MUSCLE TRANSFERS IN SHOULDER PATHOLOGY
Biomechanical rationale, Surgical technics, Results

J.Grimberg

IRCOS, Paris, France

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AIMS OF THIS LECTURE

- To present and discuss three situations of muscle/tendon deficiencies in the shoulder and their alleged solutions.
  - Massive postero-lateral irreparable cuff tears : Latissimus dorsi transfer
  - Massive irreparable subscapular tear : Pectoralis Major transfer
  - Anterior deltoïd insufficiency : Trapezius, LD, Inverse Pec Maj transfers

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MASSIVE IRREPARABLE CUFF TEARS AND MUSCLE/TENDON TRANSFERS

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WHY TENDON TRANSFERS IN CUFF SURGERY ?

- Arthroscopic surgery in rotator cuff tear is successfull
- Equivalent to open surgery
- BUT some massive tears in young patients are still an issue :
  - With fatty degeneration > 2
  - And/or retracted tendon

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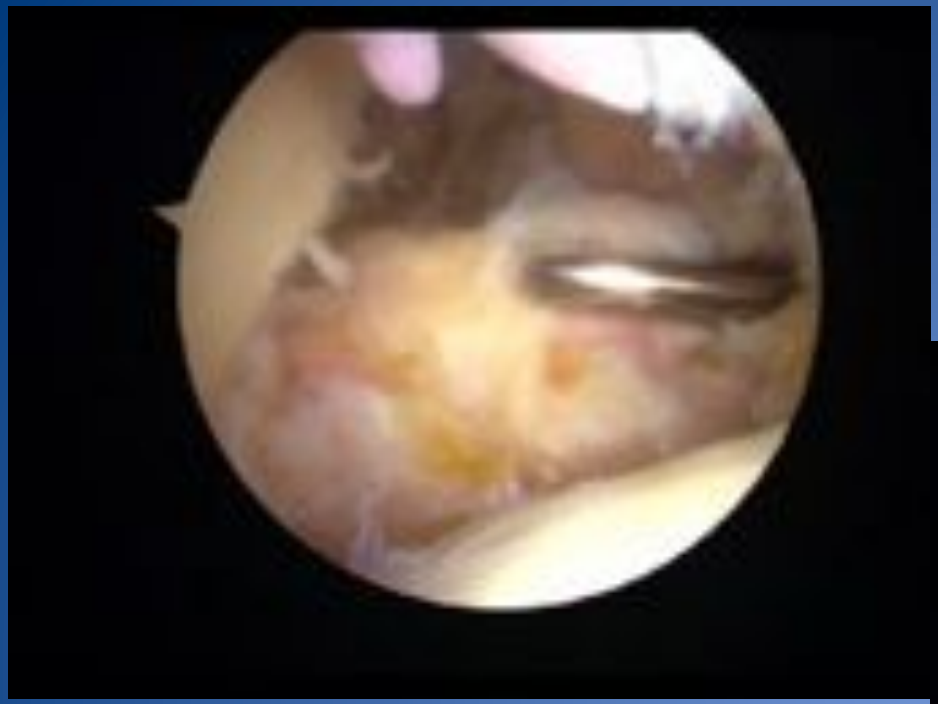
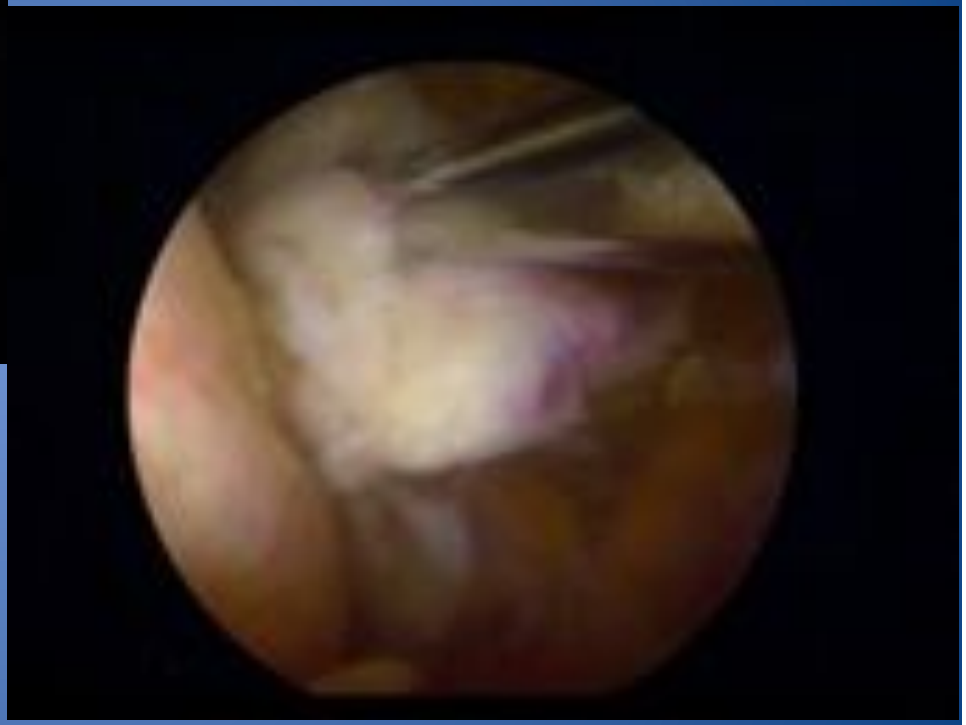


Reparable sub scap tear



Irreparable subscap tear

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Massive tear

Thin, retracted, irreparable SS tendon

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BIOMECHANICAL RATIONALE FOR TENDON TRANSFER IN ROTATOR CUFF TEARS

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BIOMECHANICAL RATIONALE
Anatomical studies

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MUSCLE TRANSFER CONDITIONS

- Potential excursion (related to length)
- Relative tension (related to cross-sectionnal area and strength)
- Direction of pull
- Localisation and traction on the neuro-vascular pedicle
- Pre-tensioning of the musculotendinous unit

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Potential Excursion (PE) and Relative Tension (RT)

MUSCLE	PE (cm)	RT (%)
Subscapularis	7,3	14,5
Pec Major (clavicular)	14,5	2,3
Pec Major (sternal)	18,8	5,4
Supraspinatus	6,7	5,2
Infraspinatus	8,6	9,7
Latissimus dorsi	33,9	5,9
Teres major	14,9	4,3
Anterior deltoïd	11,5	3,4

Herzberg et al J Shoulder Elbow Surg 1999

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PEC MAJOR TRANSFER for subscapularis tear

	SUBSCAPULARIS	PECTORALIS MAJOR
POTENTIAL EXCURSION	7,3	14,5
POSITION OF TRACTION LINE	Posterior to chest wall	Anterior to chest wall
RELATIVE TENSION	14,5	2,3 (clavicular) 5,4 (sternal)

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LAT.DORSI TRANSFER for posterosuperior tear

	supraspinatus	infraspinatus	Latissimus dorsi
POTENTIAL EXCURSION	6,7	8,6	33,9
DIRECTION OF PULL	Horizontal (lateral to medial)	Horizontal and slightly inferior	Inferior and slightly medial
RELATIVE TENSION	5,2	9,7	5,9

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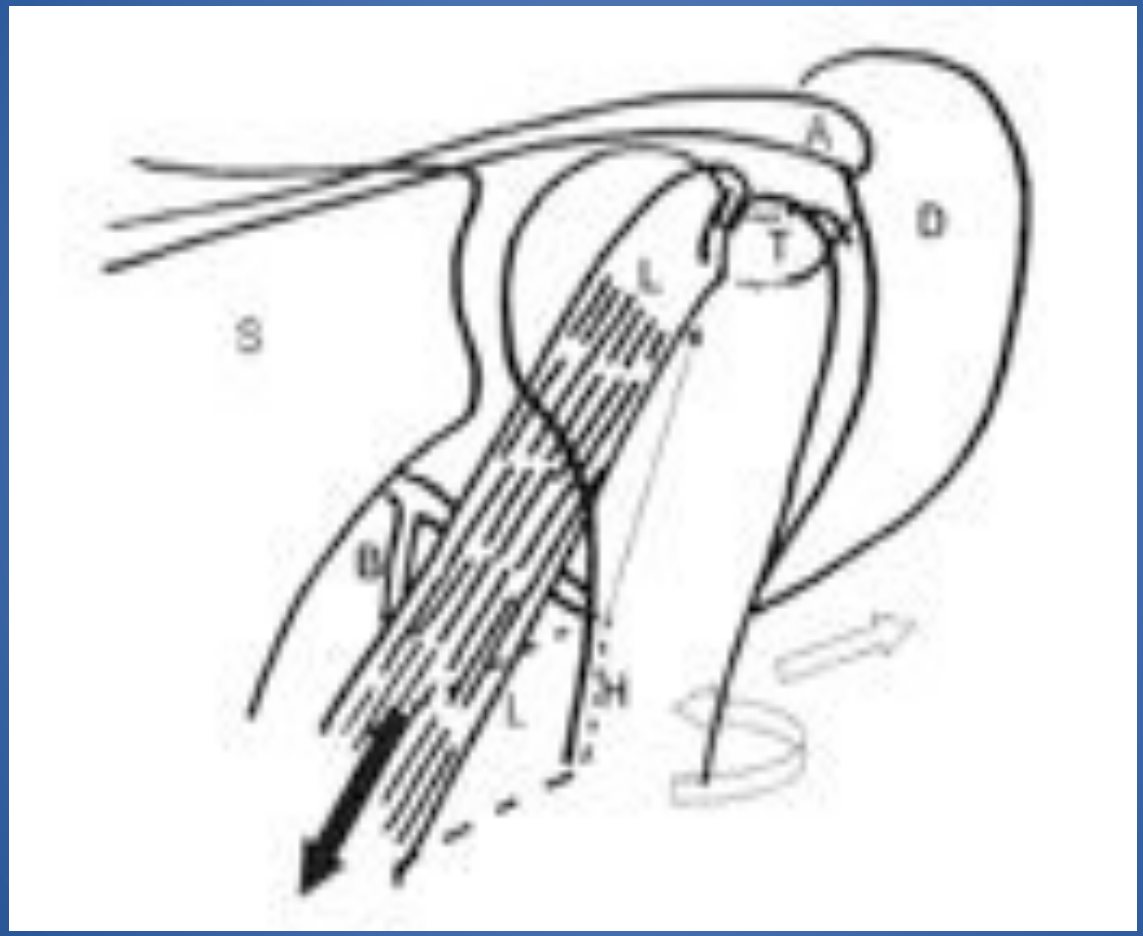
LD direction of pull



Degreef et al, Acta Ortho Belg , 2005

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MUSCLE TRANSFER CONDITIONS

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LD neurovascular pedicle

- Coming anterolaterally from the thoracodorsal artery and nerve.
- A blunt dissection is usually enough to allow 8 cm of vertical traction on the NV pedicle.

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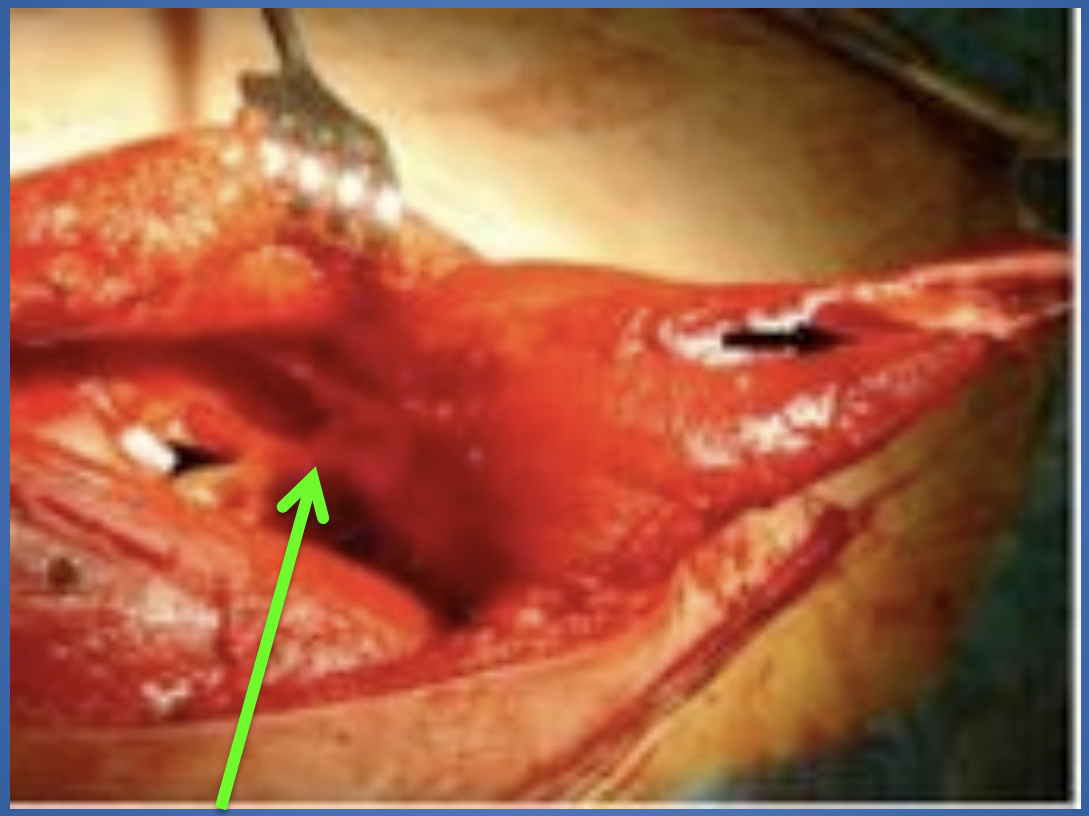
LD neurovascular pedicle



Neurovascular pedicle after humeral detachment of LD tendon
(Pearle and al JBJS 2007)

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Pre-tensioning of the musculotendinous unit

- The efficiency of the transferred muscle depends on the given length after the transfer
- The best tension (« strength ») is produced by the muscle close to its rest length in its normal insertion

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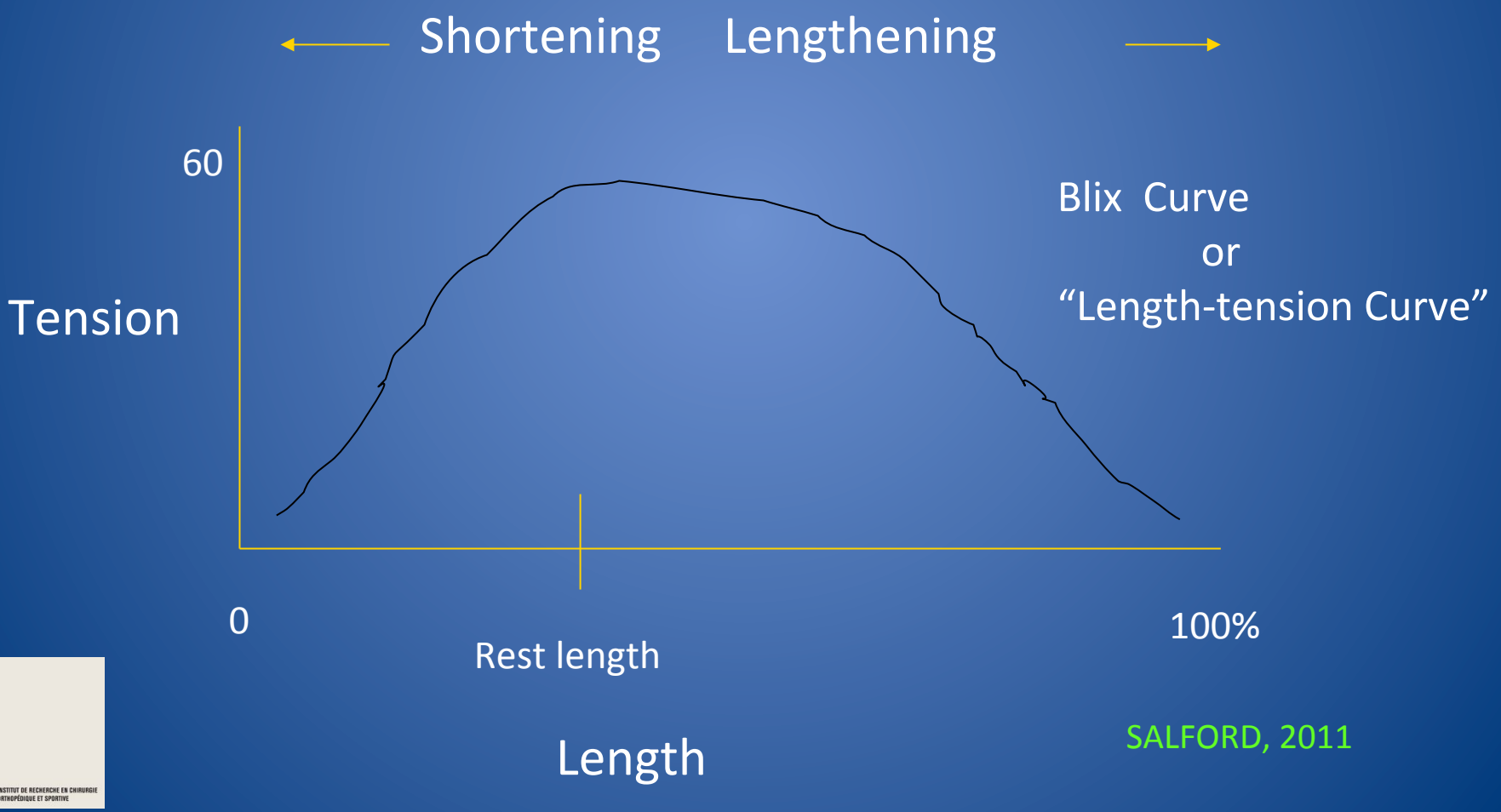
Muscle Stimulated at Various Pre-set Lengths



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BIOMECHANICAL RATIONALE

FINITE ELEMENT STUDIES

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Biomechanical analysis of tendon transfers for massive rotator cuff tears

D.J. Magermans [a,*], E.K.J. Chadwick [a], H.E.J. Veeger [a], F.C.T. van der Helm [a], P.M. Rozing [b]

CLINICAL BIOMECHANICS 2004

Biomechanics of latissimus dorsi transfer for irreparable posterosuperior rotator cuff tears

H.Y. Ling *, J.G. Angeles, M.B. Horodyski

Department of Orthopaedics and Rehabilitation, University of Florida, Gainesville, FL, USA

CLINICAL BIOMECHANICS 2009

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Material and Methods

- Transfer of the LD alone, LD + TM, TM alone to four different tendon insertions : teres minor, infraspinatus, supraspinatus , anterior part of subscapularis
- Finite Element Modeling using the Delft FEM model of the shoulder developped by Van der Helm (J Biomech 2004)
- Less evoluated model in the Ling paper

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Results

- LD becomes
  - Anteflexor of the humerus if transferred to supraspinatus insertion
  - External rotator of the humerus if transferred on the supraspinatus but mainly on the infraspinatus insertion
- LD stays retroflexor and internal rotator if fixed too anteriorly (upper subscap) or too inferiorly(teres minor)

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Results

- TM becomes
  - Anteflexor of the humerus if transferred to supraspinatus and infraspinatus insertion
  - External rotator of the humerus if transferred on the supraspinatus but mainly on the infraspinatus insertion
  - More strength than the LD

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Effectiveness of tendon transfers for massive rotator cuff tears: a simulation study

D.J. Magermans [a,*], E.K.J. Chadwick [a], H.E.J. Veeger [a], P.M. Rozing [b], F.C.T. van der Helm [a]

CLINICAL BIOMECHANICS 2004

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Results

- Simulation of different movements is better with :
  - LD on the supraspinatus insertion
  - TM on the supraspinatus insertion
  - LD+TM on the supraspinatus insertion
- TM or LD+TM > LD alone

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BIOMECHANICAL RATIONALE

IN VITRO STUDIES

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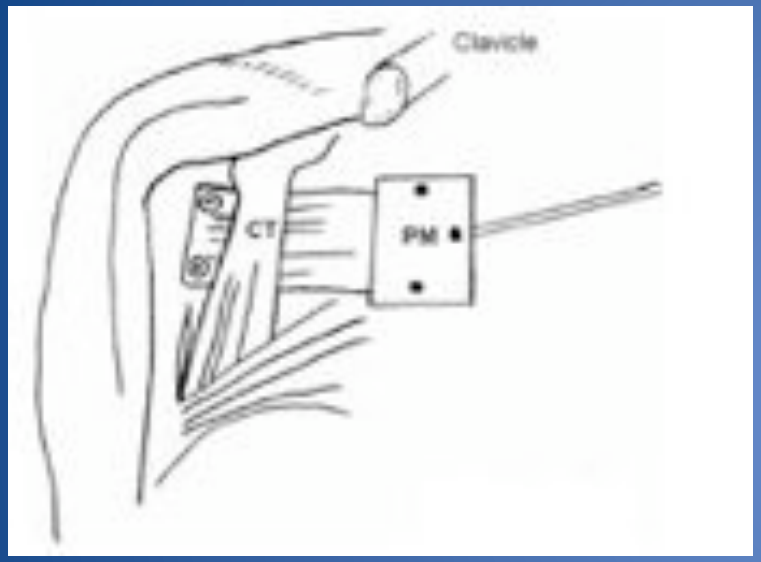
Pec Major under or over the conjoined tendon ?



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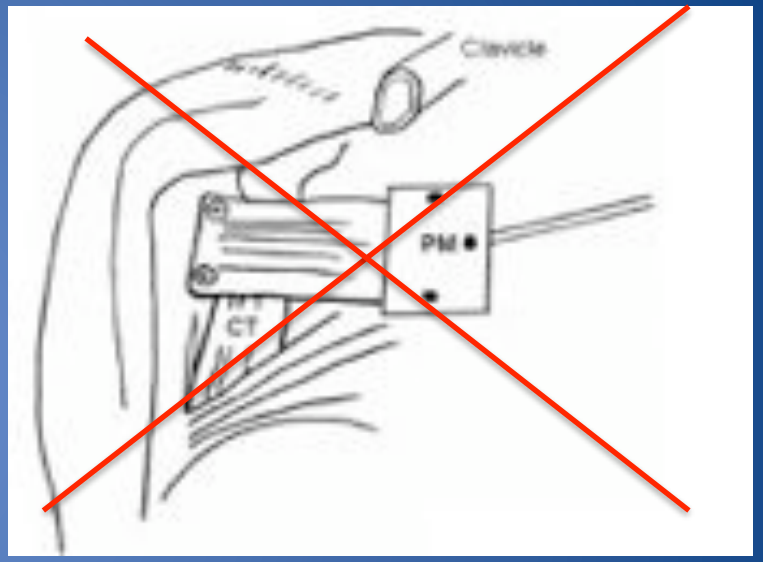

Underneath the conjoined tendon is better than over the conjoined tendon

(Konrad et al. J.Bone Joint Surg 2007)

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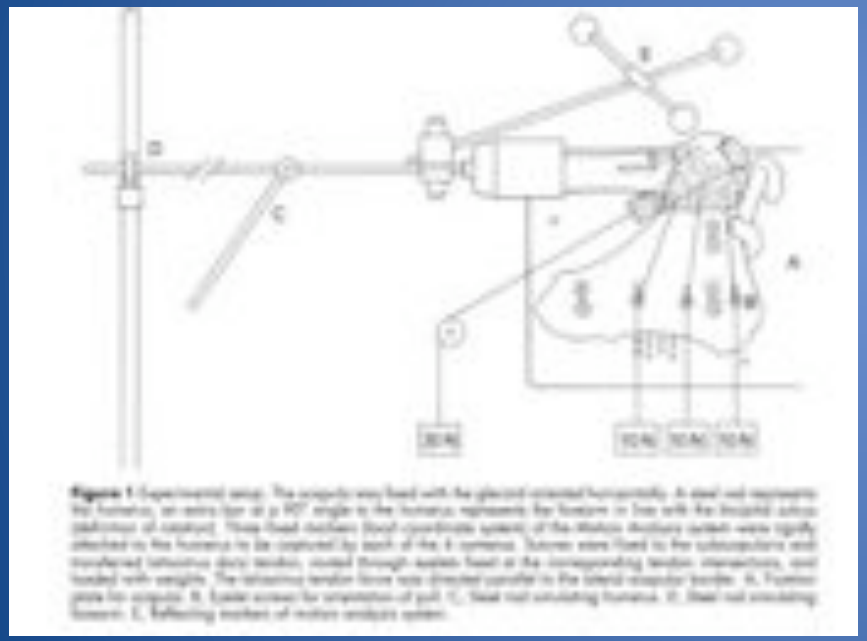
Role of subscapularis in LD transfer



- Absence of subscapularis = anterior dislocation of the humeral head after LD transfer
- Werner et al J Shoulder Elbow Surg 2006

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Teflon augmentation of LD tendon

- Increase of tensile force = 53%
- Aoki et al J Shoulder Elbow Surg 1997

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Tendon fixation in arthroscopic latissimus dorsi transfer for irreparable posterosuperior cuff tears: An in vitro biomechanical comparison of interference screw and suture anchors

. Diop A, Maurel N, Chang VK, Kany J, Duranthon LD, **Grimberg J**.
Clin Biomech, 2011 .

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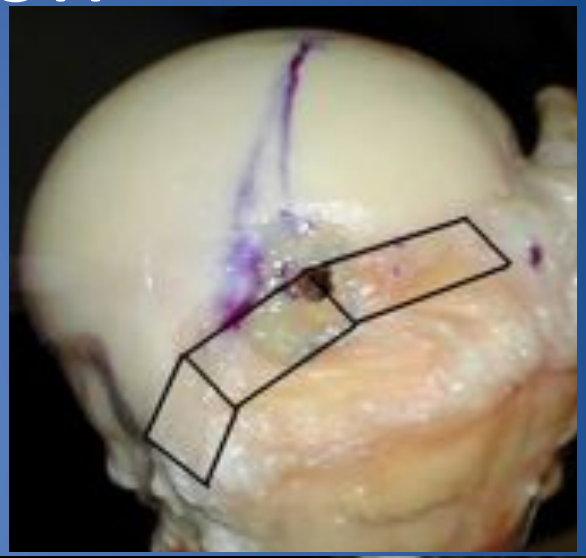
MATERIALS AND METHODS
Mode of fixation

- Interference screw technique
  – Tendon is debrided from muscles fibers
  - Tubularised with Ethibond® suture and calibrated
  - Fixed into a bone tunnel at the junction of SS and IS insertion with interference screw



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MATERIALS AND METHODS
Mode of fixation

- Anchor technique :
  - 4 anchors (Twinfix PK® 6,5 Smith&Nephew) fixed the LD tendon on the superior and middle facet of the greater tuberosity

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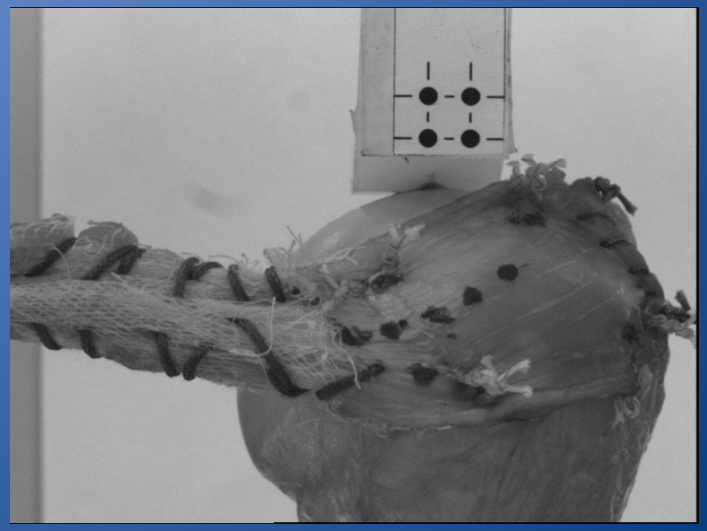
MATERIALS AND METHODS
Measurements

- Mean **stiffness** for 30N and 60N cyclic load
- The relative **bone-tendon displacement** at insertion area after 5, 100, 150, 200 cycles, for 30N and 60N loads
- The **load to failure**



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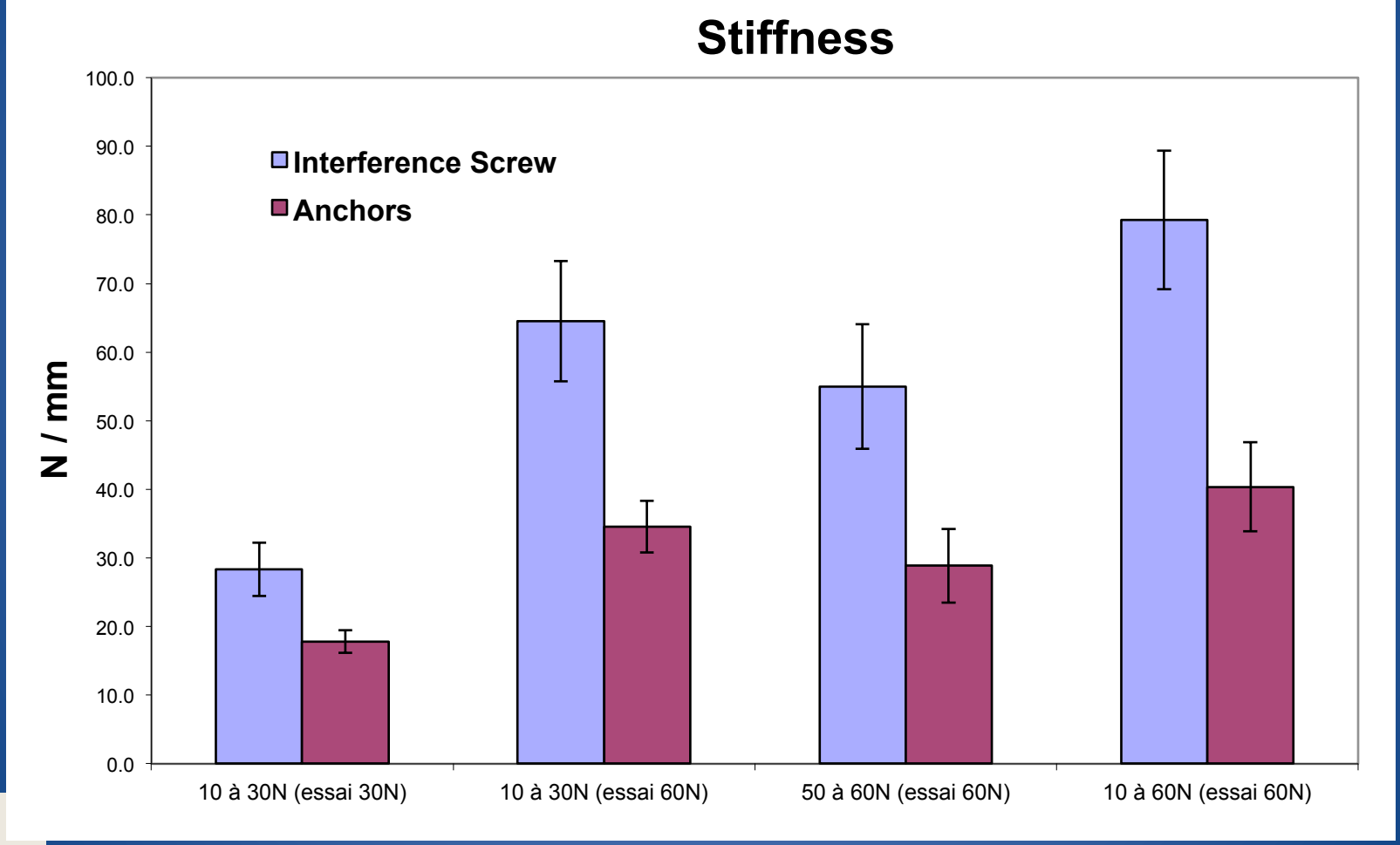
RESULTS



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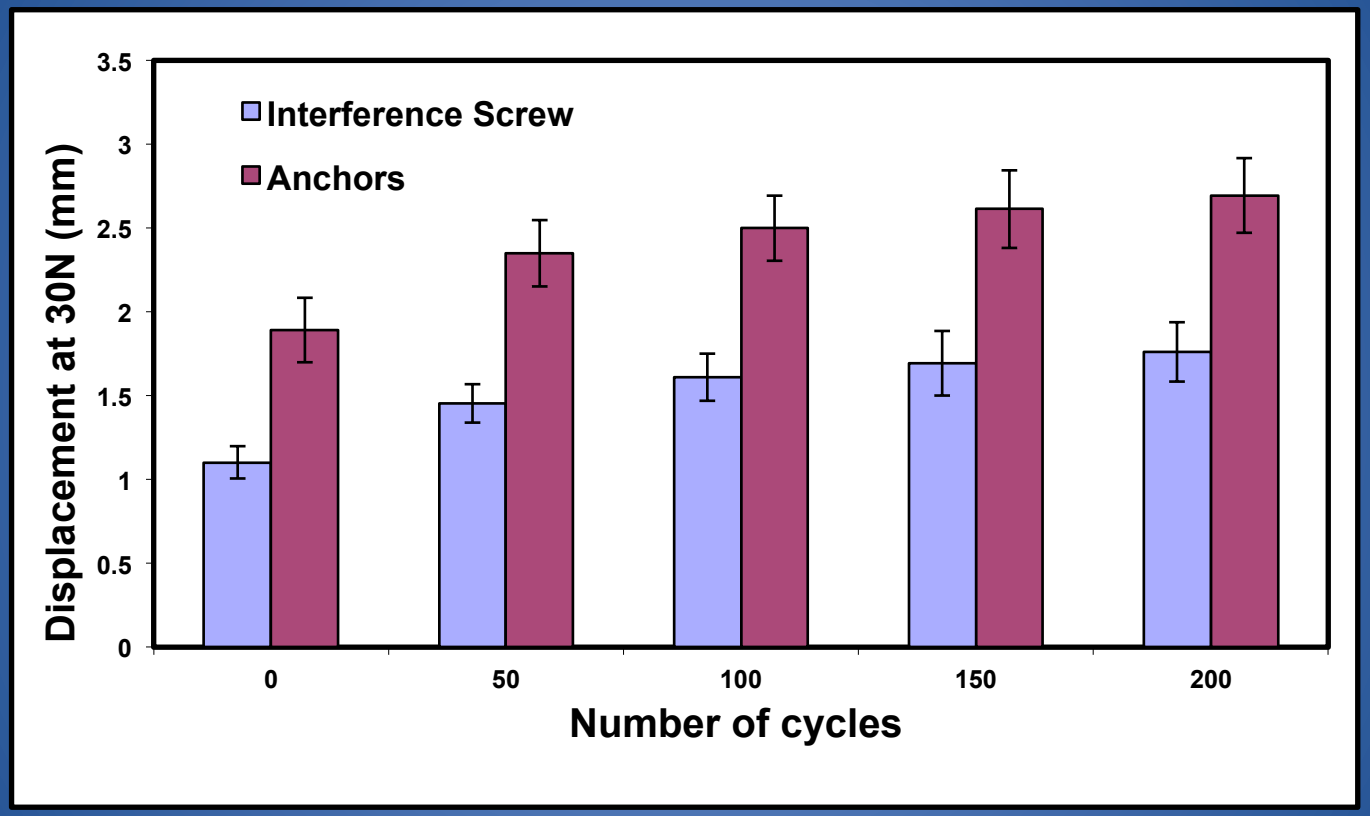

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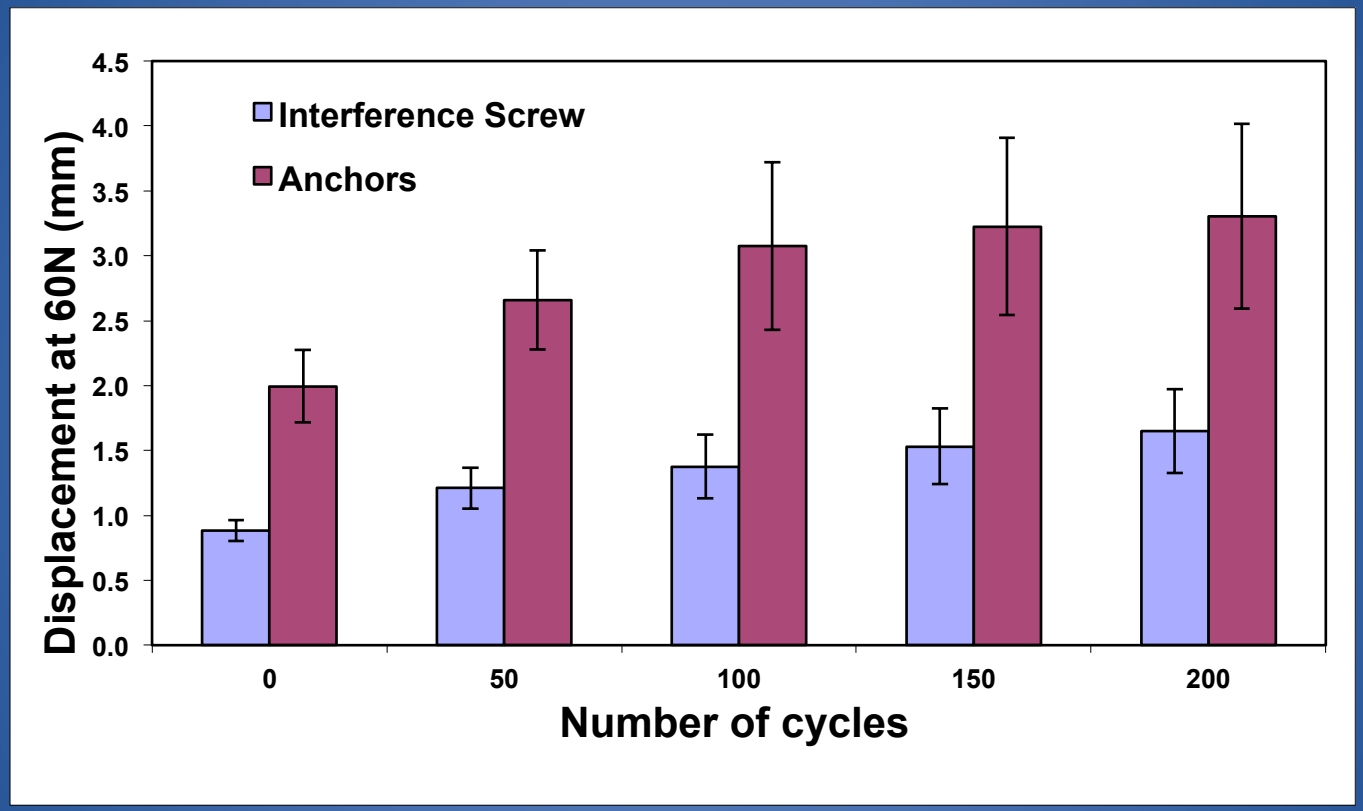

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ARTHROSCOPIC ASSISTED LATISSIMUS DORSI TRANSFER Surgical Technique

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SURGICAL TECHNIQUE FOR ARTHROSCOPIC LD TRANSFER

Mini Invasive Axillary Approach and Arthroscopic Humeral Head Interference Screw Fixation for Latissimus Dorsi Transfer in Massive and Irreparable Posterosuperior Rotator Cuff Tears

Jean Kany, MD, Hemanth Alladu Kumar, MS,† Vivian K. Chang, MD,‡ Jean Grimberg, MD,§ Jérôme Garret, MD,‖ and Philippe Valenti, MD¶*

Tech Should Surg 2010 ; 11 : 8-14

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Principles of the technique

- Tubularised LD tendon
- Arthroscopic transfer
- Interference screw fixation in a bone tunnel or button type fixation on anterior humeral cortex

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TECHNIQUE

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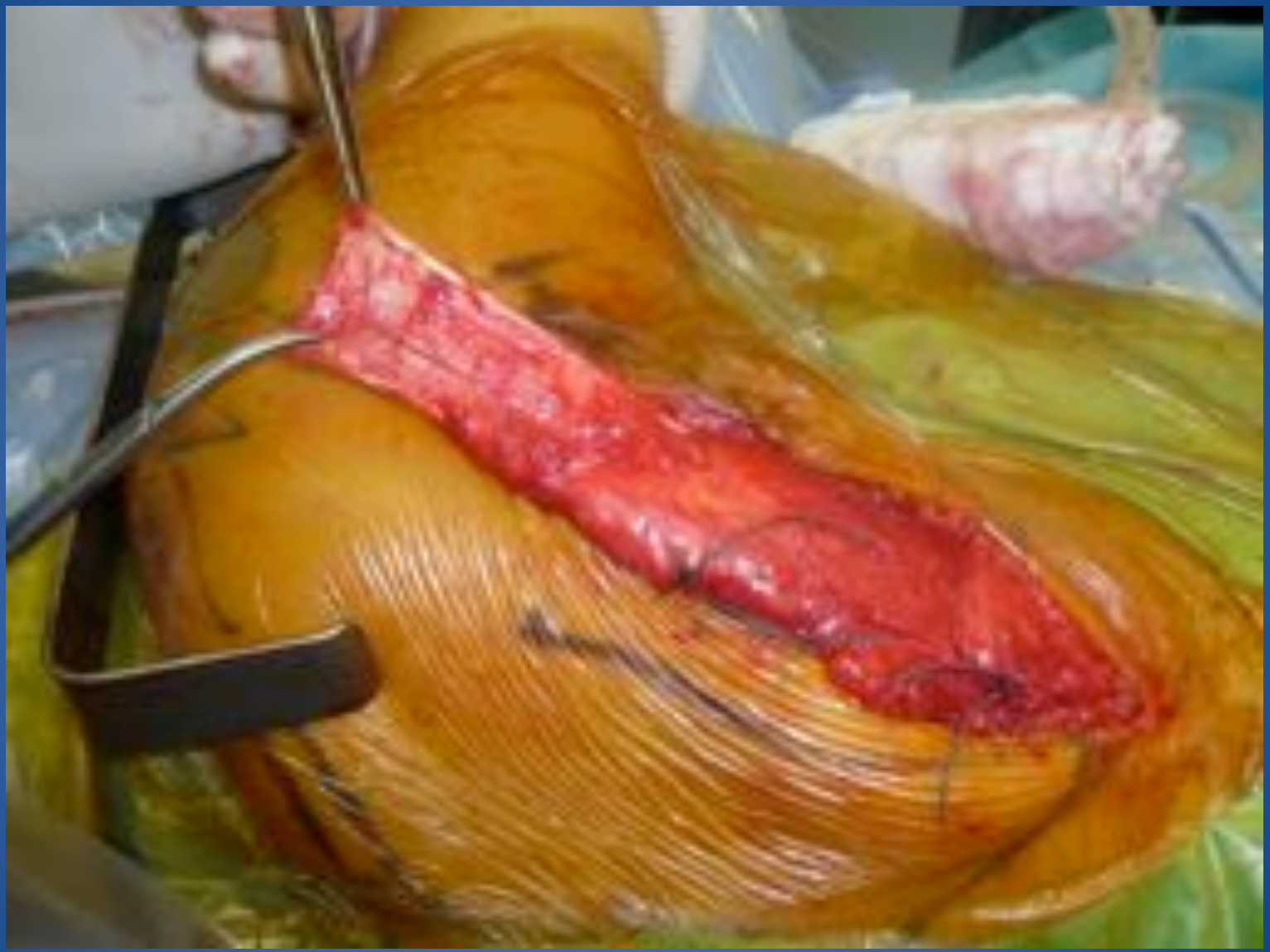

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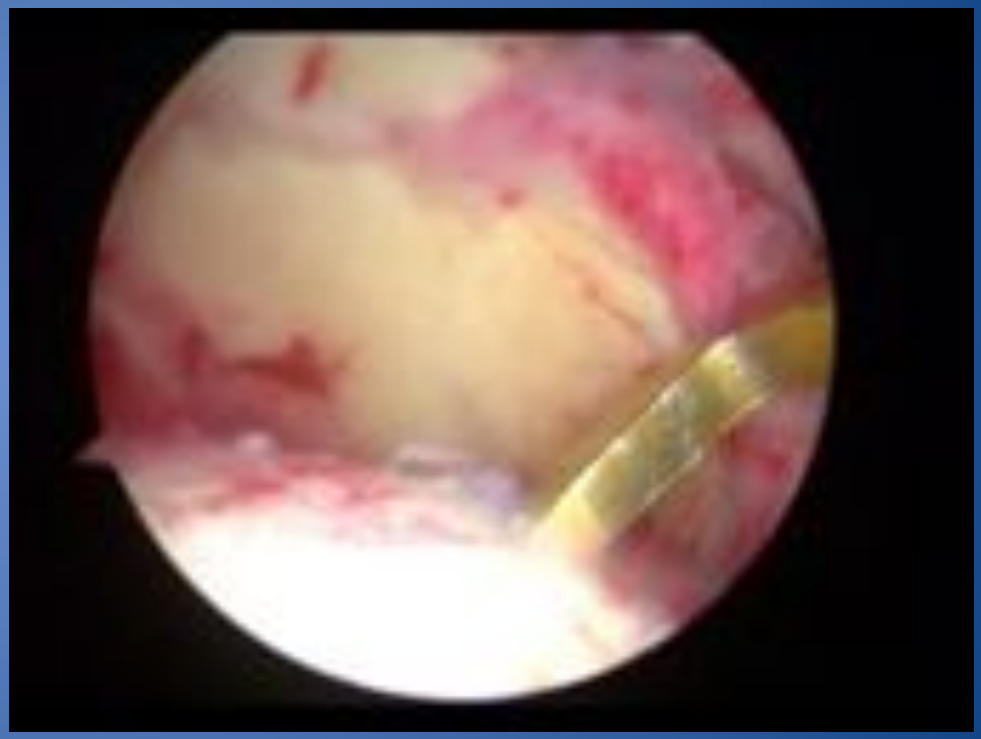
TECHNIQUE



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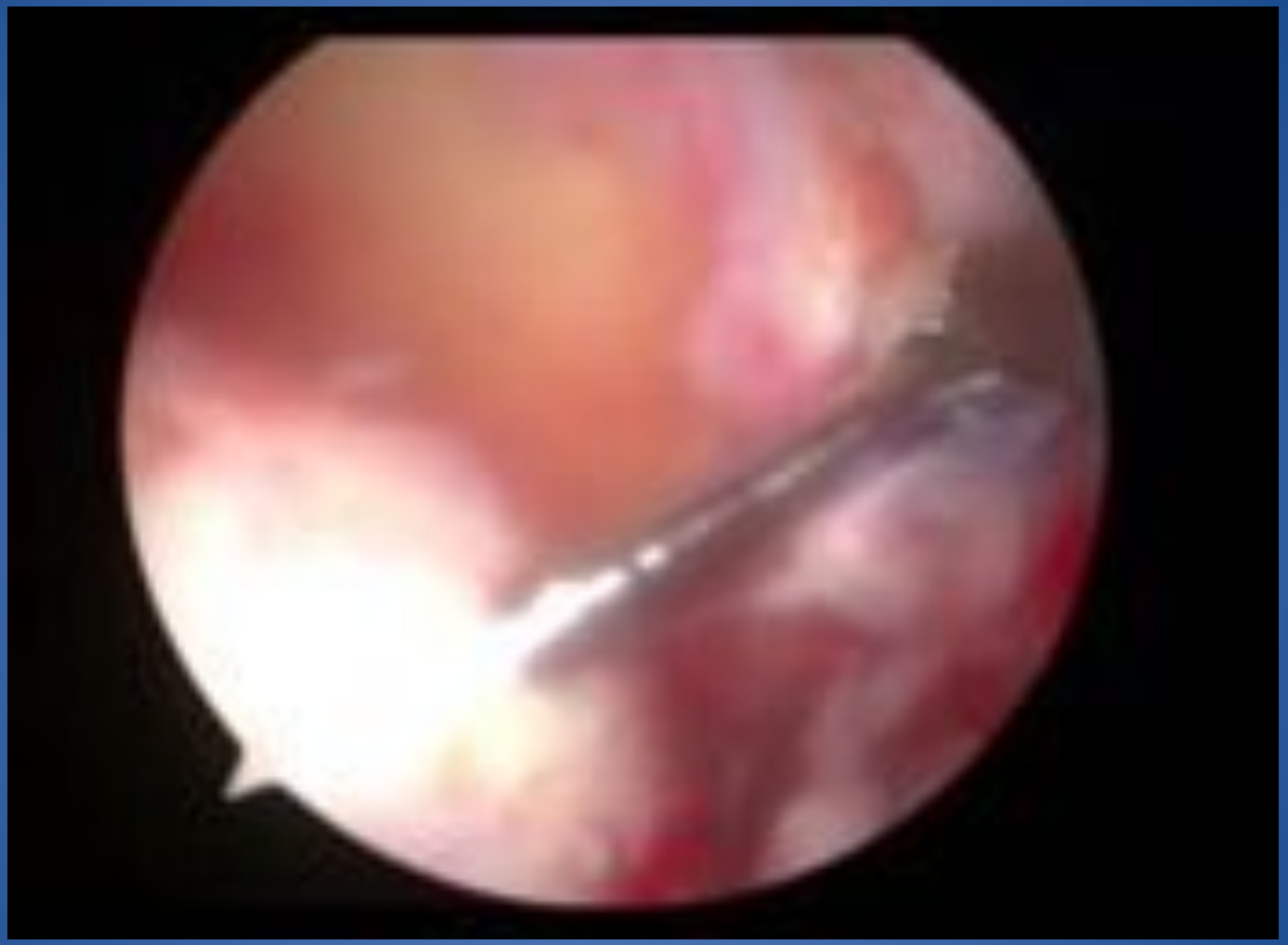

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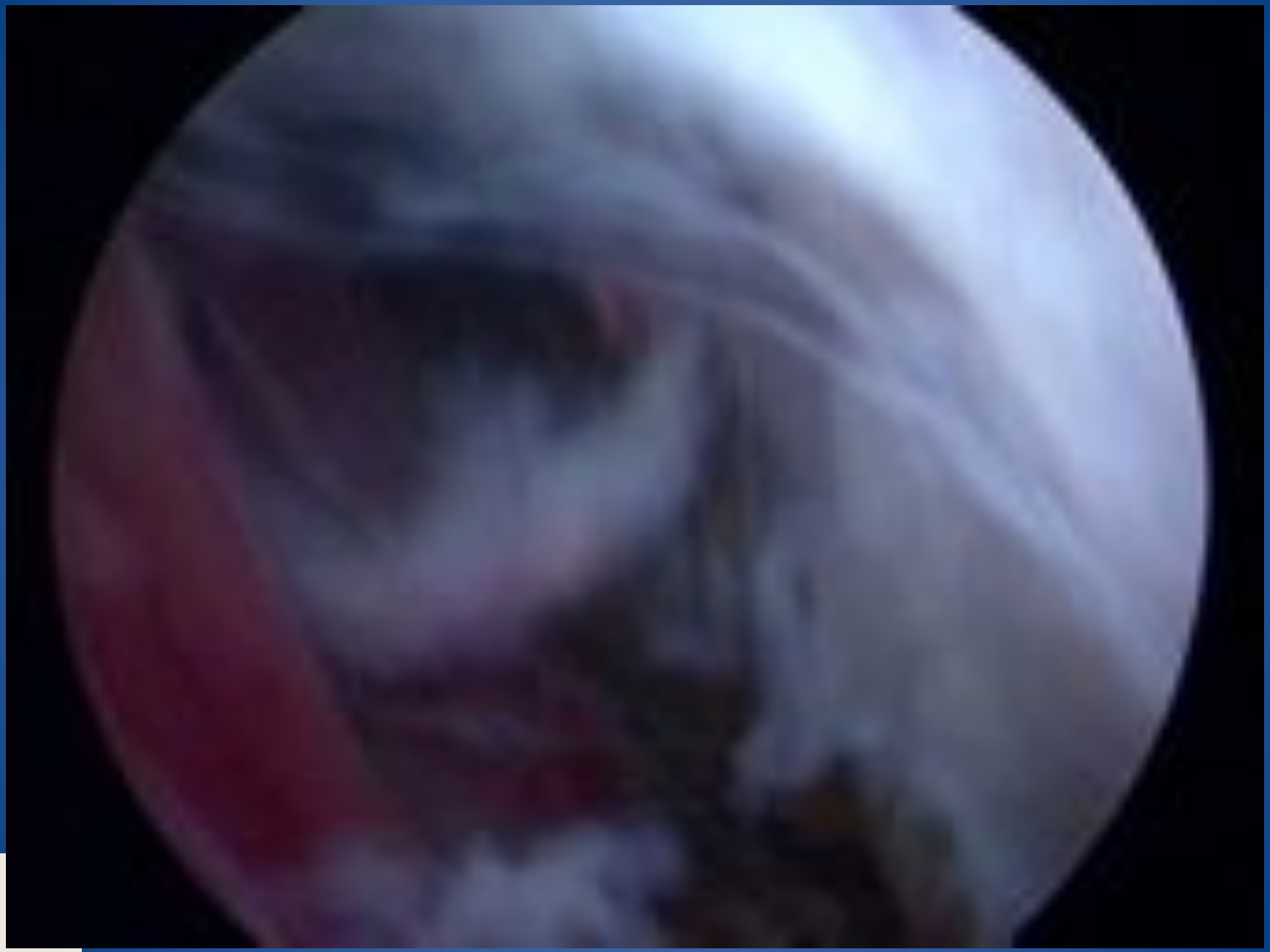

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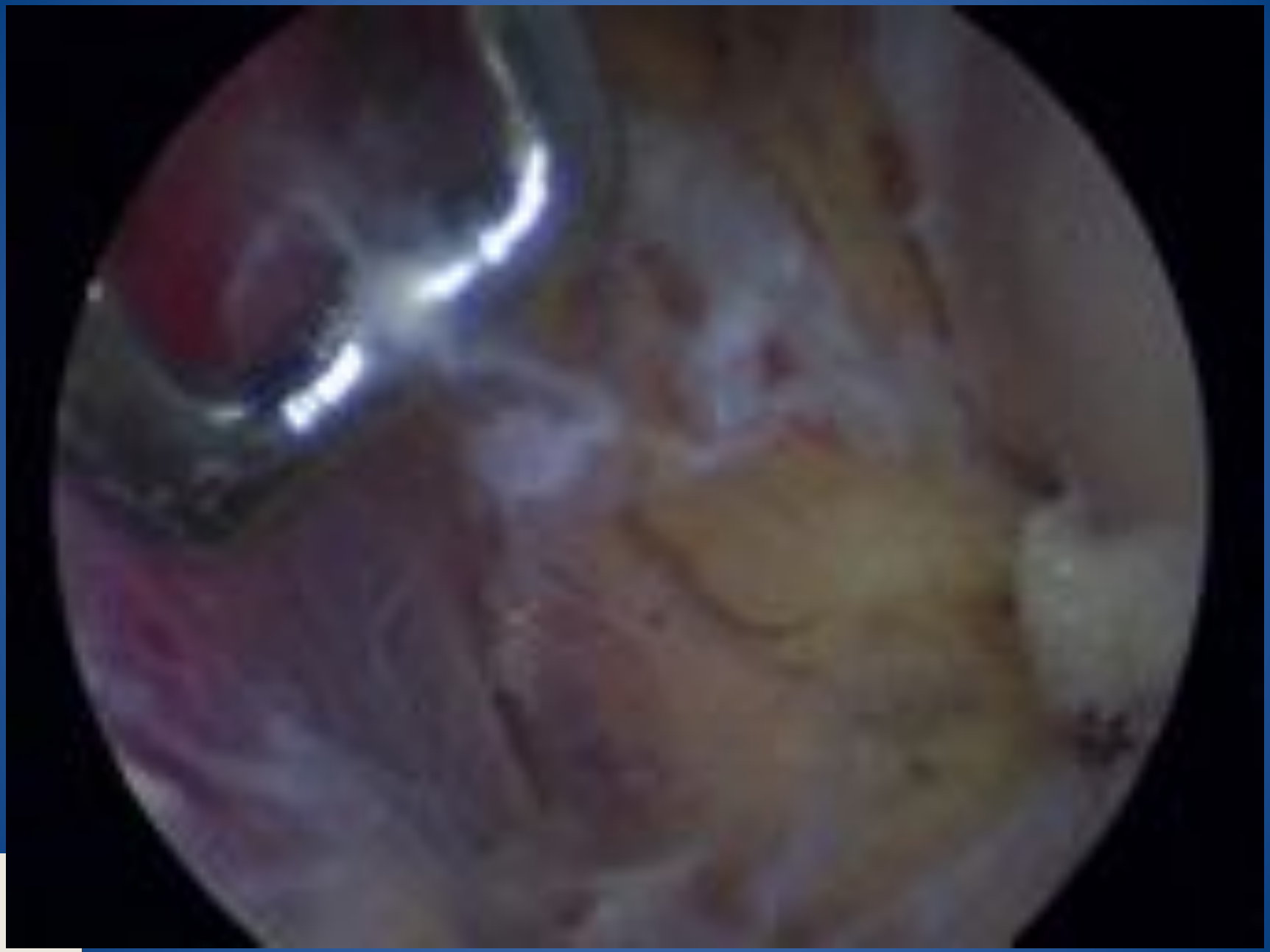

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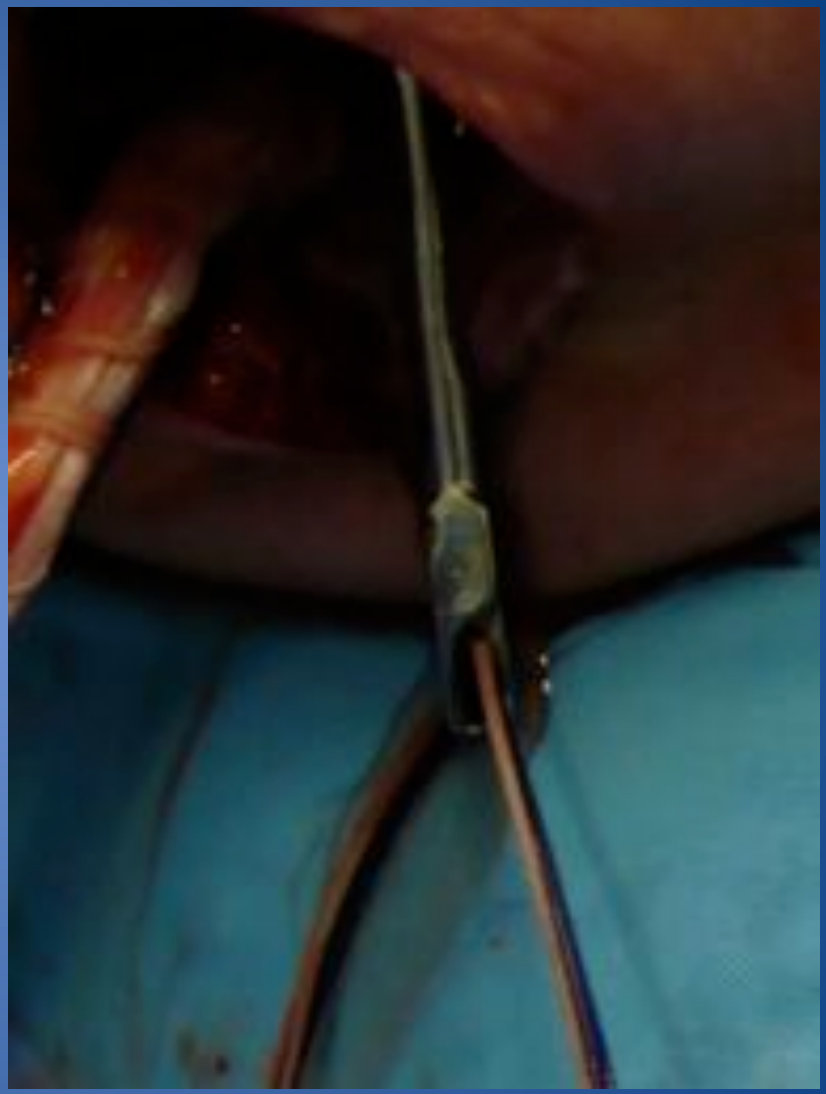

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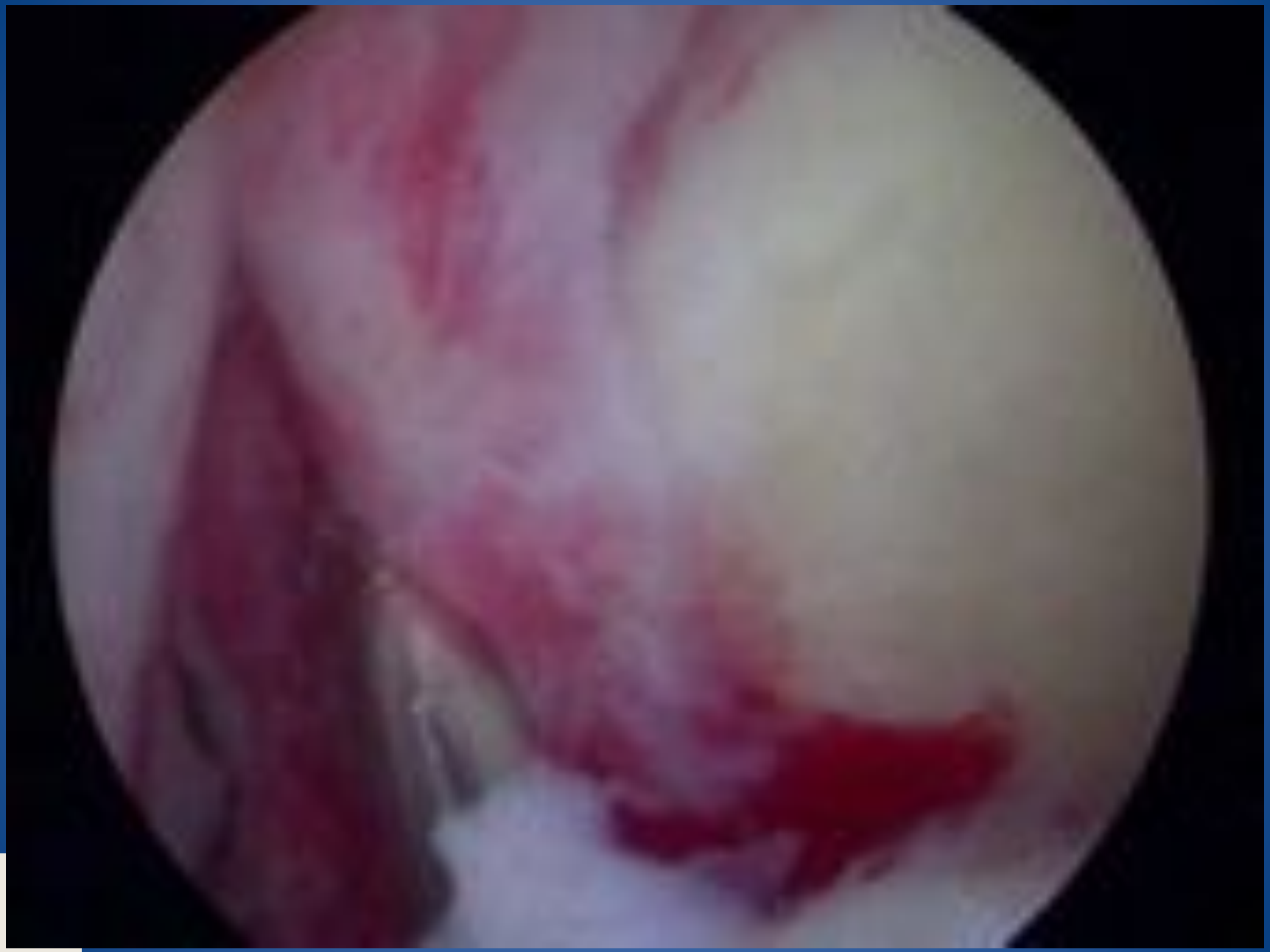

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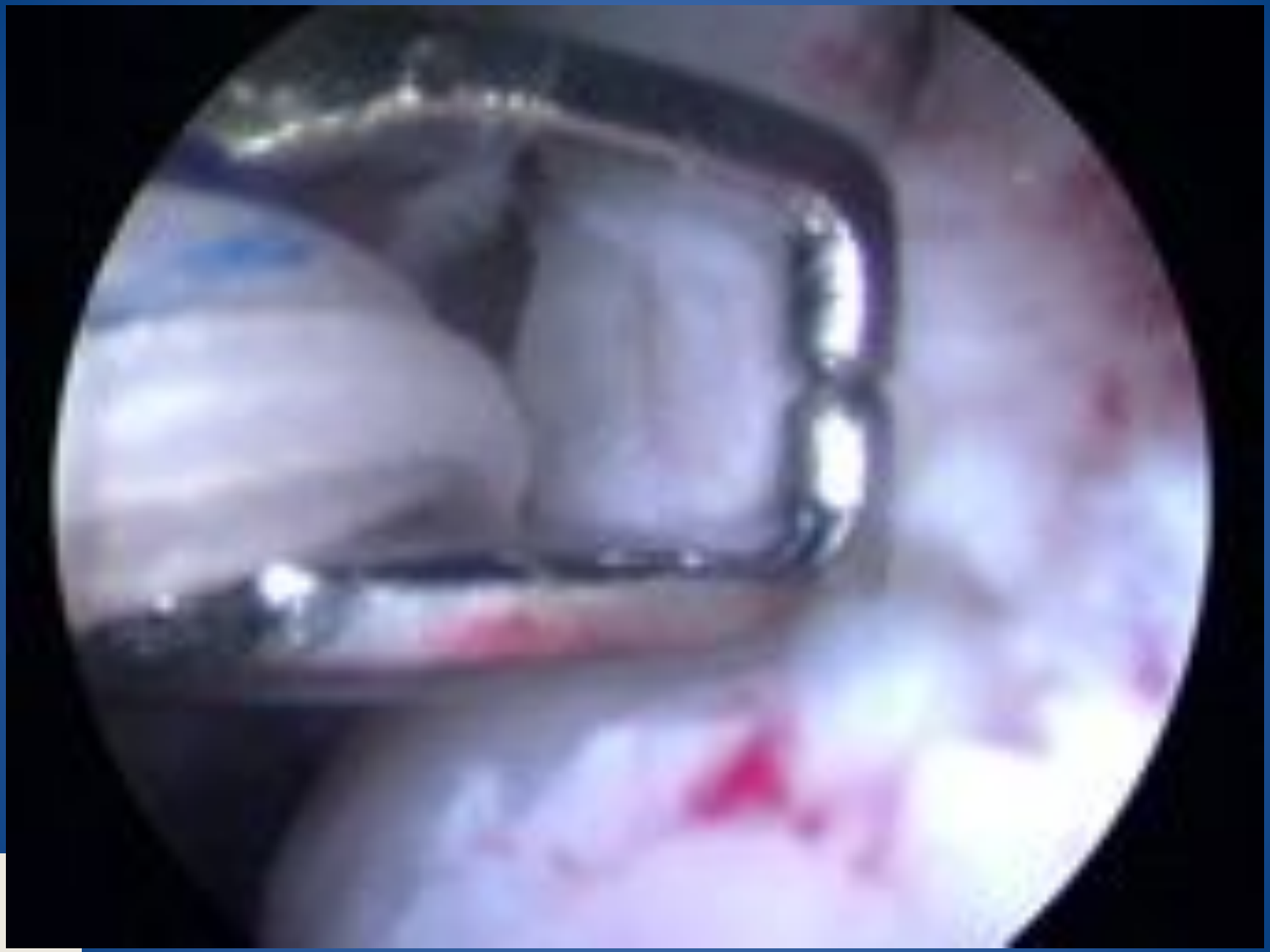

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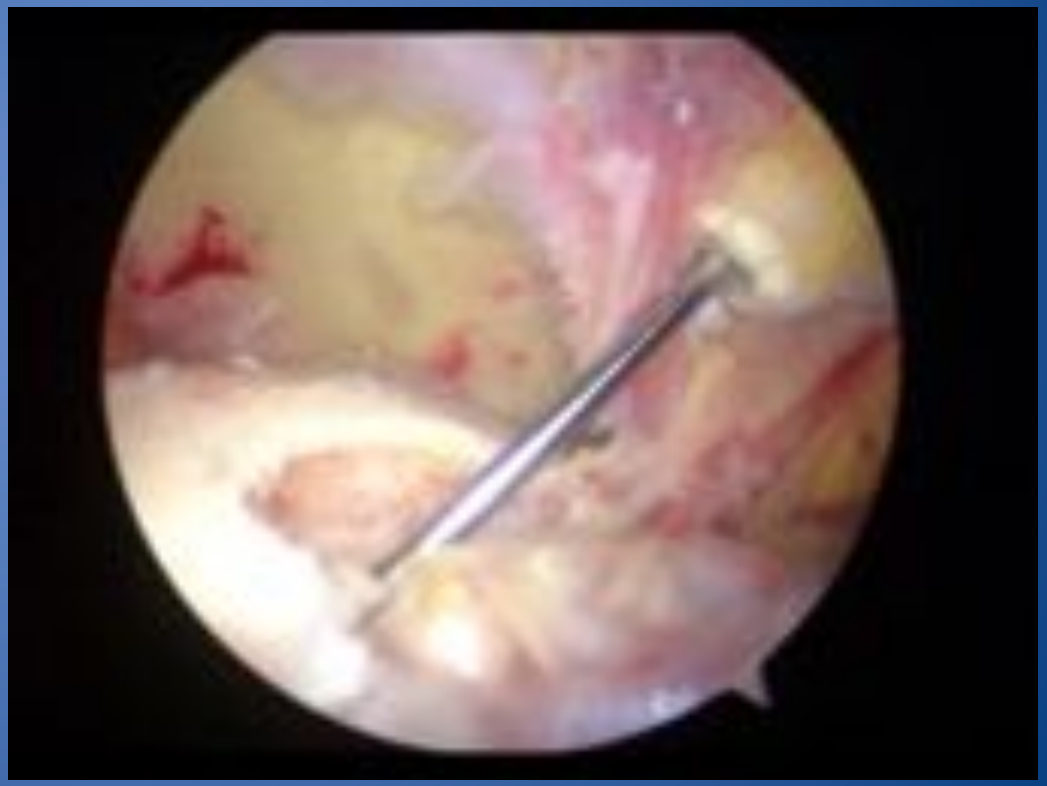
TECHNIQUE



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TECHNIQUE

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RESULTS OF LD TRANSFER

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AUTHOR	DATE	N° PATIENTS	TECHNIQUE	FU (months)	Postop Constant score	Satisfied patients
Hart	2010	8/13	primary/secondary	47	70	90%
Valenti	2010	17/8	primary/secondary	22	58	84%/50%
Lehman	2010	26	-	24	56	-
Gerhardt/ Habermeyer	2010	20	LD+TM, primary	60	-	90%
Zafra	2009	18	primary	28	70	88%
Moursy/Resch	2009	20/22	With bone/without Bone	47	74/65	90%/73%
Nové Josserand/ Walch	2009	27	primary	36	74	85%
Birmingham and Neviaser	2008	19	secondary	25	-	94%
Irlenbusch	2008	25/7	primary/secondary	50	71/60	
Pearsalls	2007	7	secondary	31	44	71%
Gerber	2006	50/19	primary/secondary	53	79%/56%	-
Ianotti	2006	14	Primary/secondary	39	-	65%
Degreef	2005	12	Primary/secondary	39	62	50%
Warner and Parsons	2001	6/16	primary/secondary	25/29	69%/52%	86%/56%
Miniaci and Mac Leod	1999	17	secondary	51	-	83%
Aoki	1996	12	Primary/secondary	35	-	75%

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INTRODUCTION

- BUT
  - Some limits : deltoïd malfunction, subscapularis tears, work related accident, revision surgery, bad tissue
  - Some clinical results less satisfying with Constant score < 60 (Valenti et al OTSR 2010, Lehman et al, 2010, Pearsall et al, 2007)
- Hypothesis : bad tendon-bone healing ?
  - Because of bone ? Because of tendon ? Fixation system failure ?

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EARLY RESULTS OF A MULTICENTER PROSPECTIVE STUDY

J.Grimberg, J.Kany, Ph. Valenti, J. Garret, LD. Duranthon, VK Chang

(Paris, Saint Jean, Lyon, Hawaï)

SECEC meeting, Lyon 2011

SALFORD, 2011

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MATERIALS AND METHOD

- Multicenter clinical prospective study
  - 3 independant surgeons (Toulouse, Dr Kany ; Paris, Dr Valenti ; Paris, Dr Grimberg)
- Inclusion criteria : Massive irreparable cuff tears
- Exclusion criteria : Omarthrosis, Deltoïd palsy, Irreparable subscapularis tear.

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MATERIAL AND METHODS

- PREOPERATIVE EVALUATION
  - Clinical evaluation : Constant score, Single Shoulder Value (SSV)
  - Radiological evaluation : MRI or CTscan.
- POSTOPERATIVE EVALUATION :
  - Clinical evaluation : Constant score, SSV, subjective satisfaction.
  - Radiological evaluation : one year postop MRI
- Statistical analysis : Paired Student t tests, Mann-Whitney U tests

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RESULTS

- **49** Patients (27 Dr JK, 11 Dr PhV, 11 Dr JG)
  - Mean age at surgery: **59,4** (31-73)
  - 23 primary surgeries, 26 secondary surgeries (1 to 6 previous surgical procedures)
  - Mean follow up : **21,2** months (12-42)
  - No lost to follow-up.

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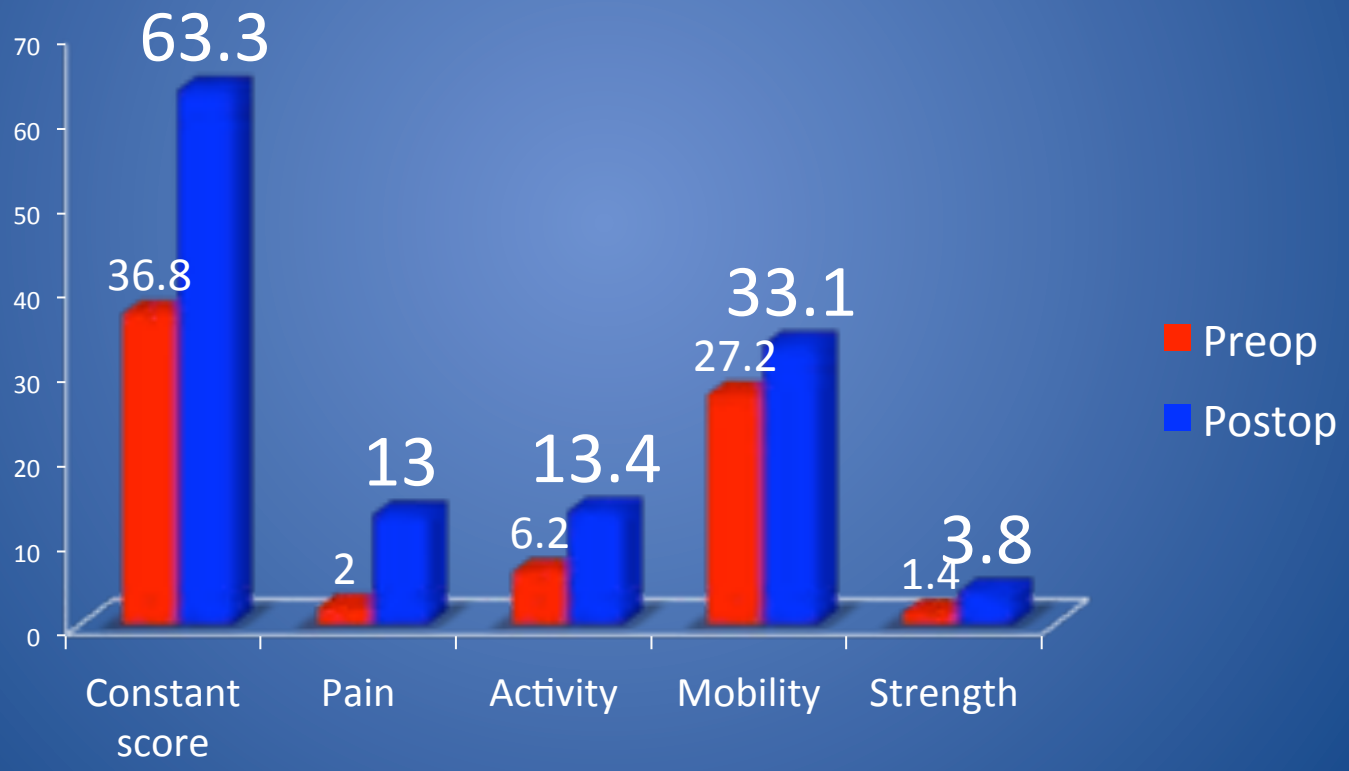
CLINICAL RESULTS

- CONSTANT SCORE



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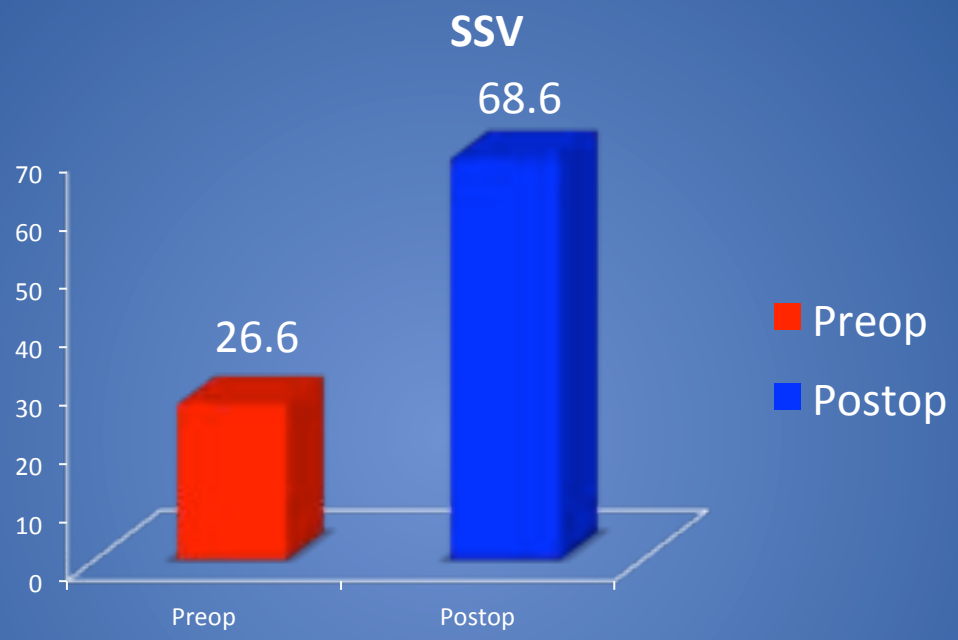
CLINICAL RESULTS

- SSV



- 39/49 = 79,5% satisfied or very satisfied
- Complications : 2 hematomas, one uninfected fat tissue necrosis

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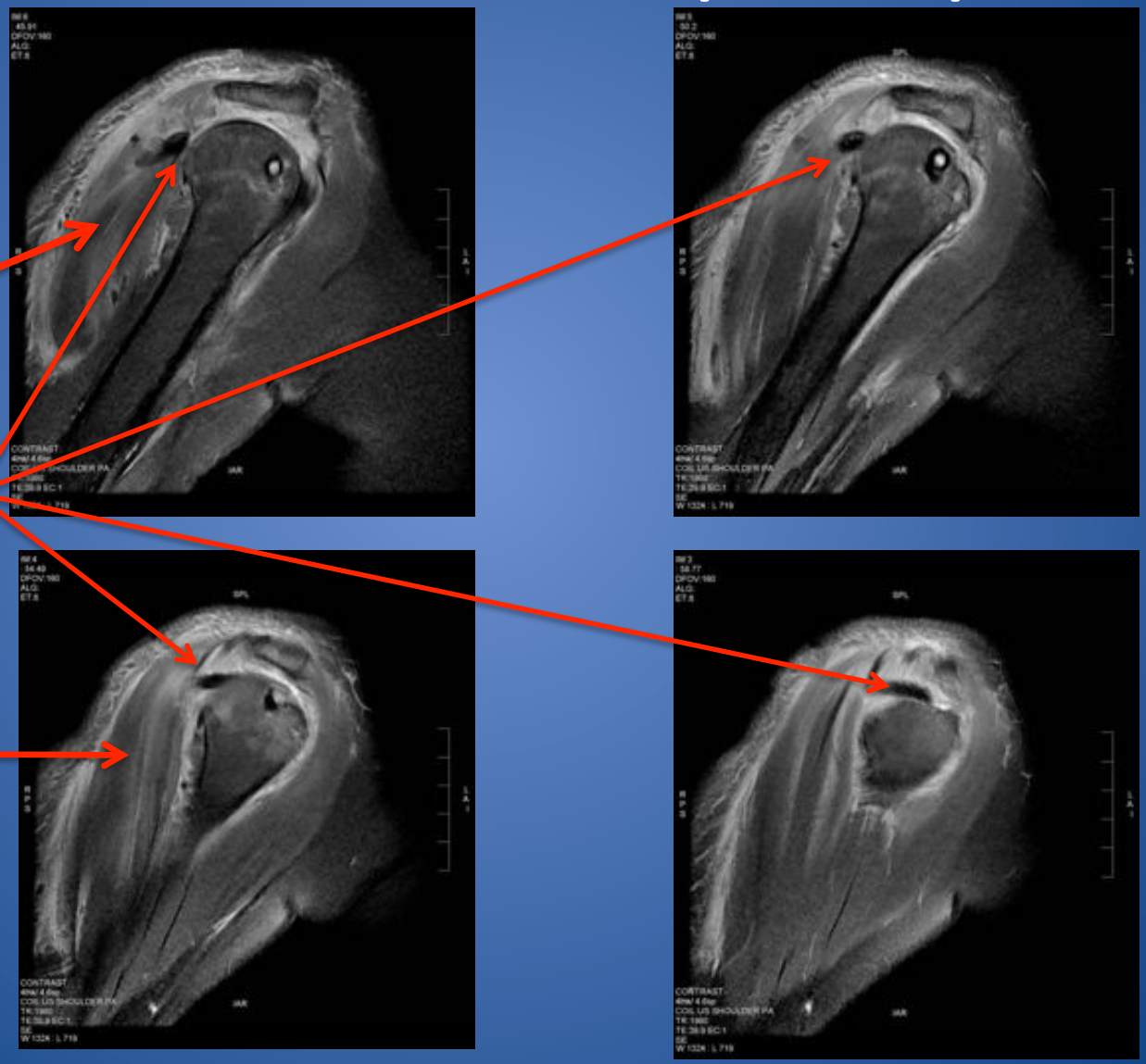
MRI : immediate postop



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MRI : one year postop

- 44 patients : 89,8% of patients controlled
  - 41 intact tendons : 93% of controlled patients
  - 3 tendon-bone secondary pull out probably linked to bone weakness

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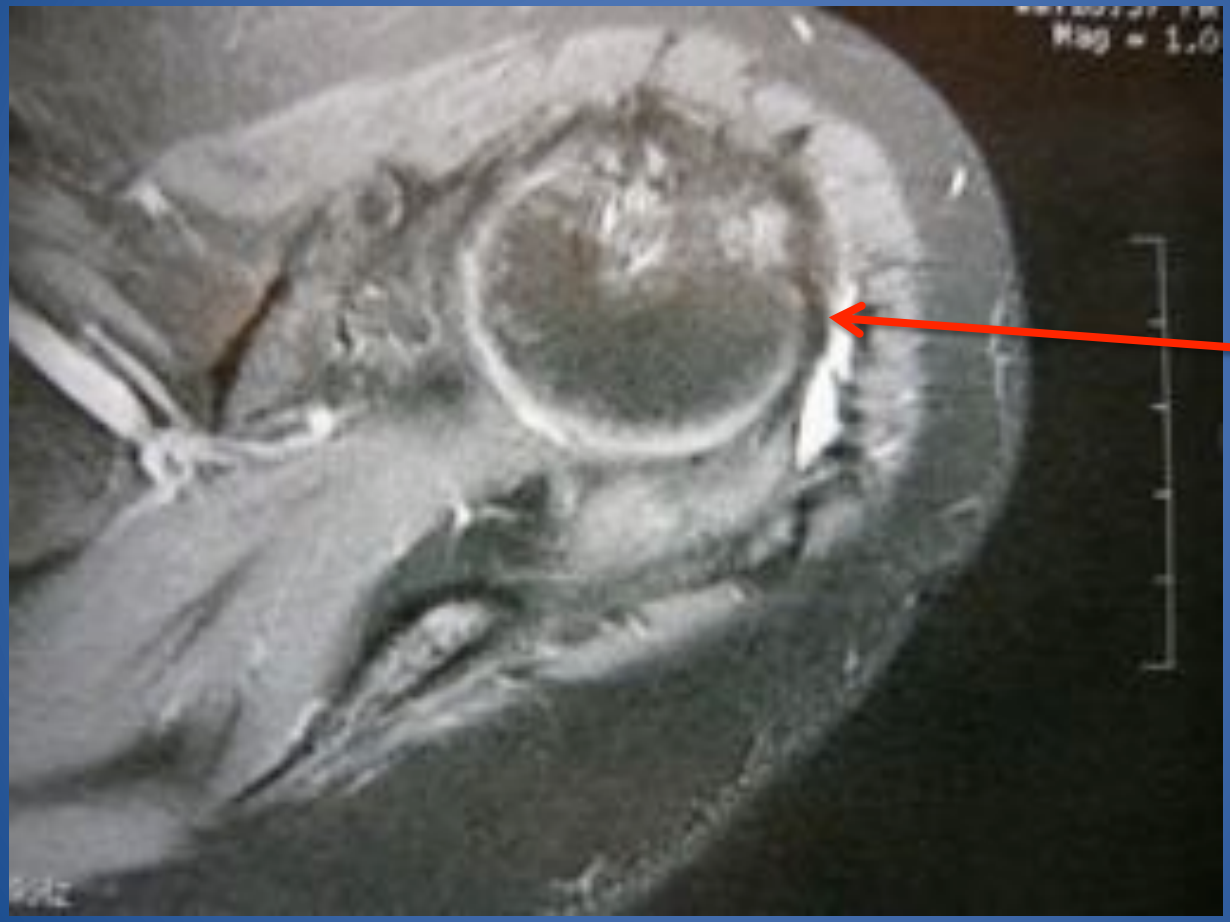
One year postop MRI



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PREDICTING FACTORS

- NO INFLUENCE ON CLINICAL RESULTS
  - Age > or < 65
  - Sex
  - Manual/Light/Sedentary work
  - Preop active anteflexion > or < 90°
  - Zone of tendon fixation : superior or posterior
- PEJORATIVE FACTORS
  - Worker's compensation
  - Preoperative surgery

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DISCUSSION

		OUR SERIE	LITTERATURE
	Mean preop Constant score	26,6	38
GLOBAL RESULTS	Mean postop Constant Score	63,3 (+36,7)	62 (+24)
	% satisfied patients	79,5	80
PRIMARY SURGERY	Mean postop Constant Score	67	71
	% satisfied patients	91	87
SECONDARY SURGERY	Mean postop Constant Score	60	52
	% satisfied patients	69	71

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DISCUSSION

- Advantages :
  - Easy and reproducible technique with solid tubularised tendon and control of muscle length.
  - One (small) incision, all arthroscopic technique
- Limits and future developments :
  - Longer follow-up with more patients
  - EMG controls after one year.
  - Improvement of the technique with endobutton-type distal humeral fixation under development

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CONCLUSION

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CONCLUSION

THANK YOU FOR YOUR ATTENTION

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MOST RECENT RESULTS OF LD TRANSFER

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- Gerber :
  - 48 patients with > 10 years FU
  - No deterioration with time
  - No prevention of subacromial space narrowing

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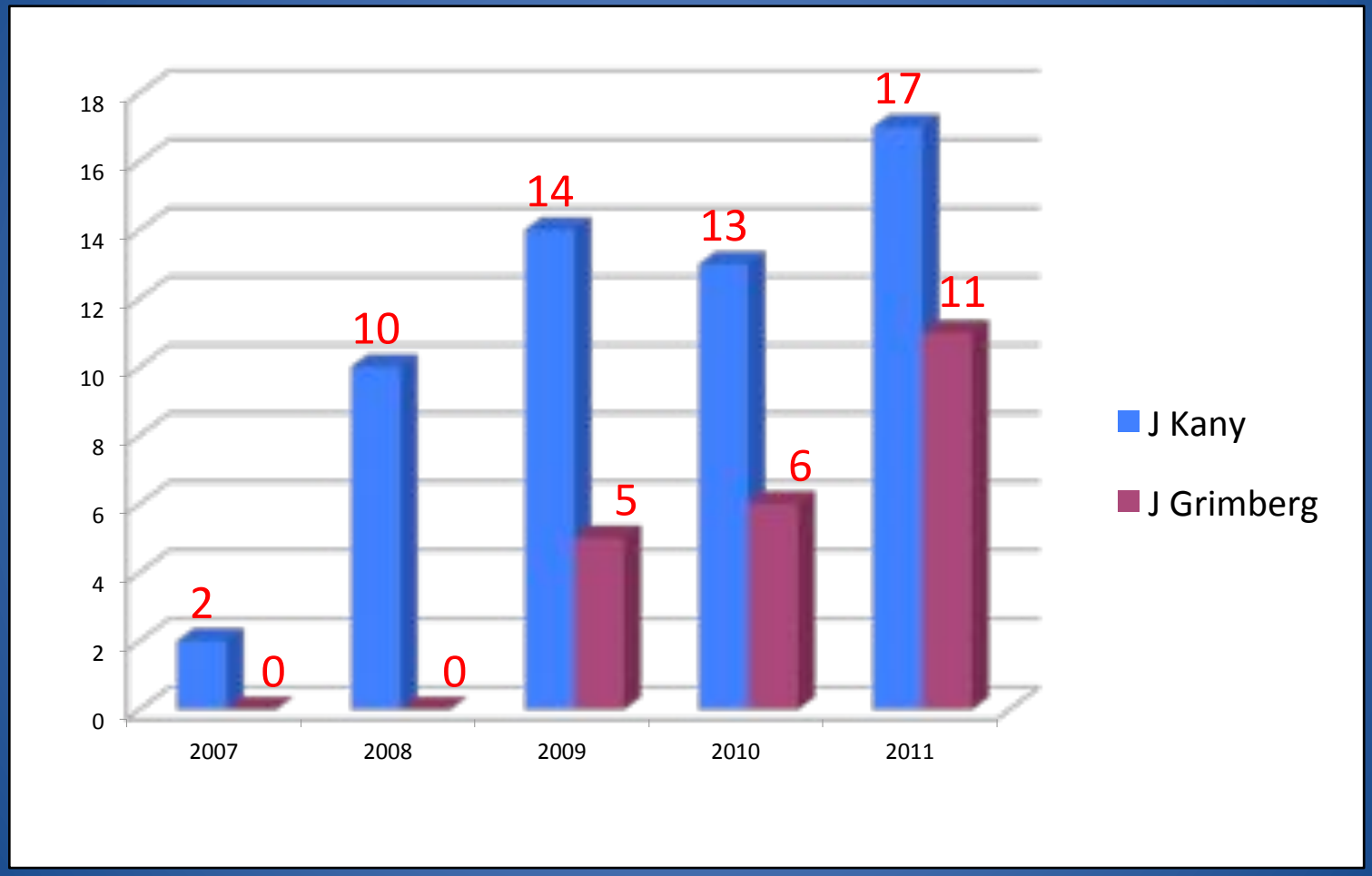
The future of LD transfer ?



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PEC MAJOR TRANSFER FOR SUBSCAP IRREPARABLE TEARS

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HISTORY OF PECTORALIS MAJOR TRANSFER IN RCT

- First paper : Wirth and Rockwood (J Bone Joint Surg Am 1997)
- 7 publications with encouraging results but
  - Low number of patients (except Jost/Gerber)
  - Variations in surgical technique
  - 20 to 30% of clinical or structural failure :
    - Mean postop Constant score : 58
    - % of satisfied patients : 75%

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RESULTS OF PM TRANSFERS

AUTHOR	DATE	No PATIENTS	CLAVICULAR/STERNAL	Over/under CT	FU (m)	Post op Constant score	Satisfied patients	MRI postop
Gavriilidis/Habermeyer	2010	15	Clavicular	Under	37	68	-	70% intact
Elhassan/Warner	2008	10 (among 30)	Sternal	Under	57	52	63%	60% intact
Galatz/Yamaguchi	2003	14	Clavicular+Sternal	Under	17,5	-	78%	-
Jost/Gerber	2003	30	Clavicular+Sternal	Over	32	62	76%	-
Vidil and Augereau	2000	5	Clavicular	Over	19	50	80%	-
Resch	2000	12	Clavicular+ Sternal	Under	28	67%	-	-
Wirth and Rockwood	1997	8	Clavicular+Sternal	Over	-	-	76%	-

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MOST RECENT RESULTS ON PM TRANSFER FOR SUBSCAP TEARS
SECEC meeting Lyon 2011

- Resch : 51 cases, 35 months FU
  - Constant score : preop 37 to postop 63
  - Better results with bone chip
  - No difference between under or over CT .
- Jost : 30 cases, 36 months FU
  - Under CT, with bone trough in humeral LT
  - Constant score preop 40 to postop 70
  - Decrease of ER
  - Better if supraspinatus intact

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DELTOID INSUFFICIENCY : A SURGICAL CHALLENGE

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DIFFERENT TECHNIQUES

- Trapezius muscle transfer
- Latissimus dorsi transfer
- Pectoralis Major Inverse transfer

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Trapezius transfer for « deltoid palsy »

- Bateman, 1955 ; Saha, Acta Orthop Scand, 1967

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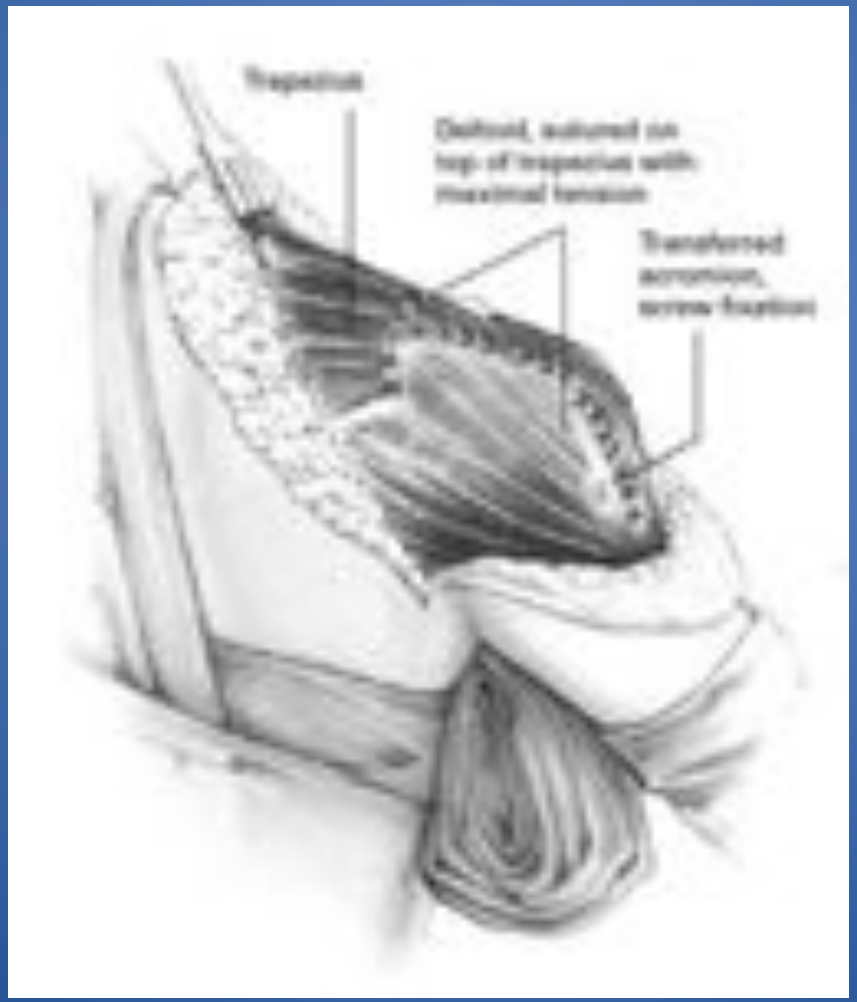
Trapezius transfer for « deltoid palsy »



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Trapezius transfer for « deltoïd palsy »= brachial plexus palsy

Author	Year	Indication	Number of patients	FU (months)	Mean active ABD postop	Mean active Flexion postop
AZIZ	1990	Plexus	27	14	48°	39°
KOTWAL	1998	Plexus/ polio	26	12	+50°	
RUHMAN	1998	Plexus	80	29	34°	30°

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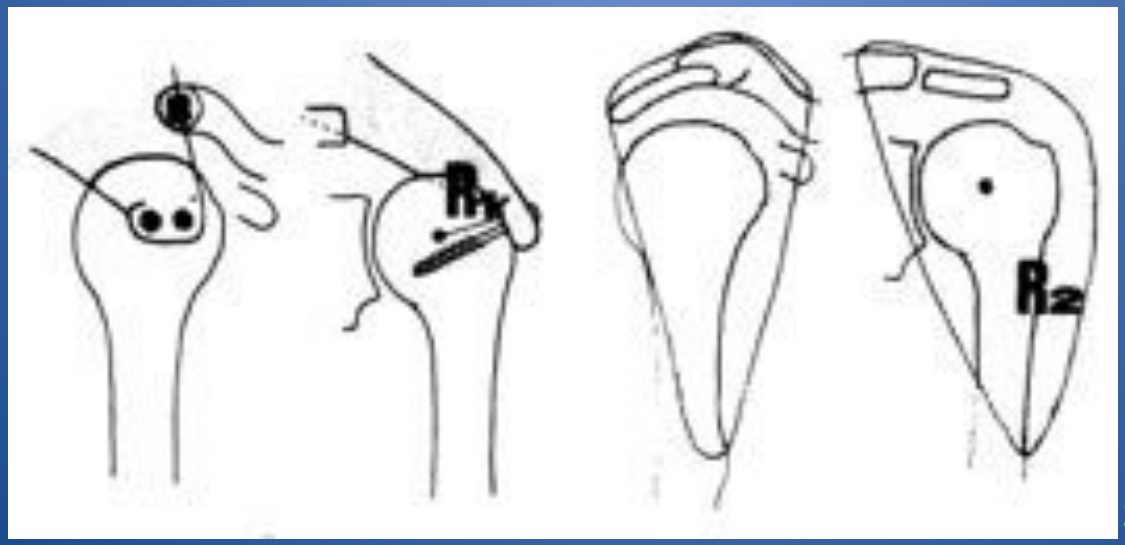
Trapezius transfer for « deltoïd palsy »

- Salvage procedure
- Surgically agressive on bone, less good results when cuff tear
- Lower arm too low to allow good function



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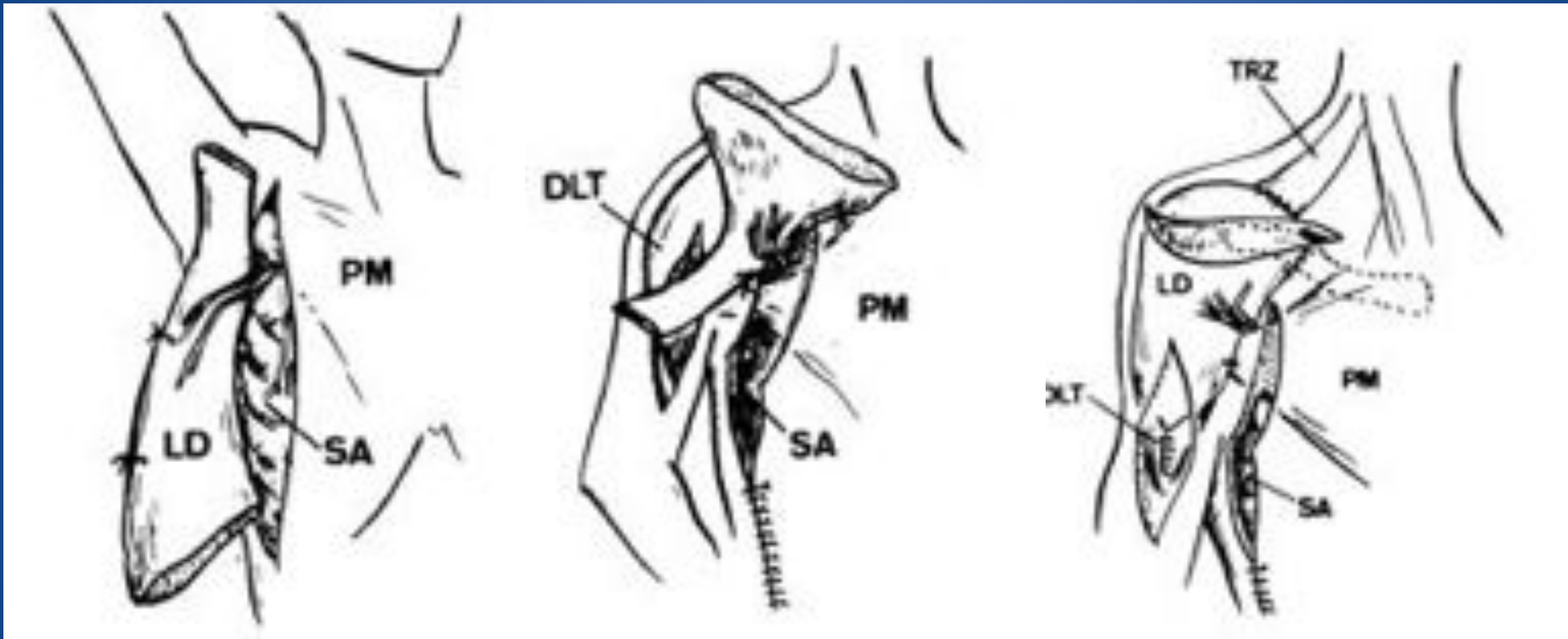
Latissimus dorsi transfer for deltoid palsy



ITOH et al, J Bone Joint Surg (Br) , 1987

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LD transfer for « deltoïd palsy »

- In fact, used in Brachial Plexus Palsy by the authors.
- 10 patients, mean follow up : 13,3 months
- Active postop flexion : 101,5°
- Active postop abduction : 37,5°
- Advantages : no bone cutting, higher lever arm, better AF results

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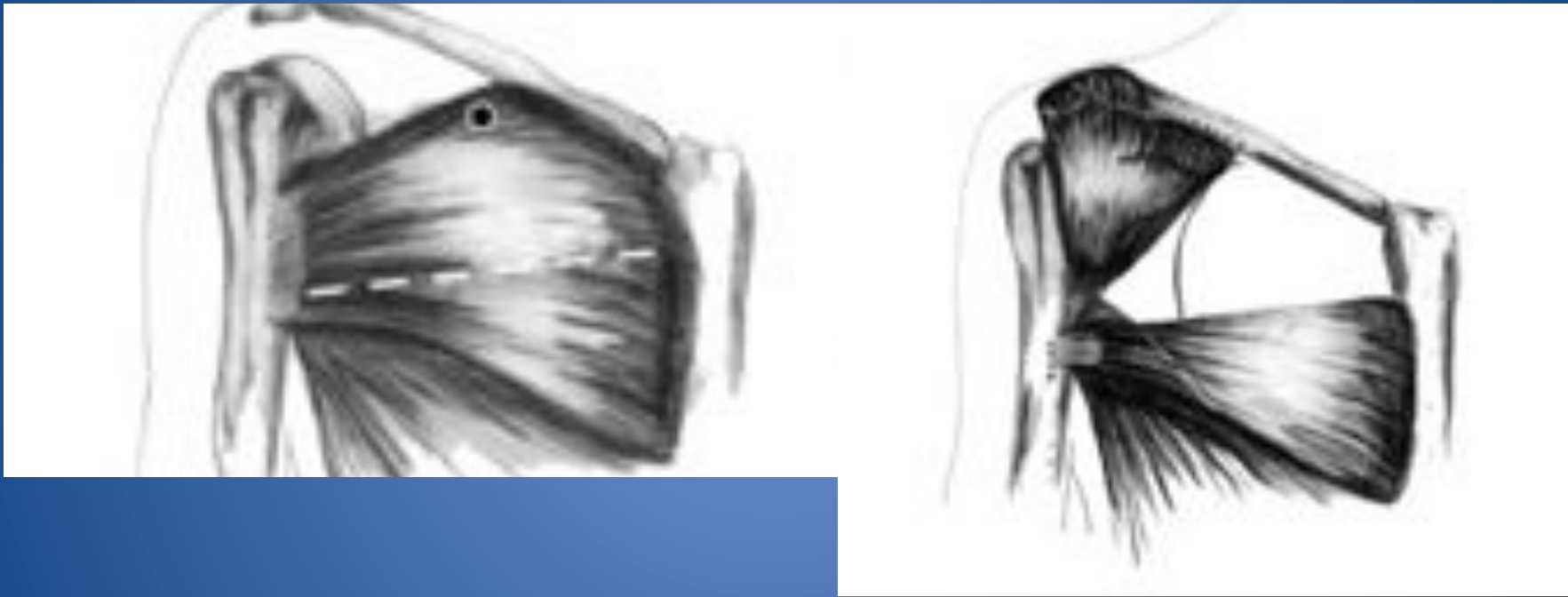
Pectoralis Major Inverse transfer for deltoïd palsy



Resch et al, J Bone Joint Surg, 2008

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Pectoralis Major Inverse transfer for deltoïd palsy

- Mixed indications : 20 patients
  - 11 deltoïd palsy+ Massive RCT
  - 7 brachial plexus palsy
  - 2 isolated axillary nerve palsy
- Mean follow up : 70 months.
- Mean postop active flexion : 77°
- Mean postop active abduction : 67°
- Much better results for isolated nerve palsy

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CONCLUSION

- PM transfer for irreparable subscap tears
  - Results acceptable
  - Not enough studies with not enough patients and follow up
- Transfers for « deltoïd palsy »
  - Best results : Inverse PM transfer on isolated axillary nerve palsy

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CONCLUSION

- LD transfer for postero-superior irreparable cuff tears
  - Reliable
  - Many studies with many patients
  - Good long term results , better in primary procedures
  - Arthroscopic technique : the future ?

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QUIZZ

- Latissimus dorsi transfer for irreparable posterosuperior cuff tears : (YES/NO)
- 1°) Has better results as a primary procedure
- 2°) Has better results if subscapularis is intact
- 3°) Has better results as an open procedure
- 4°) Has decreasing results with time

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QUIZZ : answers

- Latissimus dorsi transfer for irreparable posterosuperior cuff tears : (YES/NO)
- 1°) Has better results as a primary procedure YES
- 2°) Has better results if subscapularis is intact YES
- 3°) Has better results as an open procedure NO
- 4°) Has decreasing results with time NO

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