS[b], Eleonora Iannuzzi, BS[b], Giovanni Formica, PhD[c], Walter Lacarbonara, PhD[a]

[a]*Department of Anatomical, Histological, Forensic Medicine and Orthopaedics Sciences, Sapienza University of Rome, Istituto Clinico Ortopedico Traumatologico (ICOT), Latina, Italy*
[b]*Department of Structural Engineering, Sapienza University of Rome, Rome, Italy*
[c]*Department of Architecture, Roma Tre University, Rome, Italy*

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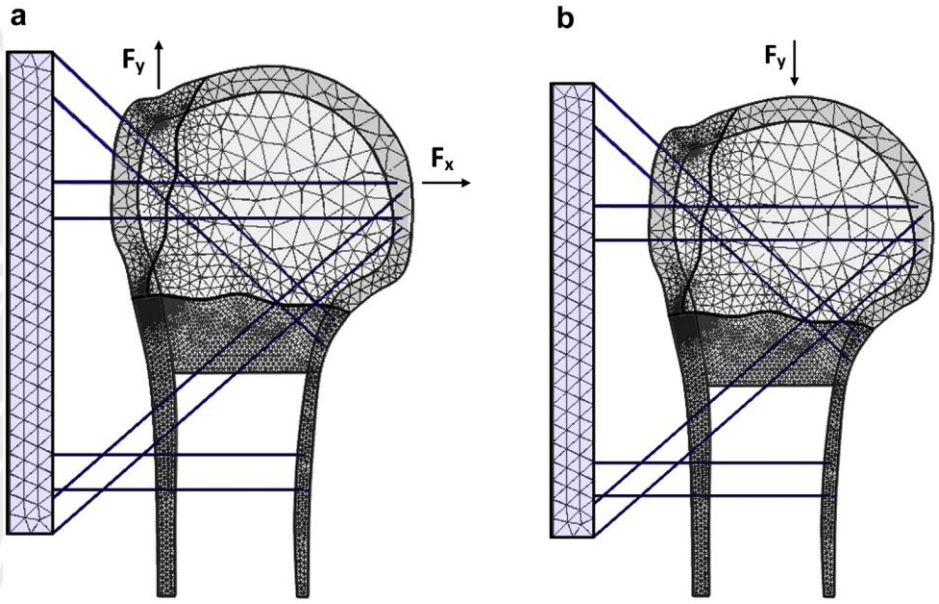
A **finite element** incremental analysis and a **parametric optimization analysis** were performed
(thanks to the collaboration with Engeneering Dep. of Sapienza)



Mesh of the finite element discretization
of the fractured humeral domain

- **Geometry of Hertel 7 fr. was created**

- **Two loading scenarios were tested**

(1) a composite tension/bending/shear Loading

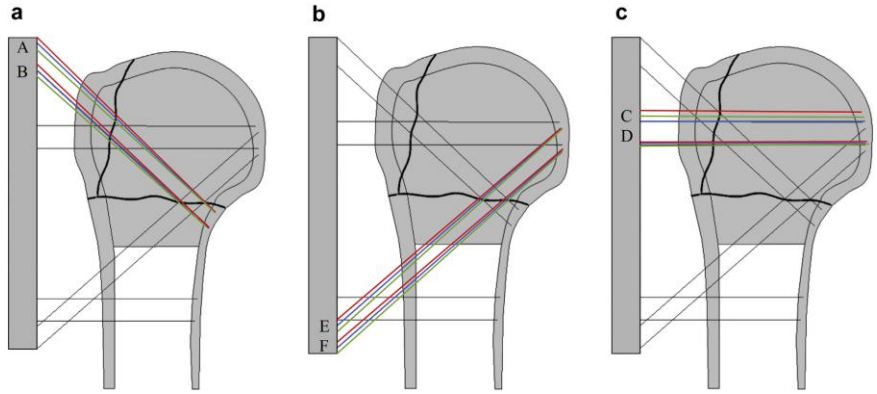
(2) a compression loading

Bone	E (GPa)	ρ (kg/m^3)	ν
Cortical bone	17.2	1850	0.300
Trabecular bone	1.2	500	0.300
Fixation system			
Composite rod	270.0	1900	0.300
Stainless steel wires	200.0	8000	0.290
Titanium wires	115.0	4500	0.340
Ti-6Al-4V wires	113.9	4430	0.342

E is Young's modulus, ρ is the mass density, and ν is Poisson's ratio.

Parametric analysis

Factors	Level 1	Level 2	Level 3
Wires AB (height)	0.3210 m	0.3250 m	0.3285 m
Wires EF (height)	0.2140 m	0.2240 m	0.2290 m
Material	Titanium	Ti-6Al-4V	Stainless steel
CD interdistance	8 mm	10 mm	13 mm



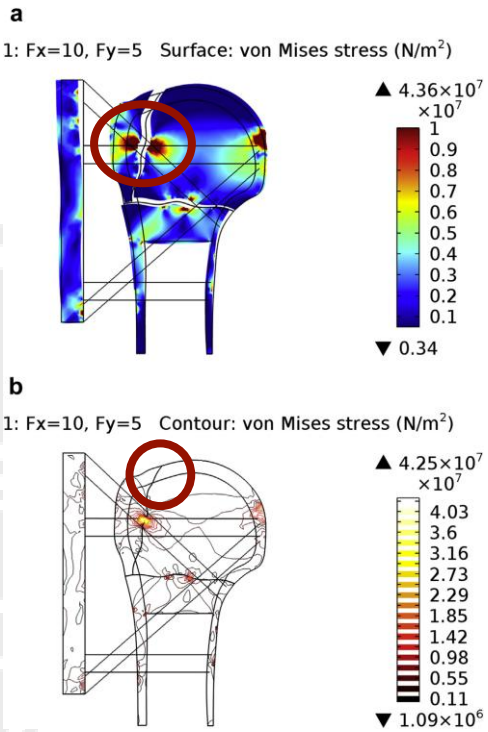
Four design parameters, each represented by three values, were tested

- Wires AB
- Wires EF
- Material
- CD Interdistance

→ 18 simulations

My current conceptions on surgical treatment of complex humeral head fractures

According to the two loading patterns

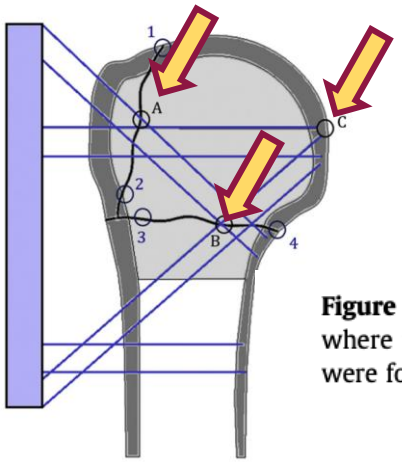


The maximum von Mises stress:
64.4 MPa (point A)

(Points B: 39 Mpa; C:22 MPa).

Where
Gap distances increase:
point 1 (from8.441 mm to 8.494 mm)

point 3 (from 7.534 mm to 7.540 mm)



2nd Load scenario

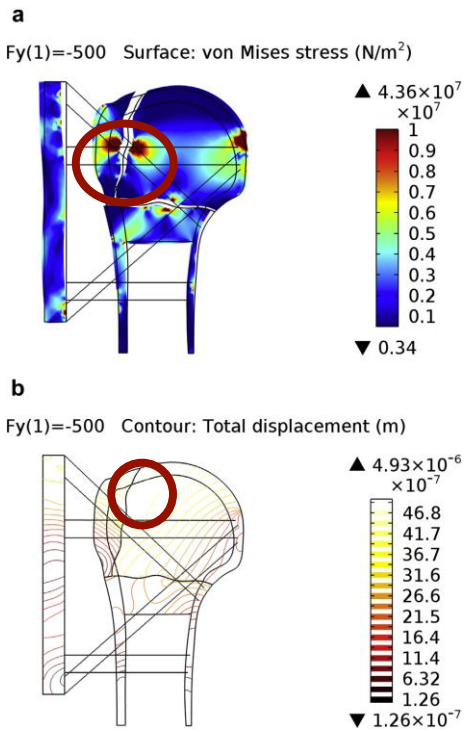


Figure 4 Four control points along the fracture lines were detected as the points where the largest through-the-fracture gaps occurred (1,2,3, and 4) and three points were found to be associated with the highest stress concentrations (A, B, and C).

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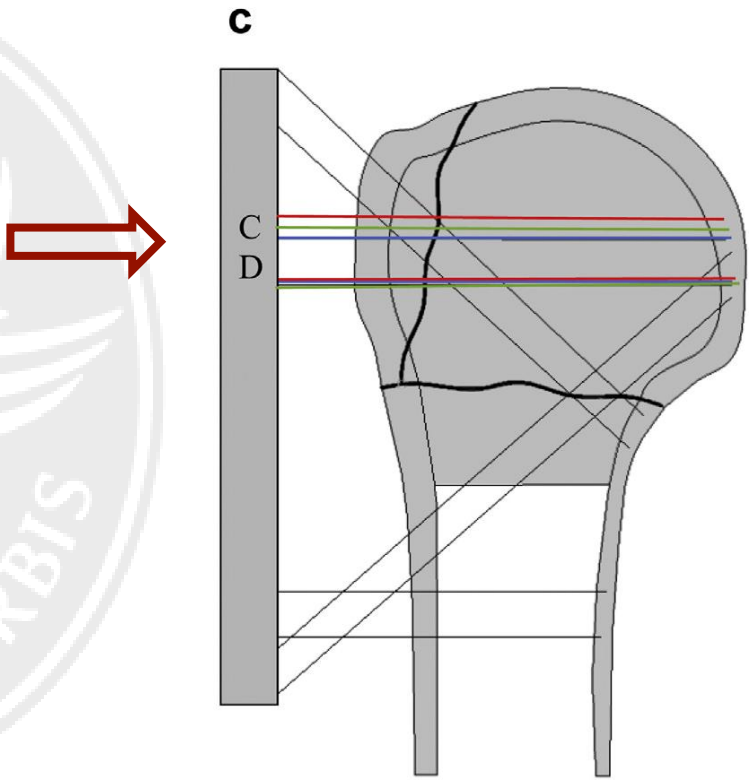
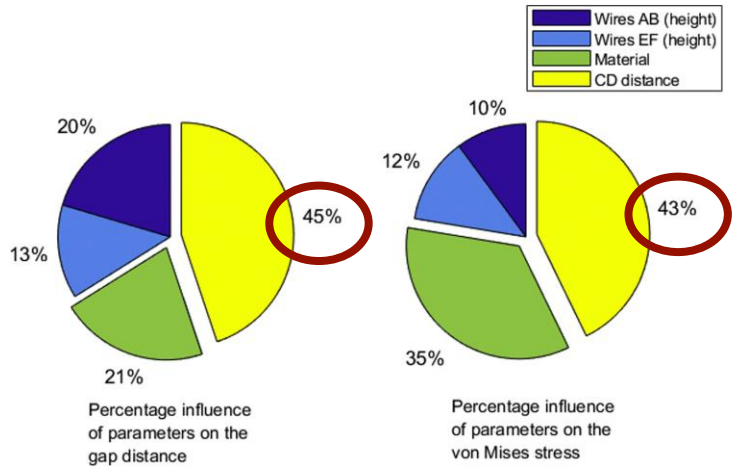
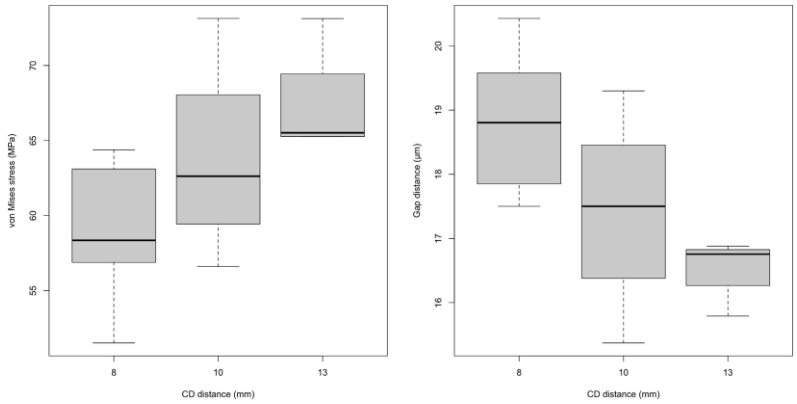
Results of parametric optimization analysis

CD distance has the maximum influence

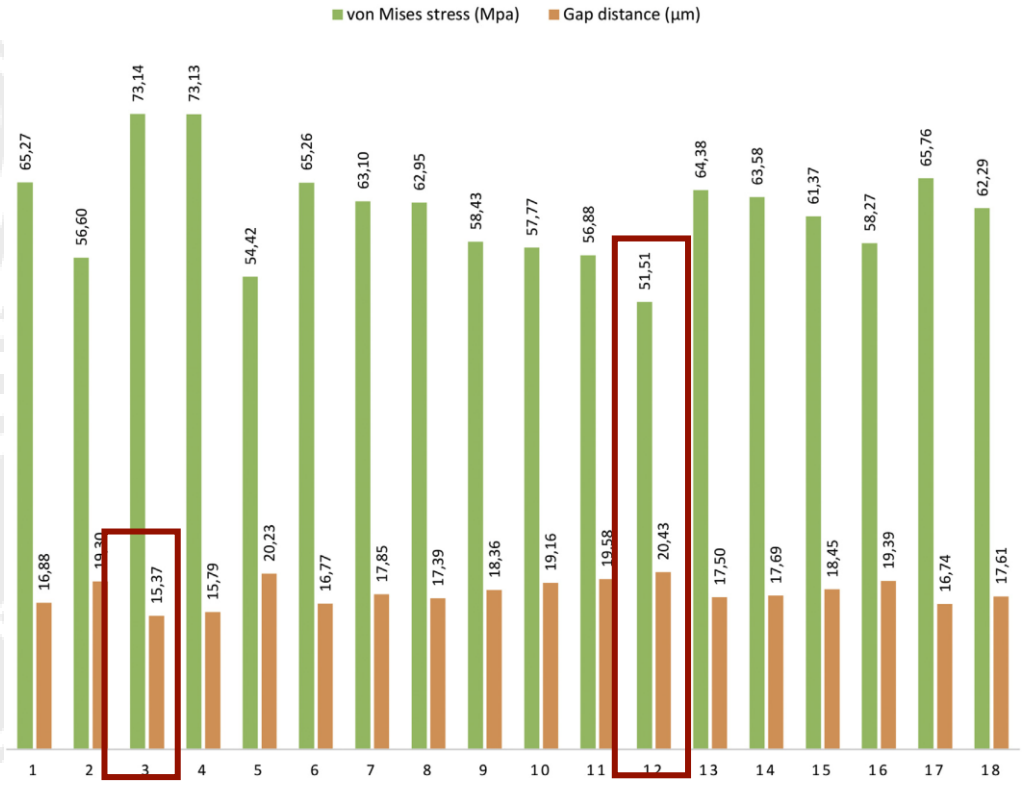






L'analisi parametrica è lo studio della variazione dei risultati in funzione di parametri variabili

My current conceptions on surgical treatment of complex humeral head fractures



18 combinations
(best values: 2 of them)

- Minimum gap distance
15.37 mm **3rd combination**

- Lowest von Mises stress
51.51 MPa **12th combination**.

The geometries which guarantee **minimum gap distance** are those making use of **stainless steel** for the wires

No influence of the external rod diameter (12 mm) (4.2%)

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3 Issues:

1. Biomechanical validation

2. Postoperative stability

3. Postoperative interference with fracture healing

My current conceptions on surgical treatment of complex humeral head fractures

J Shoulder Elbow Surg (2022) 31, 1666–1673

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2022

JOURNAL OF SHOULDER AND ELBOW SURGERY
www.elsevier.com/locate/ymse

Focus on stability: biomechanical evaluation of external fixation technique versus locking plate osteosynthesis in 3-part proximal humeral fractures

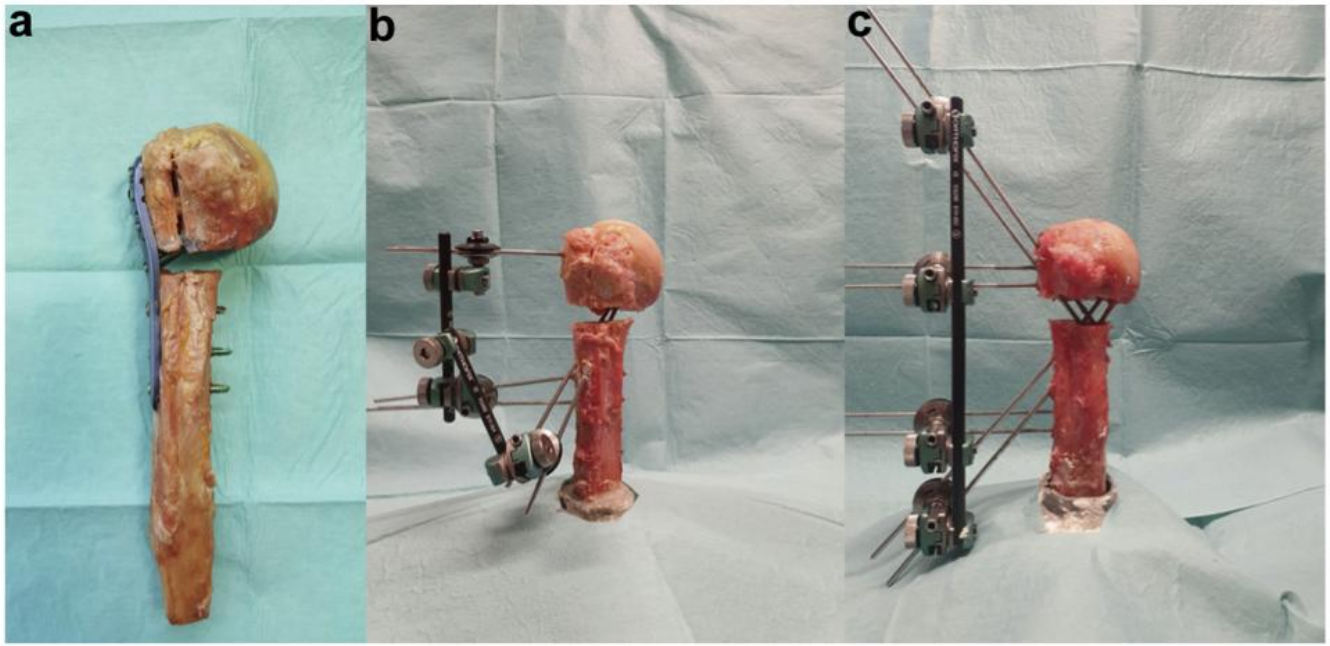
Andreas Harbrecht, MD[a,b,*], Michael Hackl, MD, PhD[a], Tim Leschinger, MD, PhD[a], Lars P. Müller, MD, PhD[a], Kilian Wegmann, MD, PhD[a]

Methods: Twenty-one fresh-frozen human cadaveric proximal humeral specimens were divided into 3 groups of 7 stripped specimens. An unstable 3-part fracture of the proximal humerus was set. Construct A consisted of the Galaxy Fixation Shoulder System, with fixation in accordance with the manufacturer's recommended technique (3 pairs of threaded wires). Construct B was fixed with an additional pair of threaded wires according to the recommendations of Gumina et al (4 pairs of threaded wires). The remaining 7 specimens were fixed with a locking plate. By use of an optical motion capture system, relative motion at the fracture site and failure load were evaluated during a cyclic loading protocol.

they evaluated the post-operative stability

Comparison:

- Plate and screws (GOLD STANDARD)
- Manufacturer's recommended technique
- Gumina's technique



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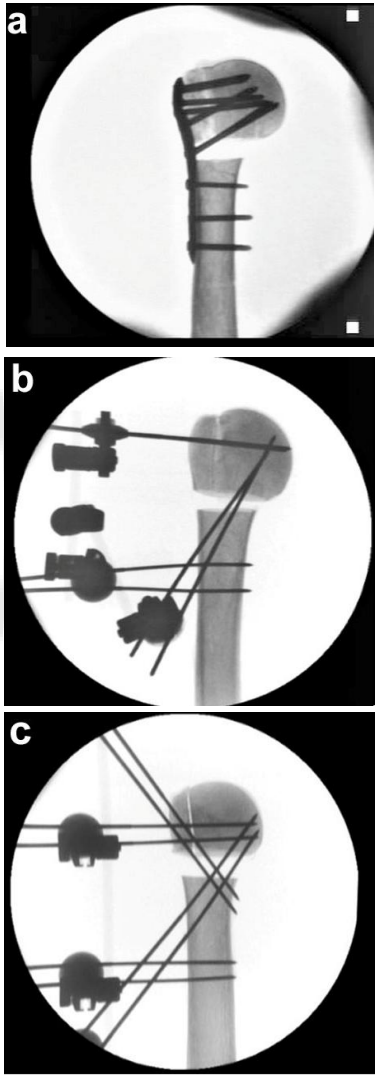
Setup



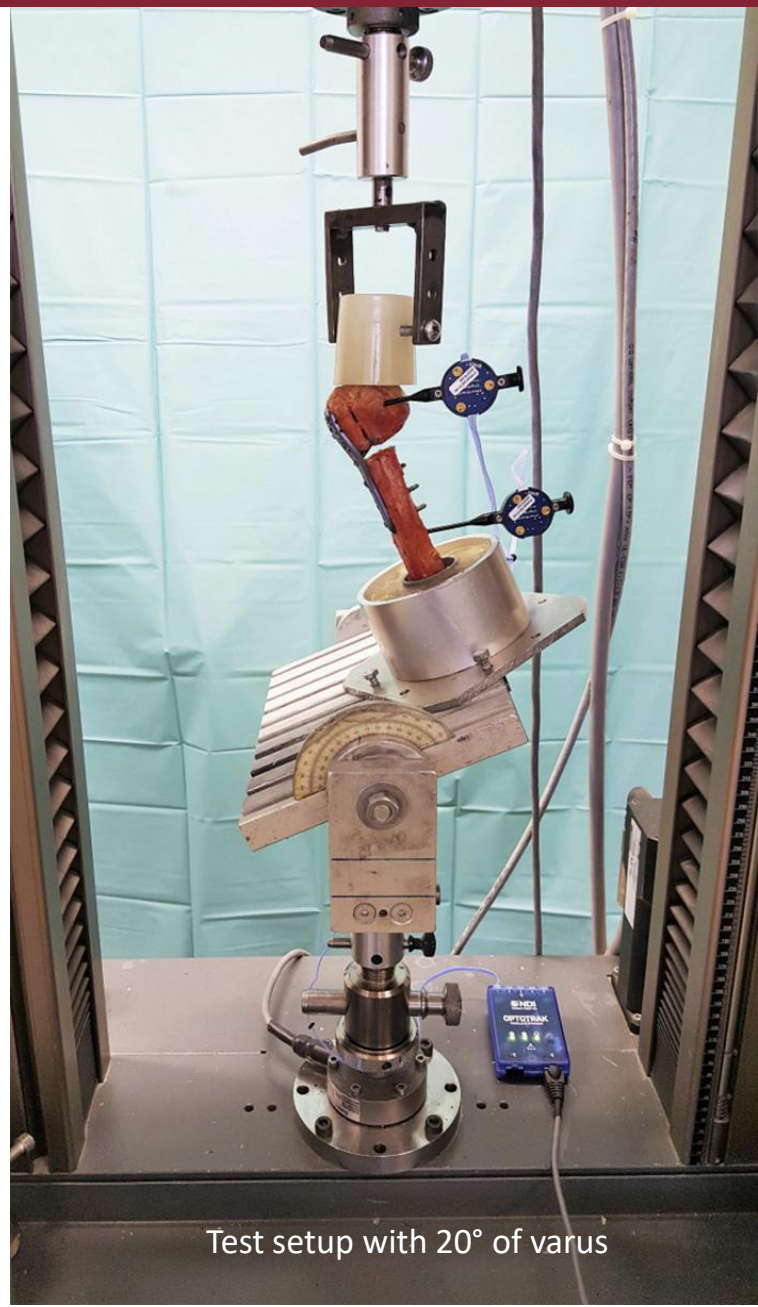
Two test protocols

- **cyclic loading**

performed at 5 mm/min for 500 cycles or until construct failure.

- **load to failure**

conducted with a displacement rate increase of 5 mm/min.



Test setup with 20° of varus

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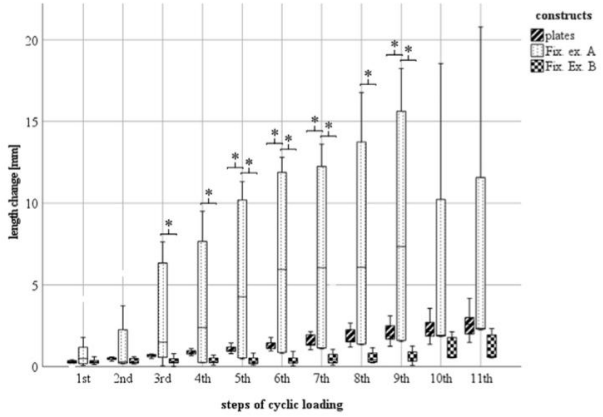
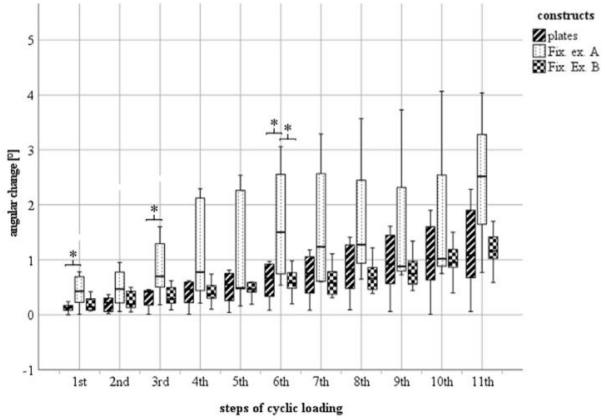
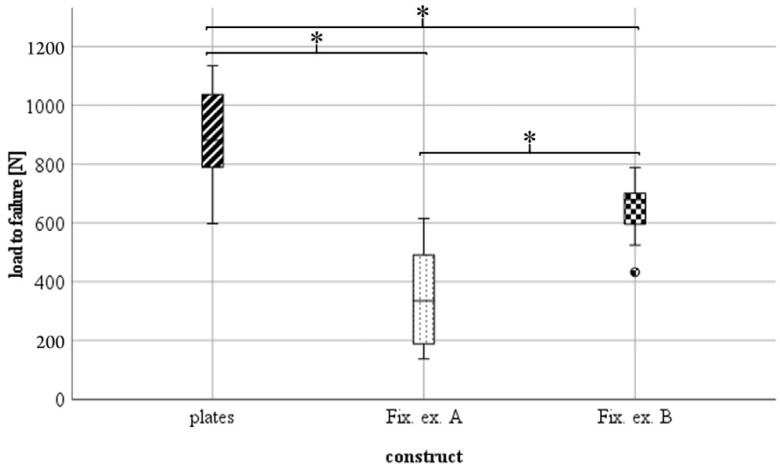


Distance change (in mm)



Angular change (in degrees)

- (**Gumina's construct**) revealed the least relative motion at the fracture site, **without a statistically significant difference** compared **with locking plates**.
- (COMPANY construct A) resulted in the **lowest stability** and the **highest rates of displacement**.



Load application (N)

3 Issues:

1. Biomechanical validation

2. Postoperative stability

3. Postoperative interference with fracture healing

3D Vibrometry analysis (response of the material)

By studying the response of the material subjected to vibrations induced by a piezoelectric, indirect information is obtained on the primary stability of the system and therefore on the possible interference of the synthesis system with the first phases of the fracture healing process.

2019 SCIENTIFIC REPORTS nature research

OPEN

Quantitative 3D measurements of tibial plateau fractures

N. Assink[1], J. Kraeima[2], C. H. Slump[1], K. ten Duis[3], J. P. P. M. de Vries[4], A. M. L. Meesters[3], P. van Ooijen[5], M. J. H. Witjes[2] & F. F. A. IJpma[3]

Emmert et al. International Journal of Implant Dentistry (2021) 7:83
https://doi.org/10.1186/s40729-021-00367-2

International Journal of Implant Dentistry

RESEARCH Open Access

An experimental study on the effects of the cortical thickness and bone density on initial mechanical anchorage of different Straumann® implant designs

Marie Emmert[1†], Aydin Gülses[1*†], Eleonore Behrens[1], Fatih Karayürek[2], Yahya Acil[1], Jörg Wiltfang[1] and Johannes Heinrich Spille[1]

Journal section: Oral Surgery
Publication Types: Research

doi:10.4317/medoral.21024
http://dx.doi.org/doi:10.4317/medoral.21024

Effect of implant macro-design on primary stability: A prospective clinical study

Naroa Lozano-Carrascal [1], Oscar Salomó-Coll [2], Marta Gilabert-Cerdà [3], Nuria Farré-Pagés [4], Jordi Gargallo-Albiol [5], Federico Hernández-Alfaro [6]

Journal of Oral Biology and Craniofacial Research 10 (2020) 629–638

Contents lists available at ScienceDirect

Journal of Oral Biology and Craniofacial Research

journal homepage: www.elsevier.com/locate/jobcr

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The clinical significance of implant stability quotient (ISQ) measurements: A literature review

Huang H[a,b], Wu G[a], Hunziker E[b,c,*]

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response to the vibrometric analysis on

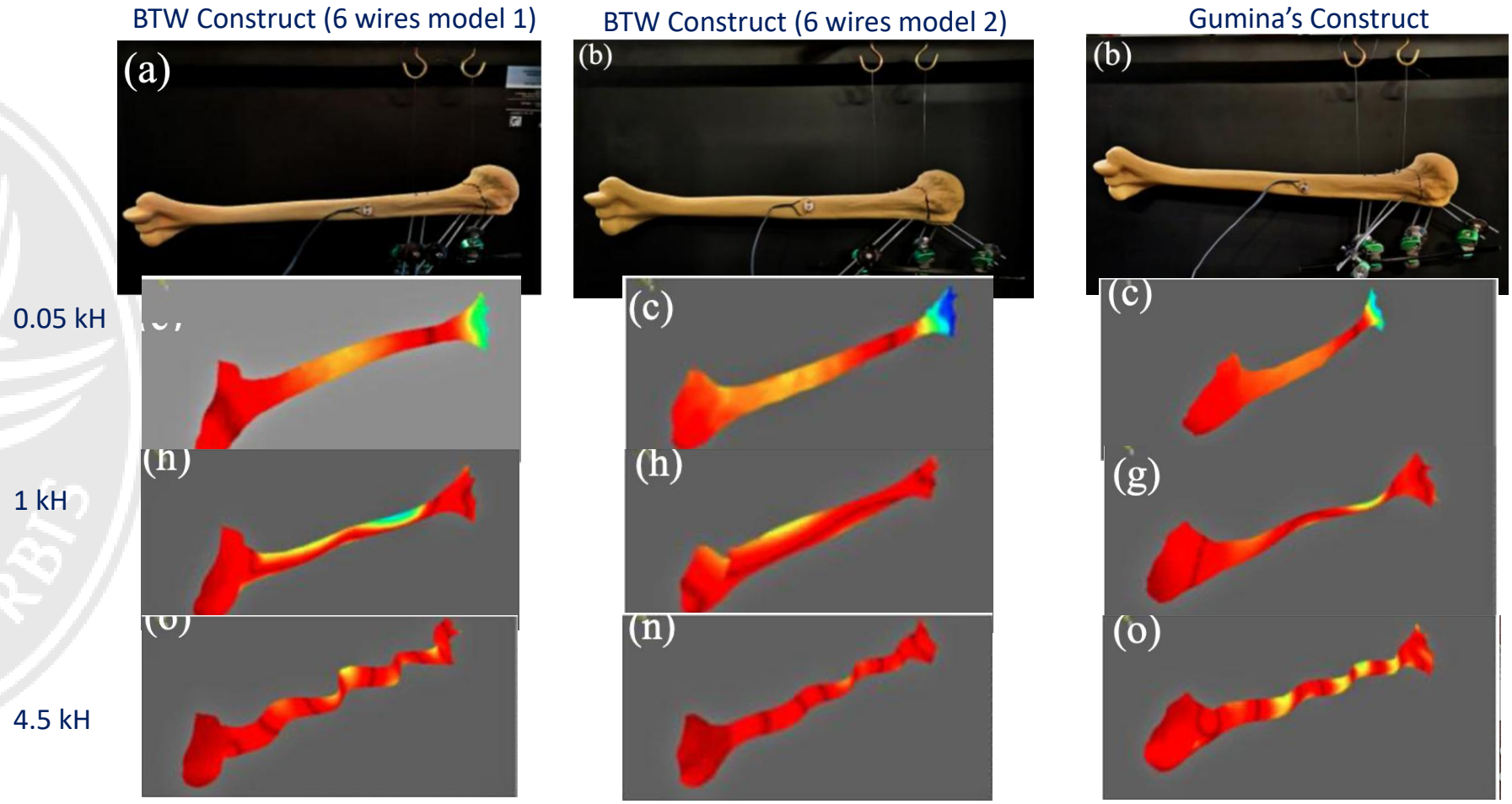
1. Healthy proximal humerus
2. Plate and screws (GOLD STANDARD)
3. BTW Construct (6 wires model 1)
4. BTW Construct (6 wires model 2)
5. BTW Gumina's Construct

blocked thread wires (BTW)

My current conceptions on surgical treatment of complex humeral head fractures

Results

3 different Frequencies of vibration



Significative **less deformation** in Gumina's construct

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Gumina's Construct

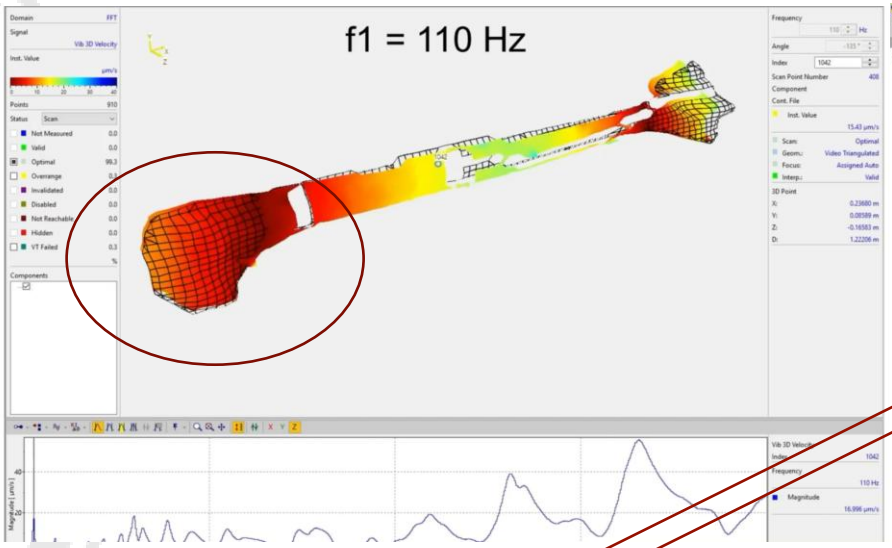
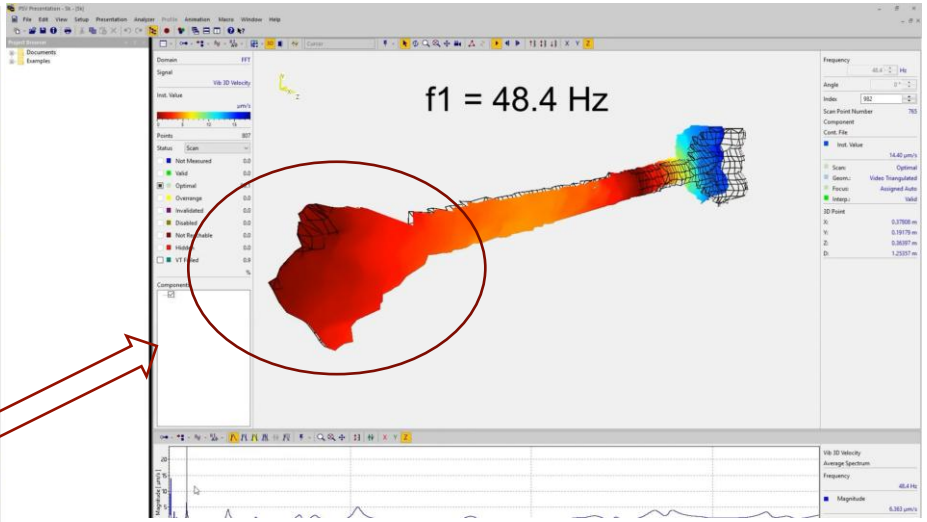


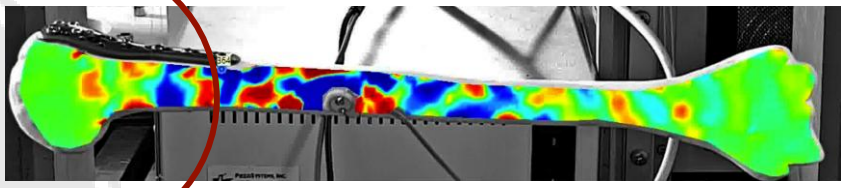
Plate and screws (GOLD STANDARD)



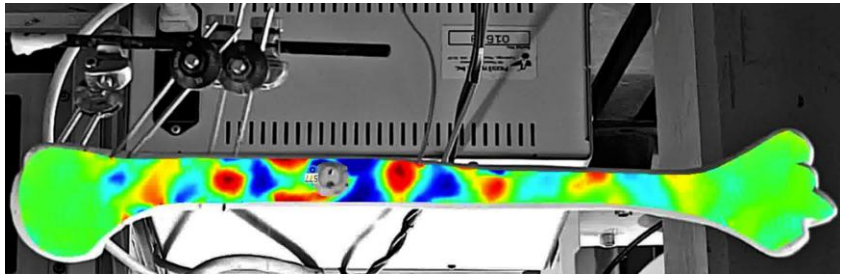
Higher **deformation** of the humeral head due to excessive stiffness (**plate**)

2nd analysis: Waves propagation

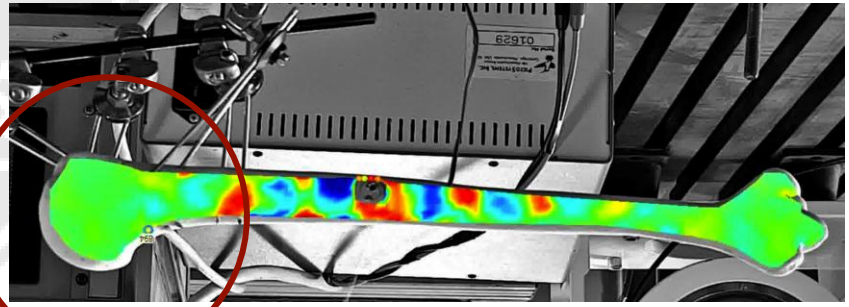
Plate and screws



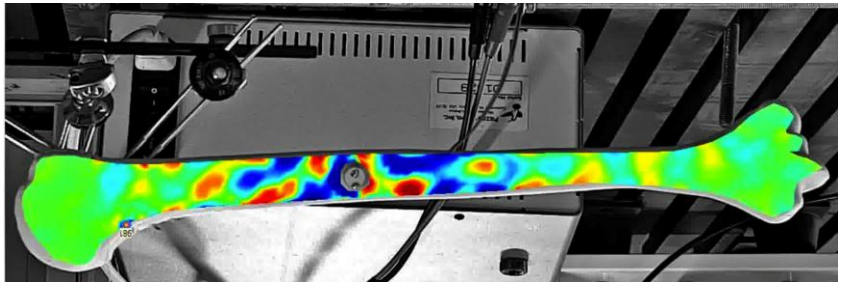
BTW Construct (6 wires model 1)



Gumina's Construct



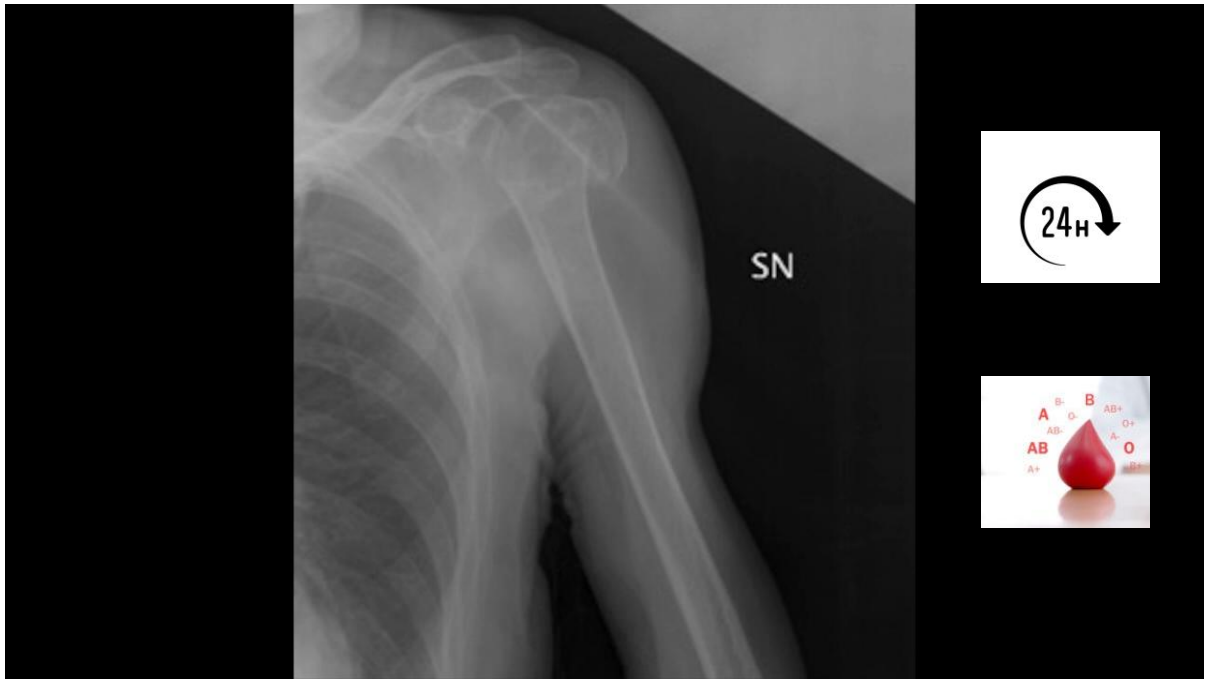
BTW Construct (6 wires model 2)



Significative **less stress (red color)** on the humeral head with BTWs

Elderly patients, without cognitive problems

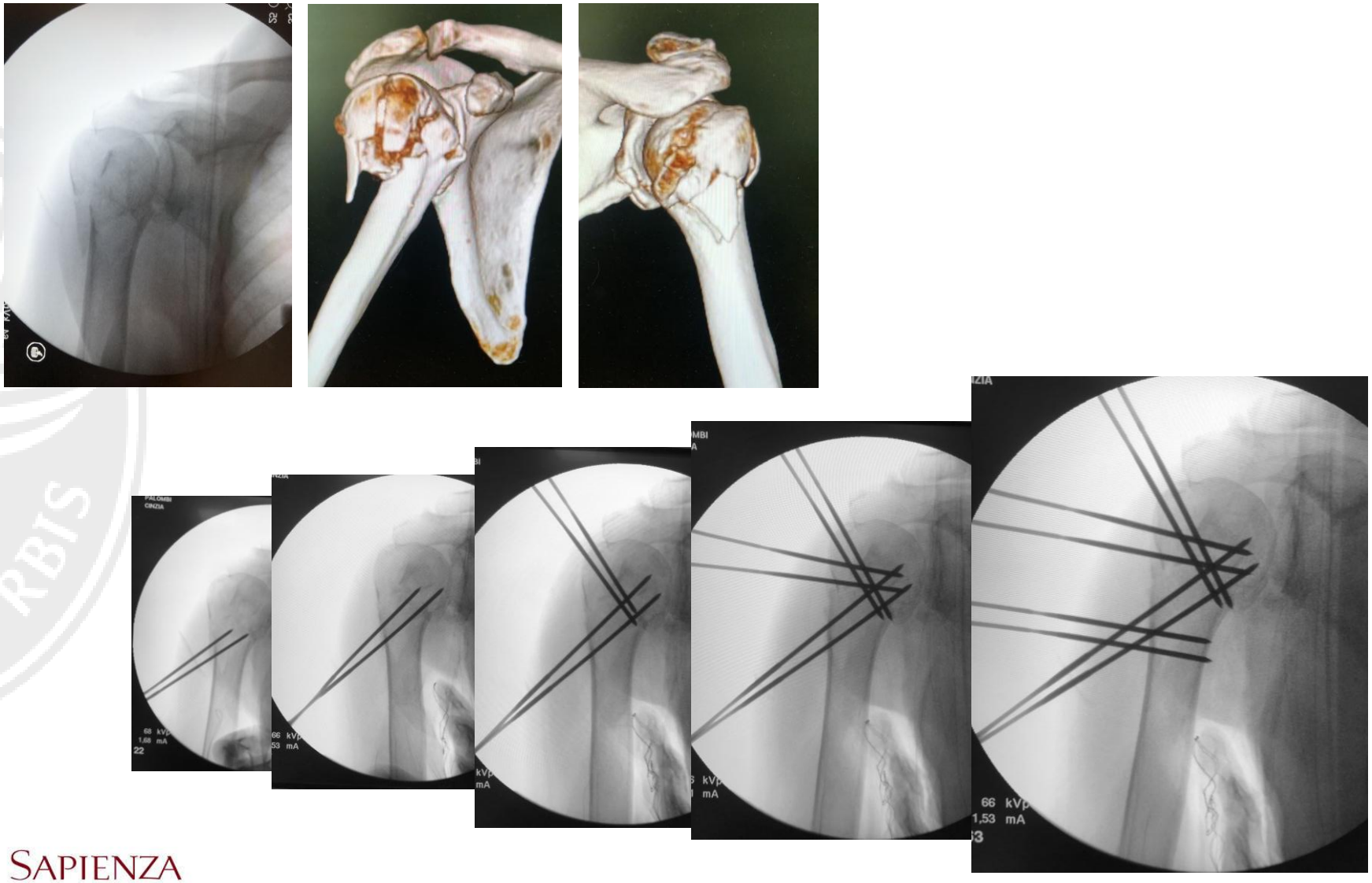
F - 81 yo, ASA 3



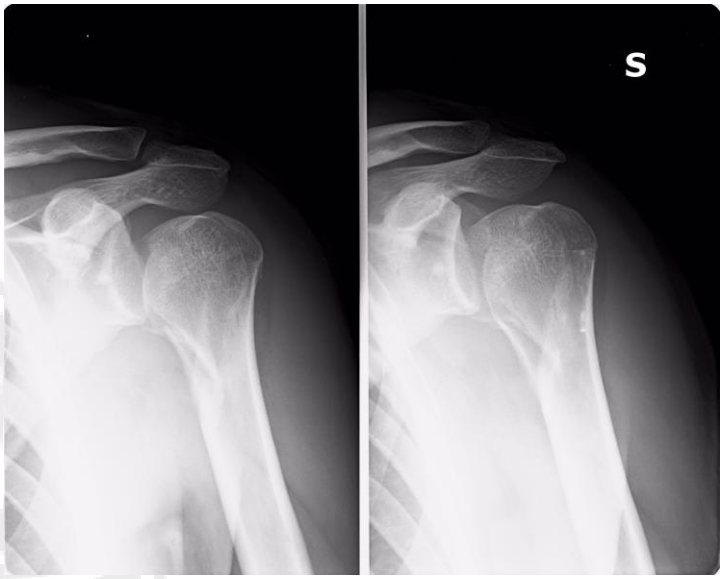
- operating times are reduced
- blood loss is low

My current conceptions on surgical treatment of complex humeral head fractures

Young patients: F, 55 yo 4-part proximal humerus fracture

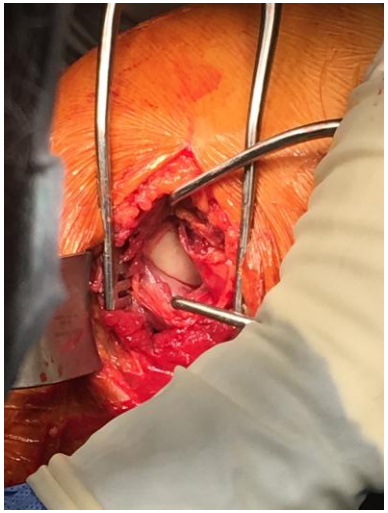


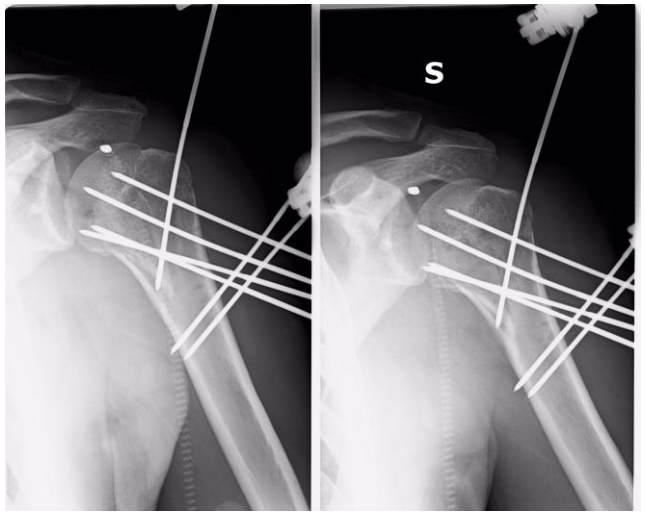
My current conceptions on surgical treatment of complex humeral head fractures



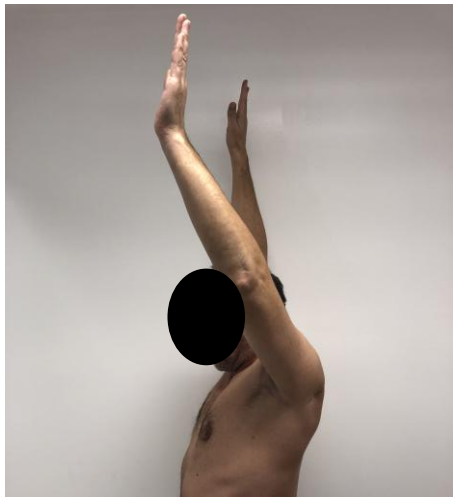
M, 53 yo
Posterior fracture dislocation

- posterior approach
- HH reduction
- posterior capsuloplasty
- TL-fixation



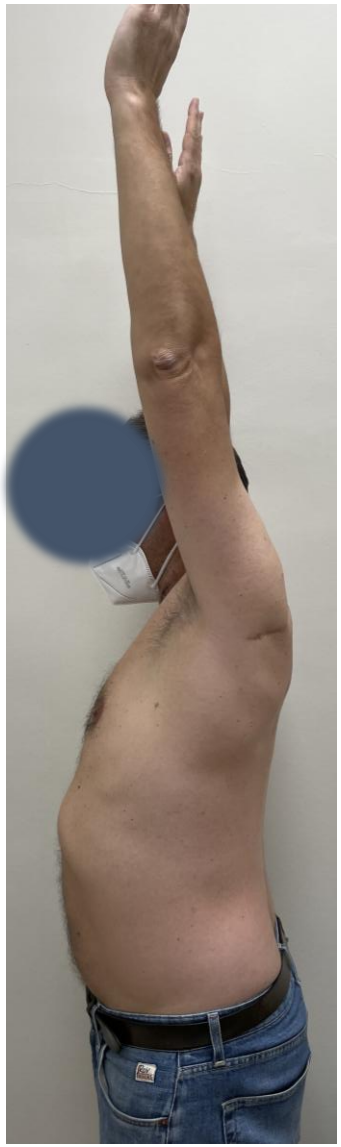


FU: 60 days



My current conceptions on surgical treatment of complex humeral head fractures

FU: 4 years



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6 reasons

Why do we use TL-fixation?

1) Hertel 7 fracture

lower incidence of major **complications** (2.5% vs 9.6% locking plate)

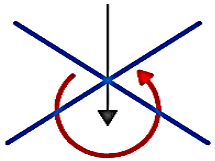
- NO periosteal or fracture hematoma removal
- NO multiple perforation of the HH (as we do when plate is used)

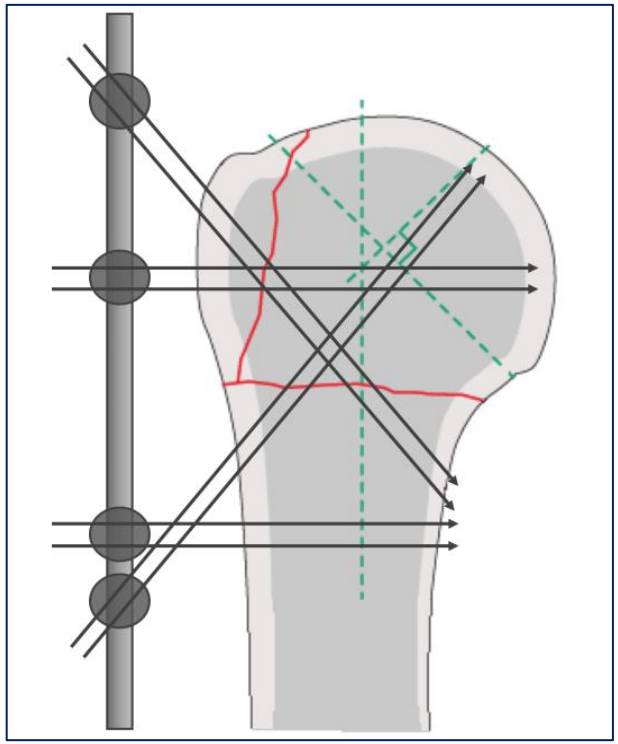
2) lower rate of **infections** (4.5% vs 6% locking plate)

- weekly antiseptic treatment of the inlet holes
- shorter surgical time (mean: 37 mins)
- often, small surgical approach (3 cm)

3)

Our construct is stable (**isostatic)**

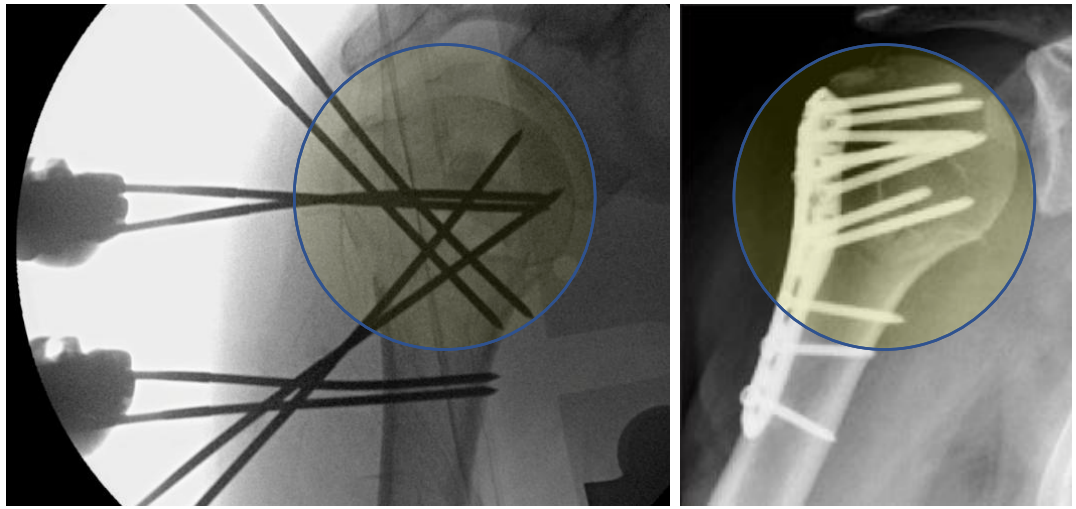




No loss of reduction in the postop period

It prevents **traslation** and **collapse** of the humeral head

Validated by **biomechanical analysis**



4)

diameter of the threaded wire is smaller than that of the screws

number of used threaded wires is less than that of the screws

all this preserves bone stock

With respect to plate and screws:

5) no permanent metallic means that may hinder the healing

6) our series:

irCS similar to those obtained with locking plates

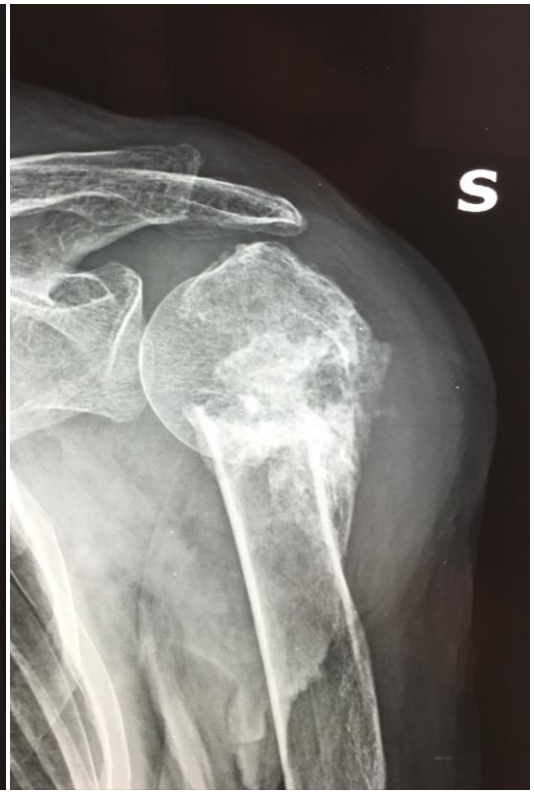
fewer complications and shorter operating times

.

When does it fail? ……interruption of the lateral wall

Patients with **comminution** of the **both/lateral metaphyseal column/s**

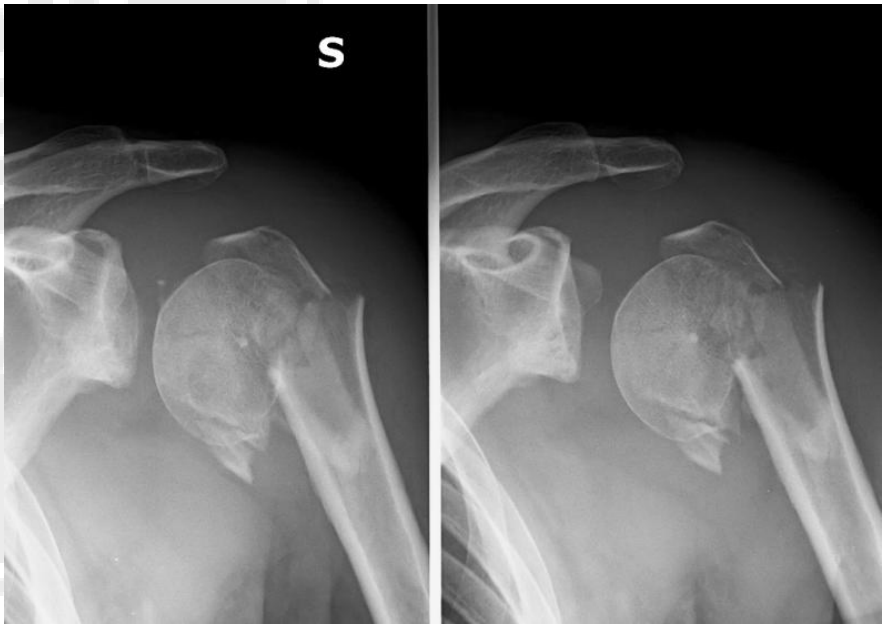
Loss of compression
Excessive micromotion



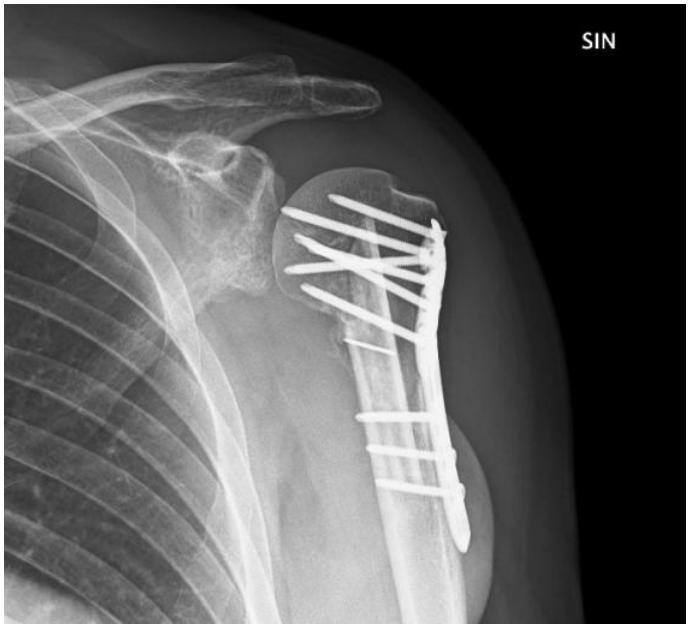
Unstable medial column: possible solutions

- endosteal strunt grafting with LLCP
- supplement tension band suturing after LLCP
- intramedullary nail
- medial buttress plating

Unstable medial and lateral columns: possible solution



- endosteal strunt grafting



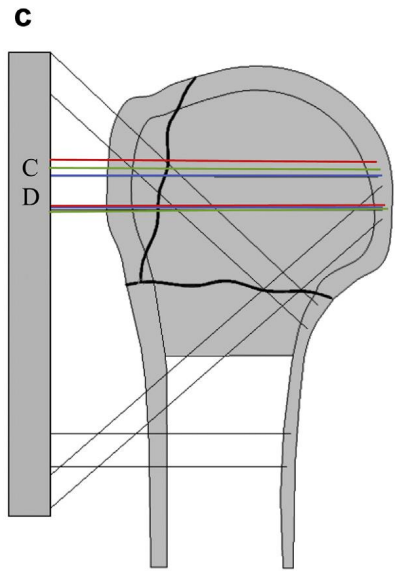
goal is not only

"how to synthetize the humeral head fracture"

but

"how to obtain the best functional result"

(reducing the percentage of major complications)



TL-fixation meets this needs

Save the Dates

September 18-21, 2025

Rome - Italy

Guest Nation: South Korea

registration fee: astonishing!!!