

# Allomatrix

## Bone Graft in a Distal Radial Fracture Model

### A Prospective Randomized Controlled Clinical Trial



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ET DE TRAUMATOLOGIE

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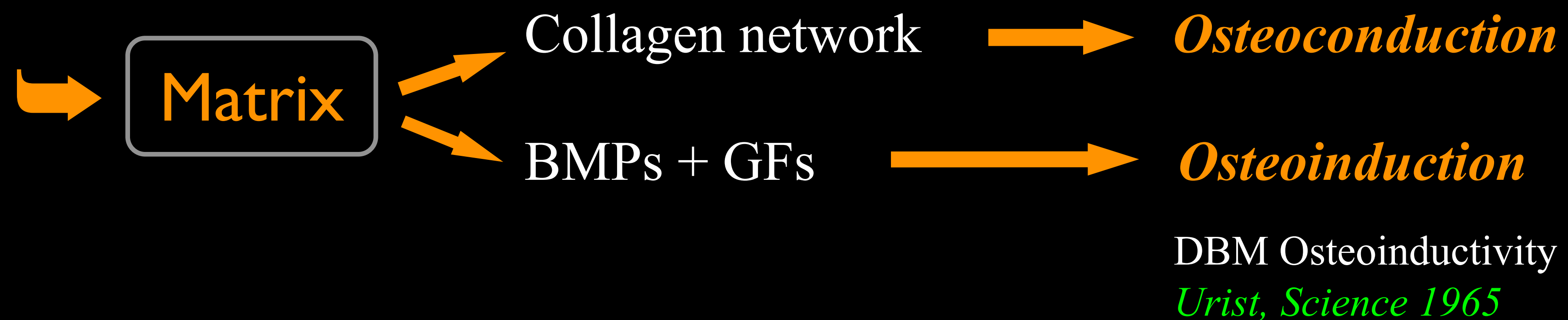


- **Disclosure**

NO FINANCIAL INTERESTS...

- **DBM definition**

Acid extraction from human cortical bone



- **Interest of DBM grafts in Humans?**

Literature ➤ **No Proven**

- **Study Objectives**

**Primary**

➔ AlloMatrix and bone-healing ?

**Secondary**

➔ AlloMatrix and functional recovery?

## ● Study Design

- ✦ One Center
- ✦ Ethical Committee Approval (UCL)
- ✦ Registered by US NIH
- ✦ Prospective Randomized Controlled
- ✦ Between 2005 and 2008
- ✦ 50 patients
- ✦ DRF
- ✦ One Surgeon (+Assistants)
- ✦ AlloMatrix injectable DBM
- ✦ Randomization Envelopes
- ✦ Two R/ groups : Static K-wires stabilization +/- DBM graft
- ✦ No Blinding

## ● Fracture Model

Unstable DRF with dorsal bending of metaphysis +/- ulnar styloid

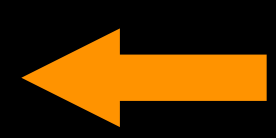


Orthopaedic Surgery most common fracture *Court-Brown and Caesar, Injury 2006*

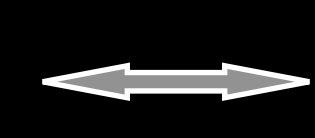


## ● Study Population

Young patients



Quality of anatomic result



Wrist residual capacity

*Villar and March, JBJS 1987*

*McQueen and Caspers, JBJS 1988*

*Young and Rayan, JBJS 2000*

*Kopylov et al., J Hand Surg 2002*

*Hollevoet and Verdonk, Acta Orthopaedica Belgica 2003*

## ● Inclusion Criteria

- ✦ Unstable DRF  
*Lafontaine et al., Injury 1989*
- ✦ High demand patient
- ✦ 18-70 years of age
- ✦ Follow-up possible
- ✦ Informed consent

## Exclusion Criteria

- ✦ Complex DRF
- ✦ Bilateral DRF
- ✦ Other skeletal injury
- ✦ Pregnancy
- ✦ Preexisting conditions



## ● Patient Evaluation Schedule and Sequence

	IC	Fonctional evaluation	DASH questionnaire	Standard X-rays	BMDs
Pre-Op	●			●	
Surgery				●	
1 W F-U		●	●	●	●
3 W F-U		●	●	●	
6 W F-U		●	●	●	●
9 W F-U		●	●	●	
6 M F-U		●	●	●	
12 M F-U		●	●	●	●

## ● Implant Data

**AlloMatrix™** = Injectable DBM Allograft + Calcium Sulfate carrier (Wright USA)

- *kit with different components*
- *5cc volume / syringe*



In vitro bio-assay test for osteoinductivity *Adkisson et al., J Orthop Res 2000*

Indication : fill bony voids (surgical or traumatic)

- **Surgical Protocol**

Operated within a week / Previous manual closed reduction or Japanese fingers traps + cast

External closed reduction and criteria  
*Friberg and Lundström, Acta Radiol Diagn 1976*

Static 2 or 3 K-wires stabilization

➔ 2 transtyloid K-wires +/- 1 dorso-ulnar K-wire



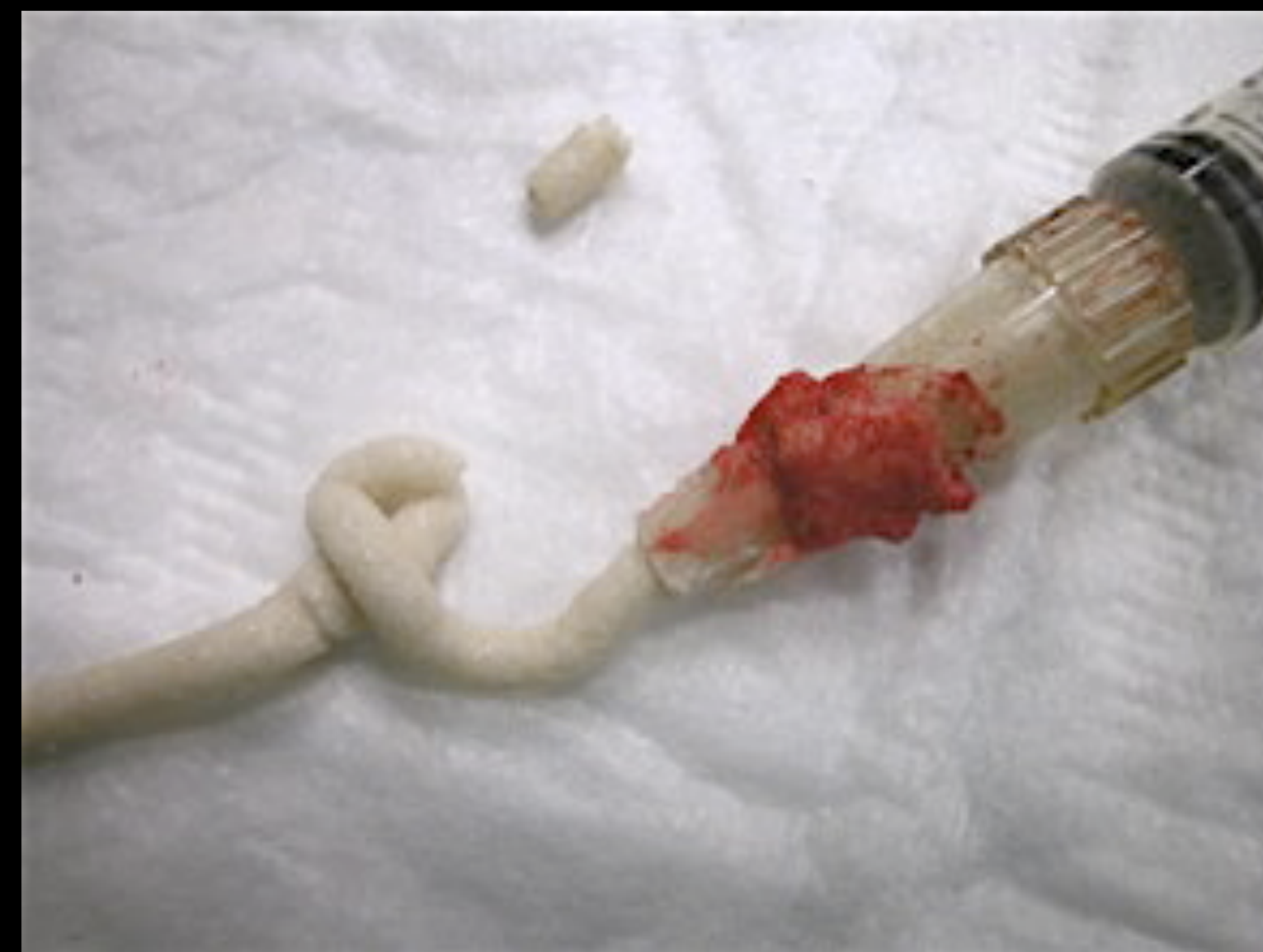
*Fernandez and Jupiter 1996*

*Fernandez and Wolfe 2005*

- **Surgical Protocol**

Randomization envelope

+/- Grafting by limited dorsal approach



Open cast → Removable thermoplastic / Early active digital and forearm motion

Removal K-wires between 6-8 W

Hand therapist active and passive wrist motion

- **Clinical Evaluation Protocol**

Objective Functional Analysis : - Range of motion *Solgaard et al., Scand J Rehab Med 1986*  
- Strength *Mathiowetz, Muscle Strength Testing 1990*

Subjective Functional Analysis : - DASH questionnaire *Hudak et al., Am J Ind Med 1996*

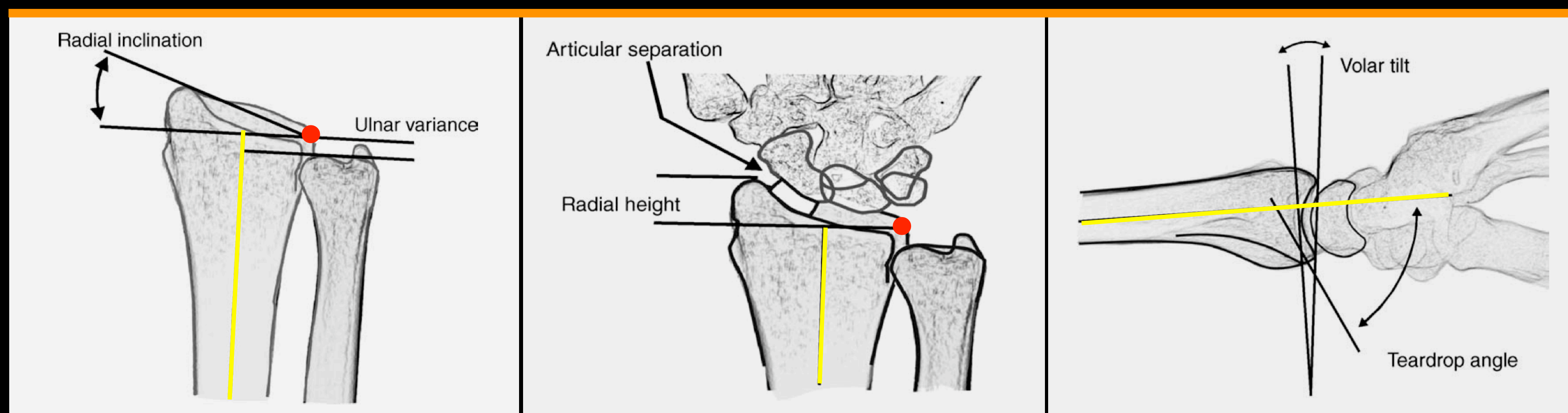


Standardized and Reproducible Methods (ASHT)

## ● Radiographic Analysis Protocol

PA and lateral views :

- Morphology assessment *Medoff, Hand Clin 2005*

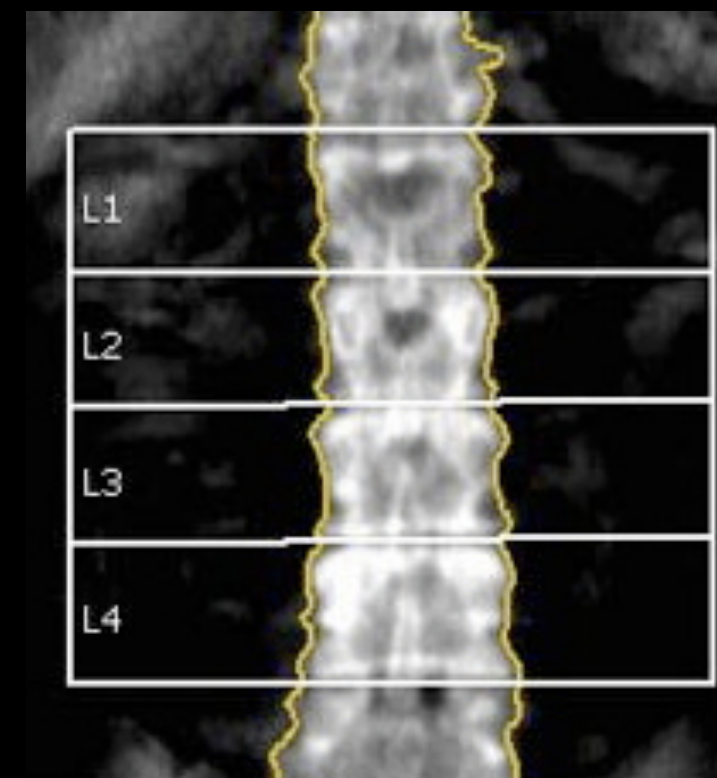
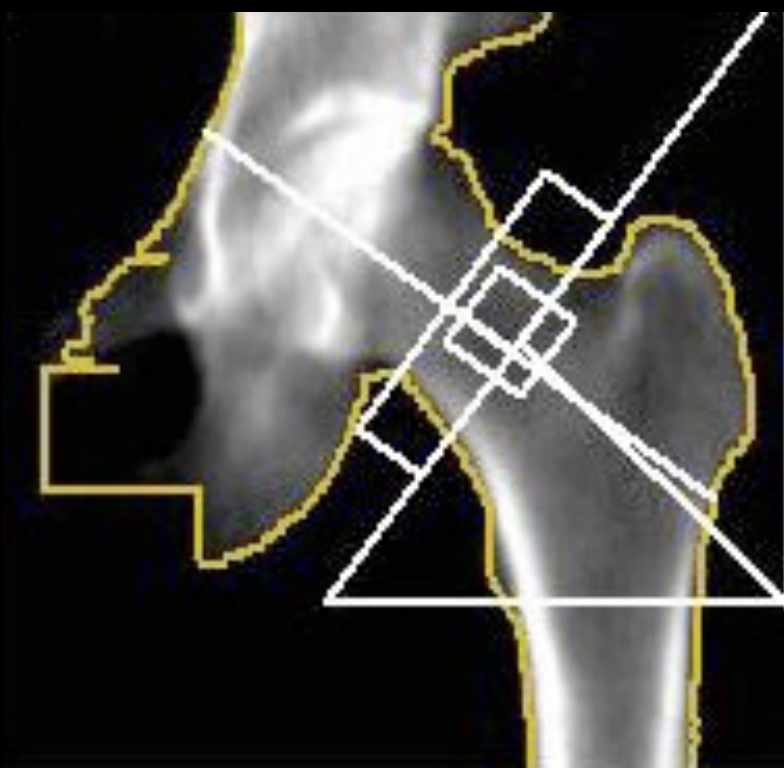


- Union criteria  
*Morshed et al., JBJS 2008; Corrales et al., JBJS 2008*
- Extraskelatal AlloMatrix deposits occurrence

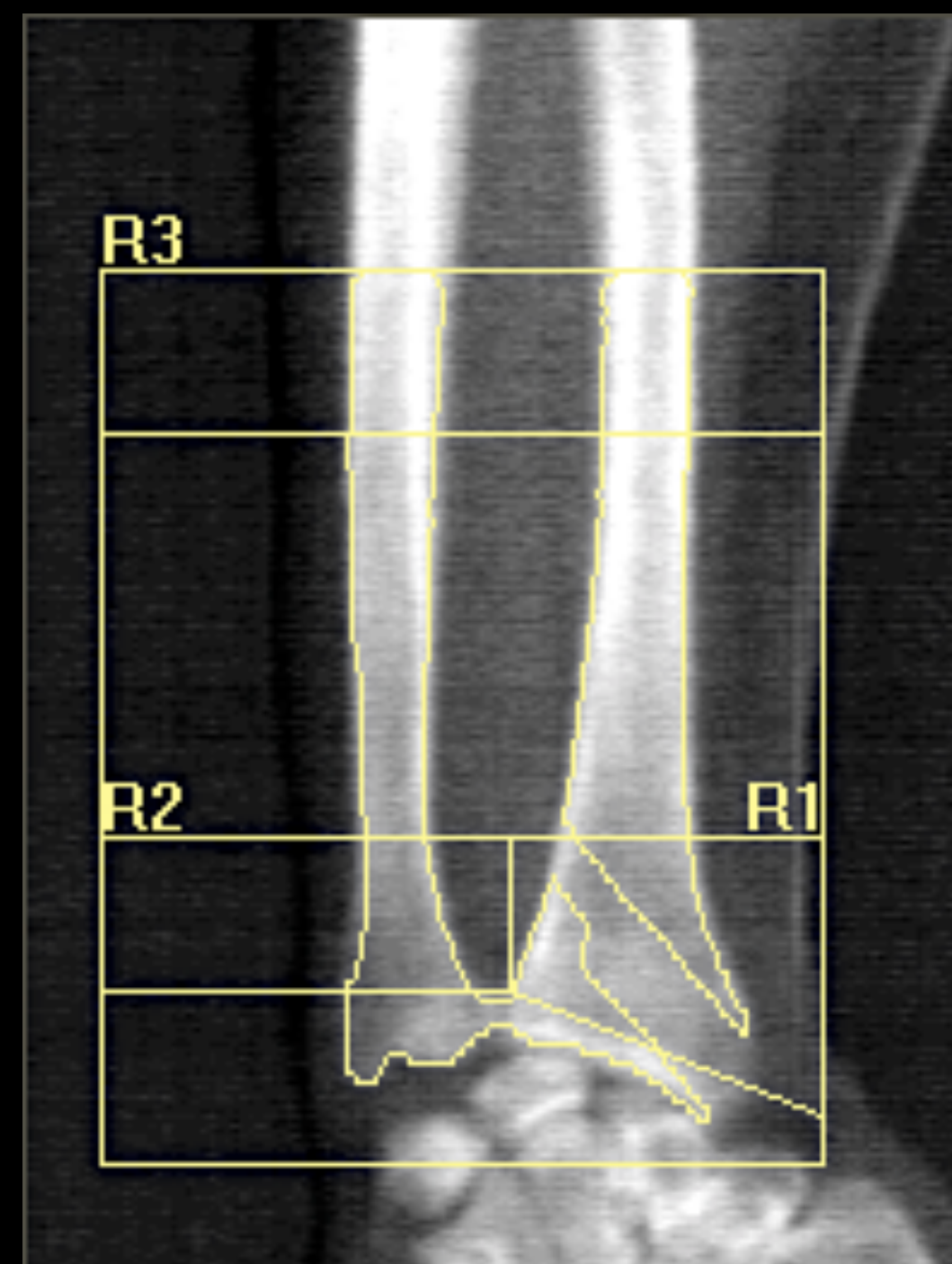
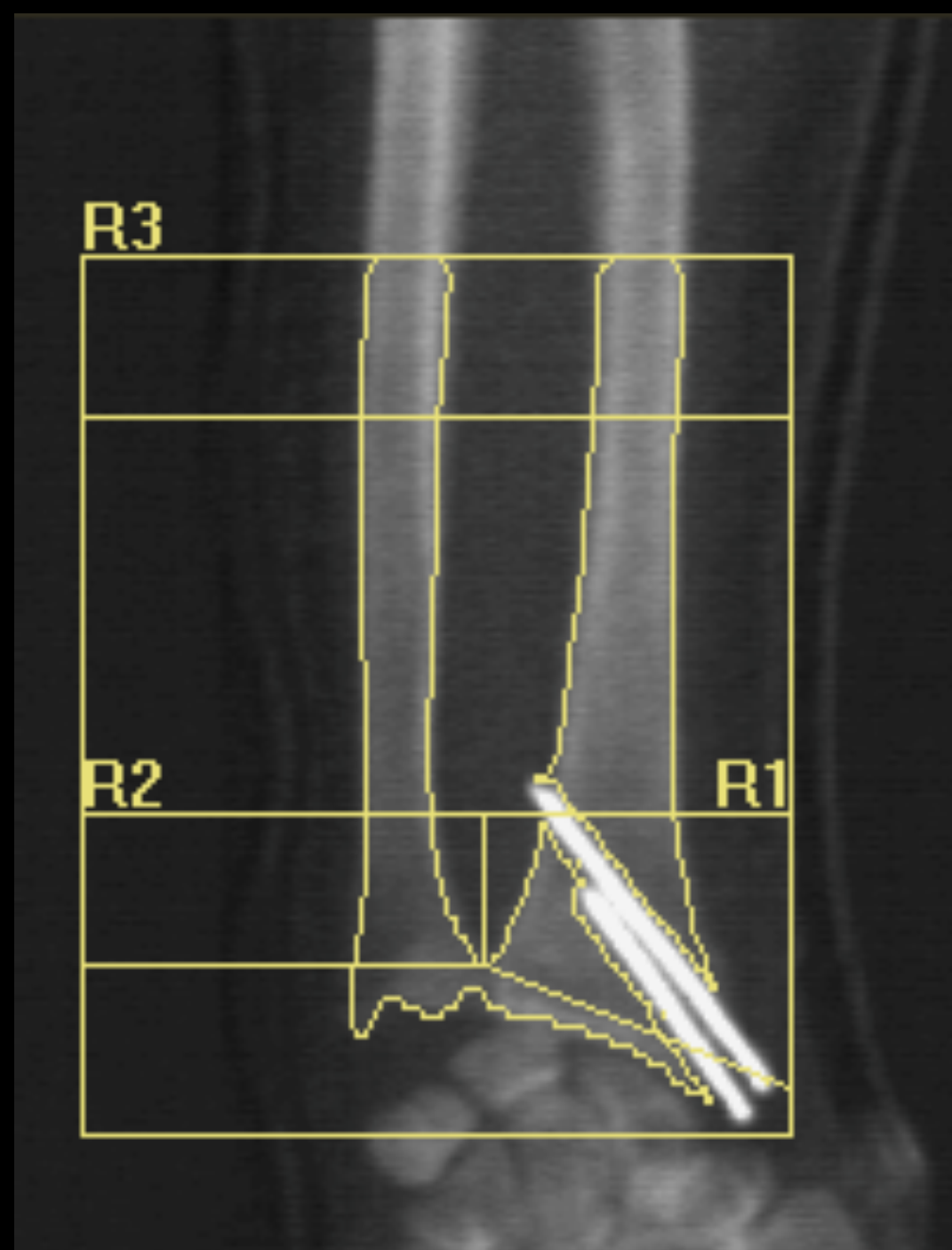
*Kodak® Carestream PACS software (Eastman Kodak Company, 2005)*

- **Bone Density Evaluation Protocol**

Hip and lumbar spine at **1w**



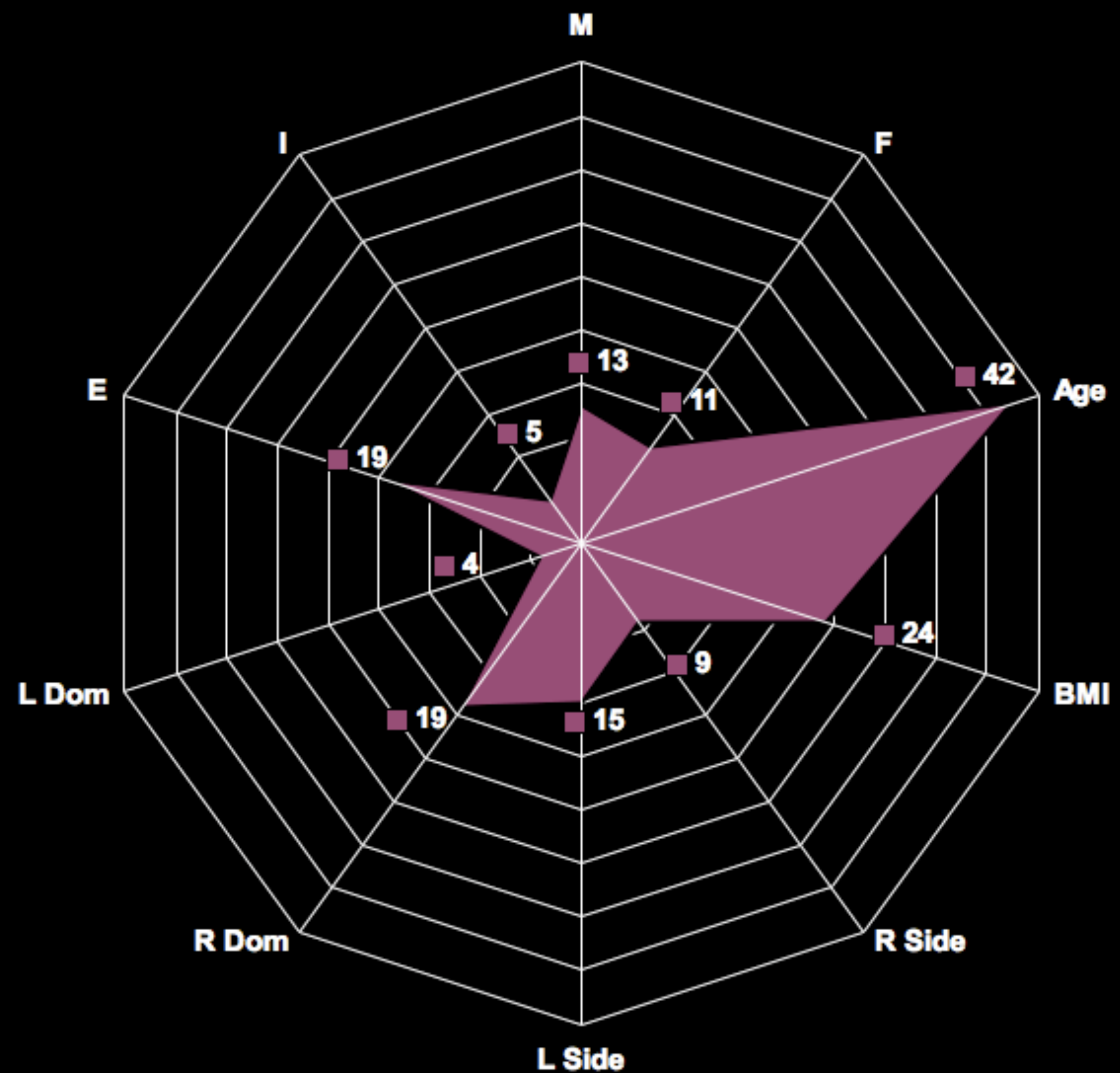
Both wrists at **1-6w** and **1Y**



***HOLOGIC® Dual Energy X-ray Absorptiometry Scan (DEXA scan)***

## ● Preoperative data

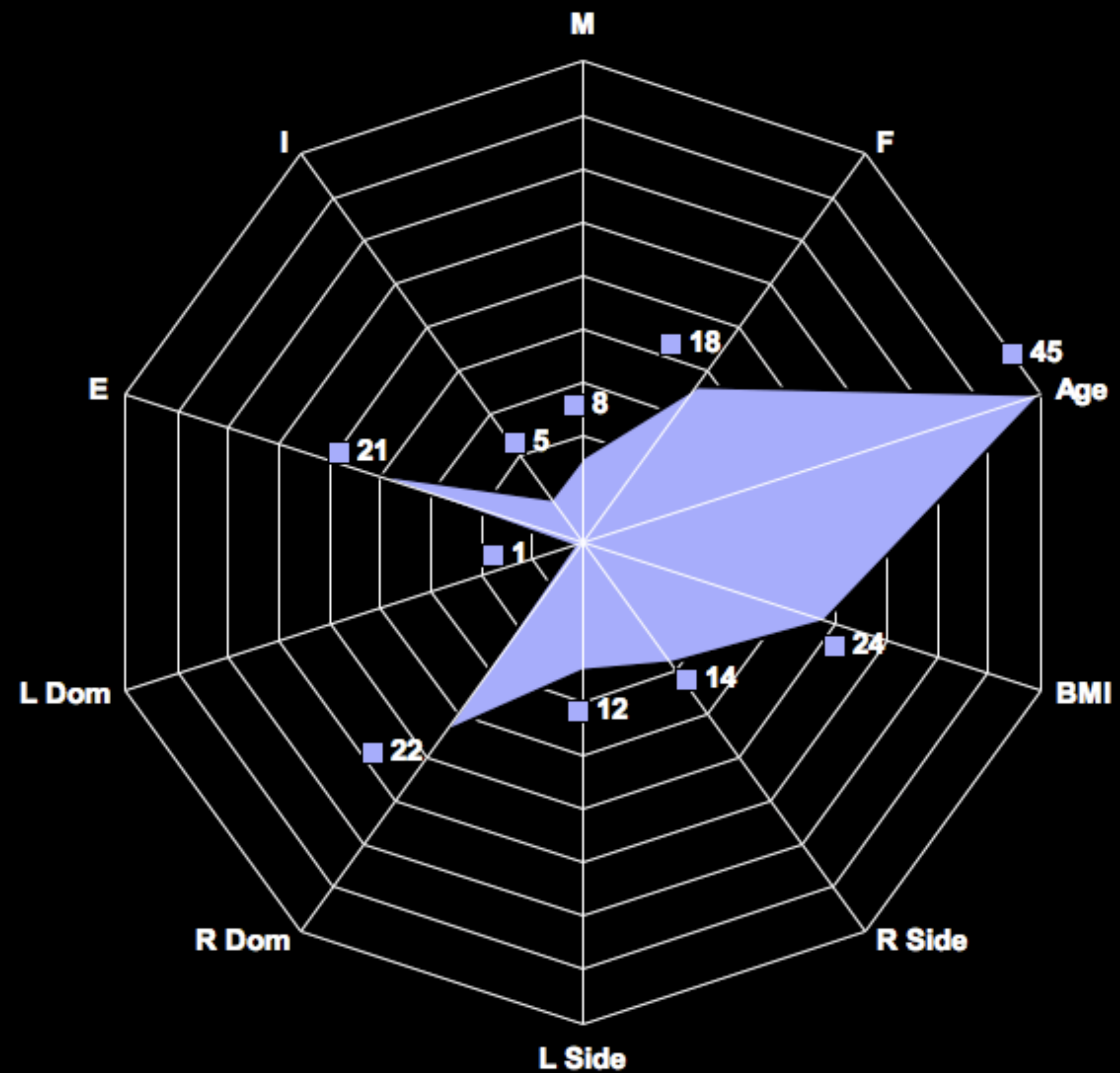
Parameters	Graft Group
Gender (sex) †	M = 13 (26 %) F = 11 (22 %)
Age (years) *	42,25 (SD: 11,40) 20-62
Height (cm) *	171,6 (SD: 7,44) 158-182
Weight (Kg) *	70,8 (SD: 12,05) 49-98
BMI (Kg/m <sup>2</sup> ) *	24,02 (SD: 3,60) 18,67-35,16
Injured side †	R = 9 (37,5 %) L = 15 (62,5 %)
Dominance †	R = 19 L = 4 ? = 1
Fracture type †	E = 19 (38 %) I = 5 (10 %)
Ulnar fracture †	Ulnar Styl. = 13 (26 %) Ulnar Head = 2 (4 %)





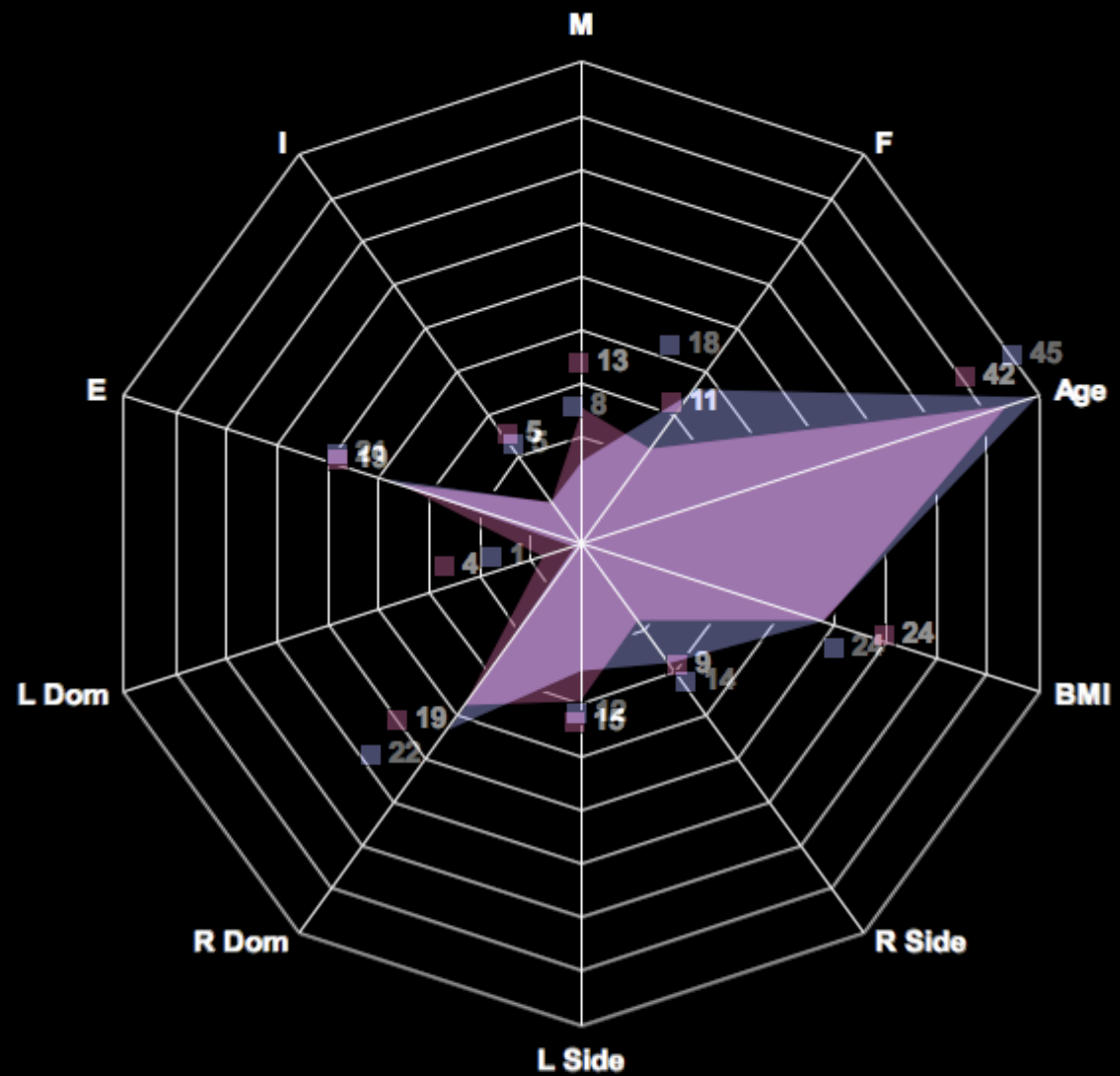
## ● Preoperative data

Parameters	No Graft Group
Gender (sex) †	M = 8 (16 %) F = 18 (36 %)
Age (years) *	45 (SD: 14,39) 17-69
Height (cm) *	168,6 (SD: 11,35 ) 151-200
Weight (Kg) *	67,3 (SD: 14,25 ) 47-90
BMI (Kg/m <sup>2</sup> ) *	23,58 (SD: 3,96) 17,53-31,63
Injured side †	R = 14 (53,8 %) L = 12 (46,2 %)
Dominance †	R = 22 L = 1 ? = 3
Fracture type †	E = 21 (42 %) I = 5 (10 %)
Ulnar fracture †	Ulnar Styl. = 15 (30 %) Ulnar Head = 0 (0 %)



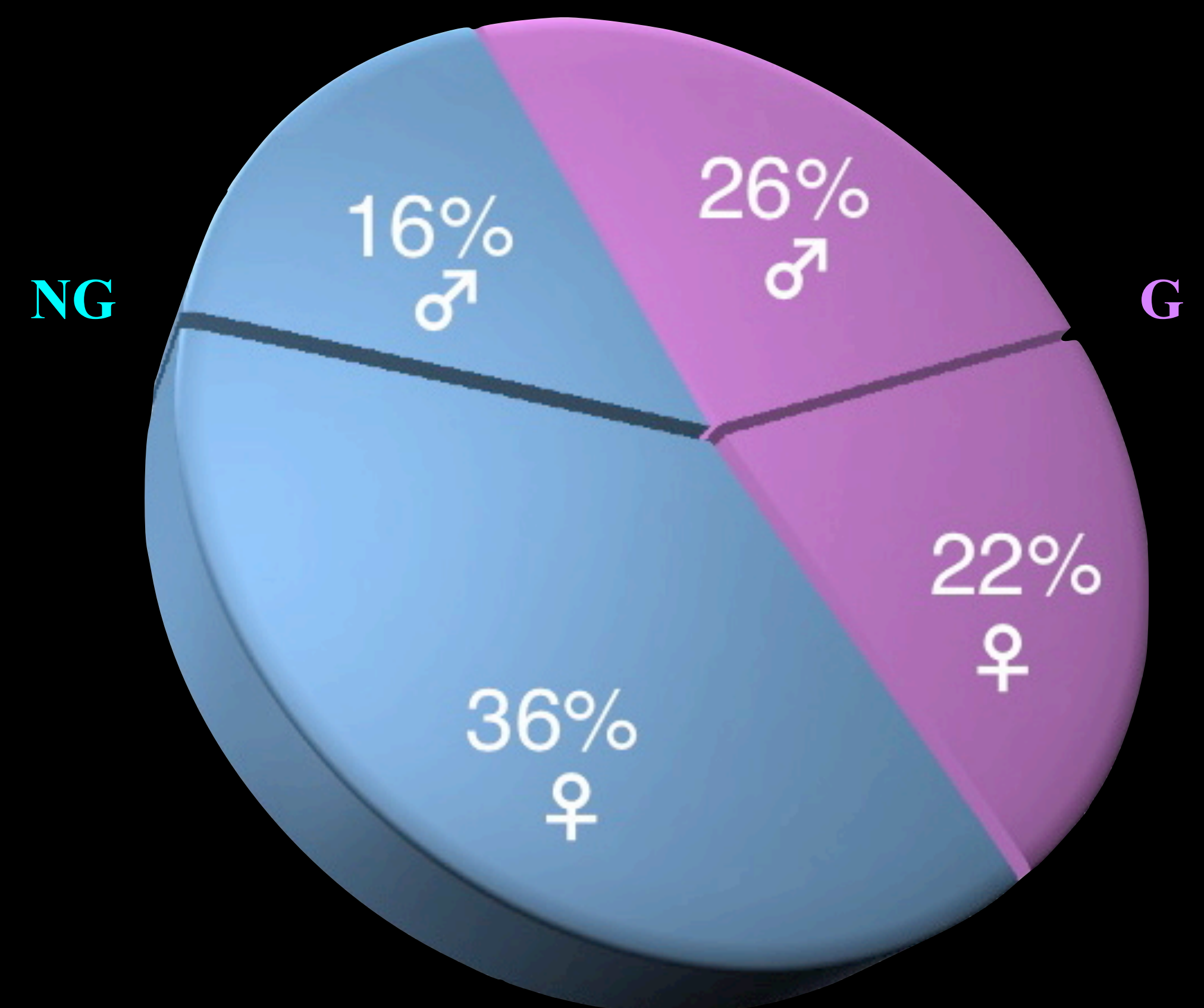
## ● Preoperative data

Parameters	P Value
Gender (sex) †	0.15
Age (years) *	0.46
Height (cm) *	0.28
Weight (Kg) *	0.19
BMI (Kg/m <sup>2</sup> ) *	0.62
Injured side †	0.27
Dominance †	0.35
Fracture type †	1.00
Ulnar fracture †	0.68



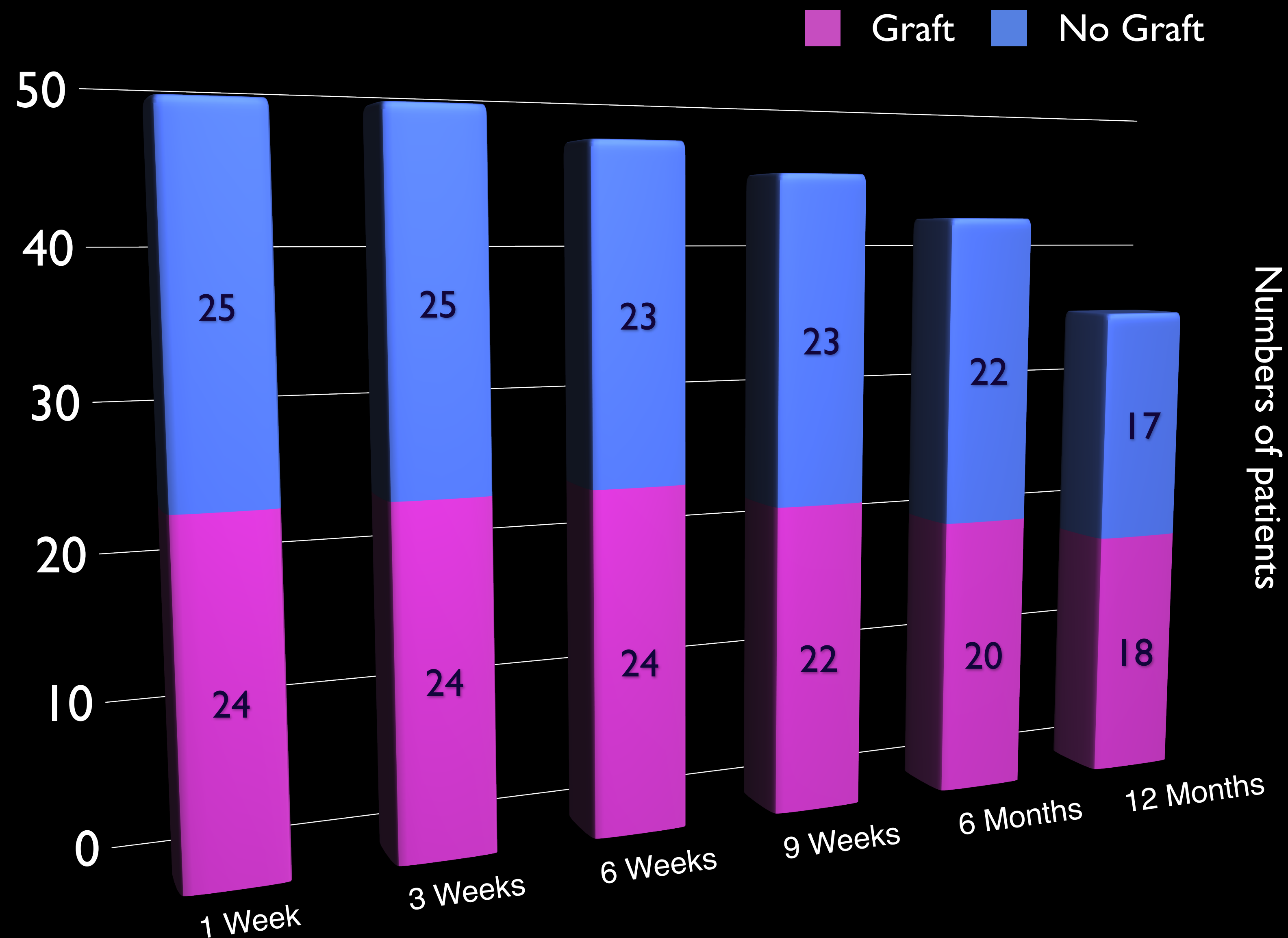
## ● Surgery data

- ✦ Interval injury-operation = 1,9 days **G** / 2 days **NG**
- ✦ 52% static 2 K-wires / 44% 3 K-wires / 4% others
- ✦ 24 **G** / 26 **NG** patients
- ✦ Mean volume AlloMatrix = 2,3cc (1-4cc)
- ✦ Mean time tourniquet inflation = 31,2 min (0-65min)
- ✦ Mean surgery duration = 45min **G** / 30min **NG**  
***Significantly higher in G (p=0,004)***
- ✦ Mean time removal K-wires = 8,3W (4-17W)



## ● Patient Flow

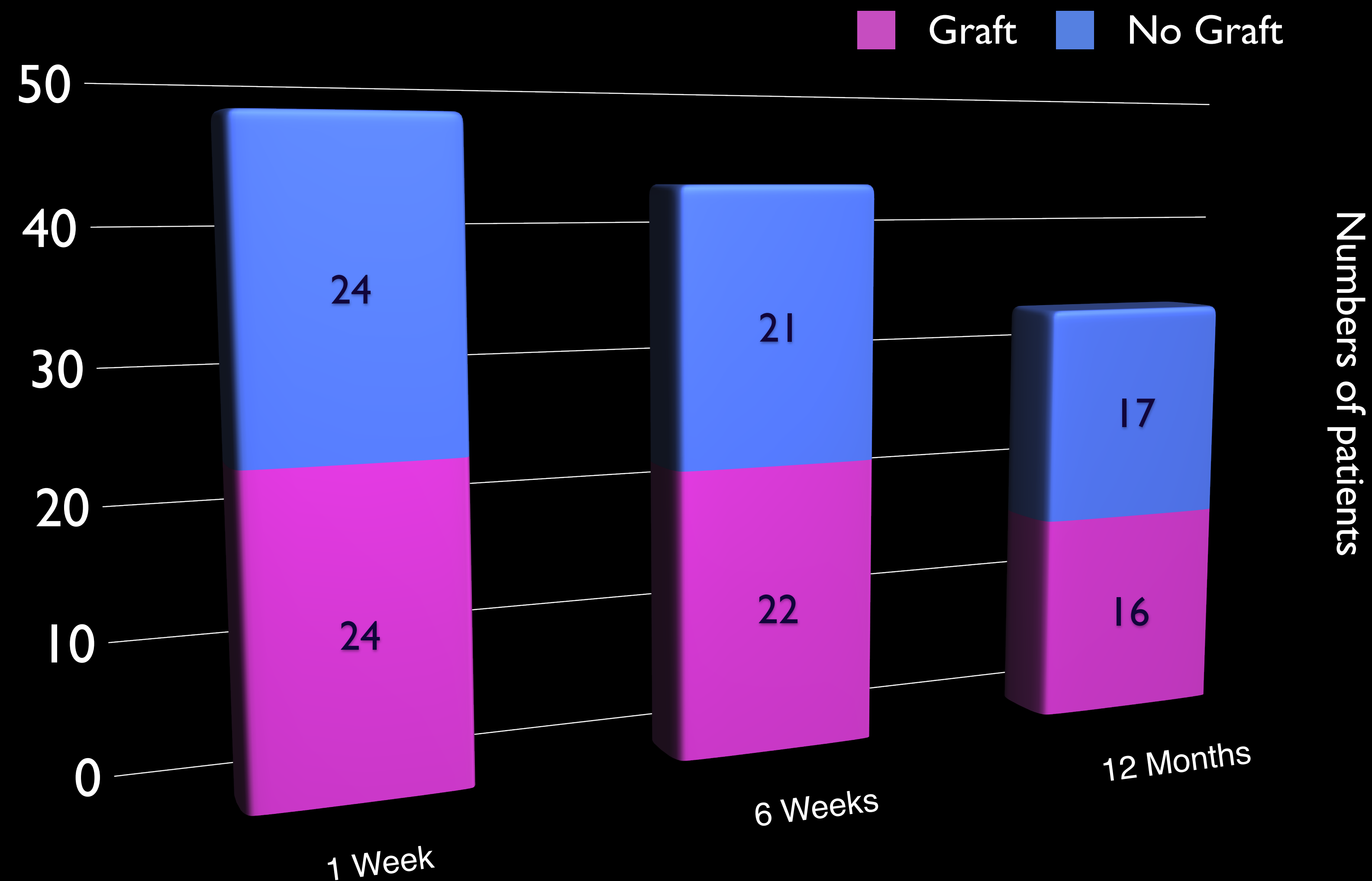
### Clinical and Radiological Follow-up



Data analysis on an intention-to-treat basis

## ● Patient Flow

### BMDs Follow-up



Mean post-op Follow-up = 15 months **G** / 14,2 months **NG**

No statistical significant difference between both groups ( $p=0,9$ )

## ● Preoperative Radiological Results

PA projection parameters	Graft group *	No Graft group *	P Value **
RI ( ° )	13 (SD: 5,94)	15,4 (SD: 6,32)	0,19
UV (mm)	0,8 (SD: 1,97)	1,1 (SD: 1,82)	0,63
RH (mm)	7,5 (SD: 3,60)	6,4 (SD: 3,30)	0,27

Standard lateral projection parameters	Graft group *	No Graft group *	P Value **
VT ( ° )	23,1 (SD: 6,67)	25 (SD: 10,24)	0,46
TD $\alpha$ ( ° )	41,8 (SD: 11,7)	39,1 (SD: 12,56)	0,46

**No statistical significant difference in preoperative fractures instability**

- **Clinical Results : Objective and Subjective Outcomes**

*Did AlloMatrix improve and allow a faster functional recovery ?*

No statistical significant differences between both groups

Statistical significant difference (strength) between noninjured and injured side

- pinch strength ( $p=0,01$ ) at 6W (G)
- grip strength ( $p=0,04$ ) at 9W (G)

- **Postoperative Radiological Results**

*Did AlloMatrix increase postoperative fracture stability ?*

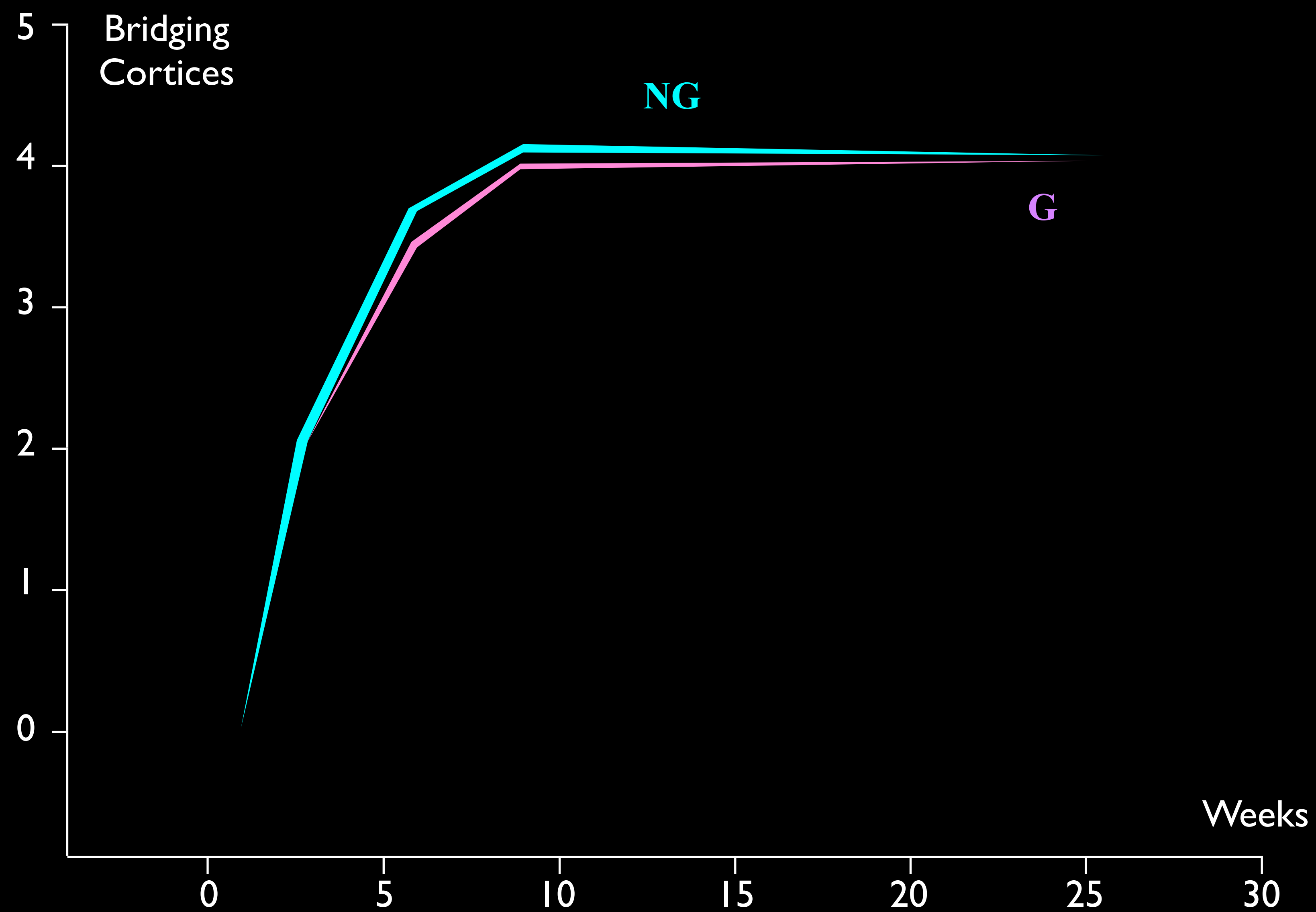
No statistical significant difference between both groups

## ● Union Rate

*Did AlloMatrix enhance bridging of the skeletal gap, bone union ?*

No statistical significant difference in union rate and speed of union

Complete bridging of the fracture gap at 9W





- **BMDs Results**

*Did AlloMatrix enhance bone density ?*

**No statistical significant difference** on the injured side between both groups

**Statistical significant difference** in bone density higher in R1 zone ( $p=0,05$ ) on the injured side in the Graft group at 1W

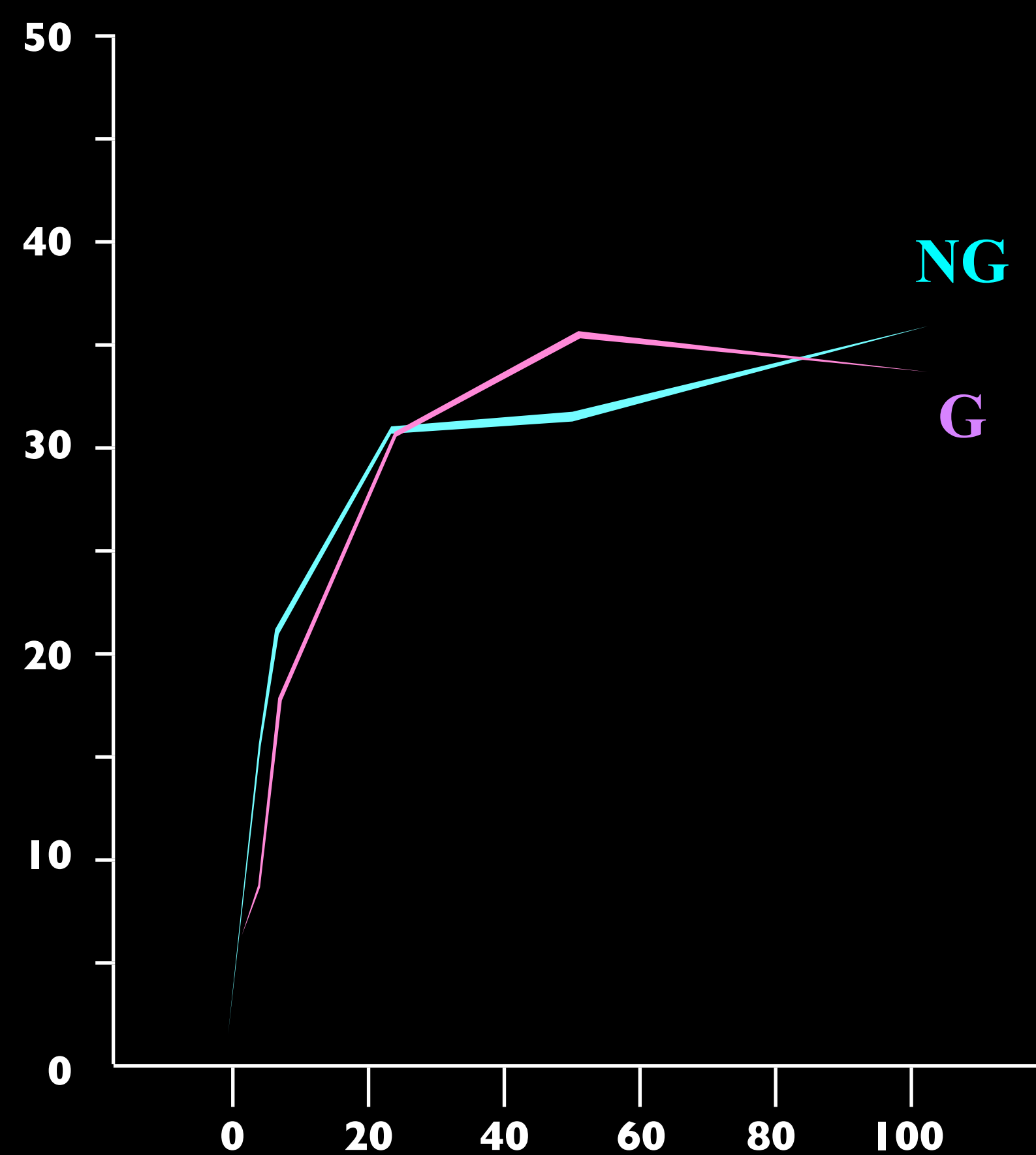
- Improvement between one week and one year within groups

### *Clinical and Radiological Outcomes*

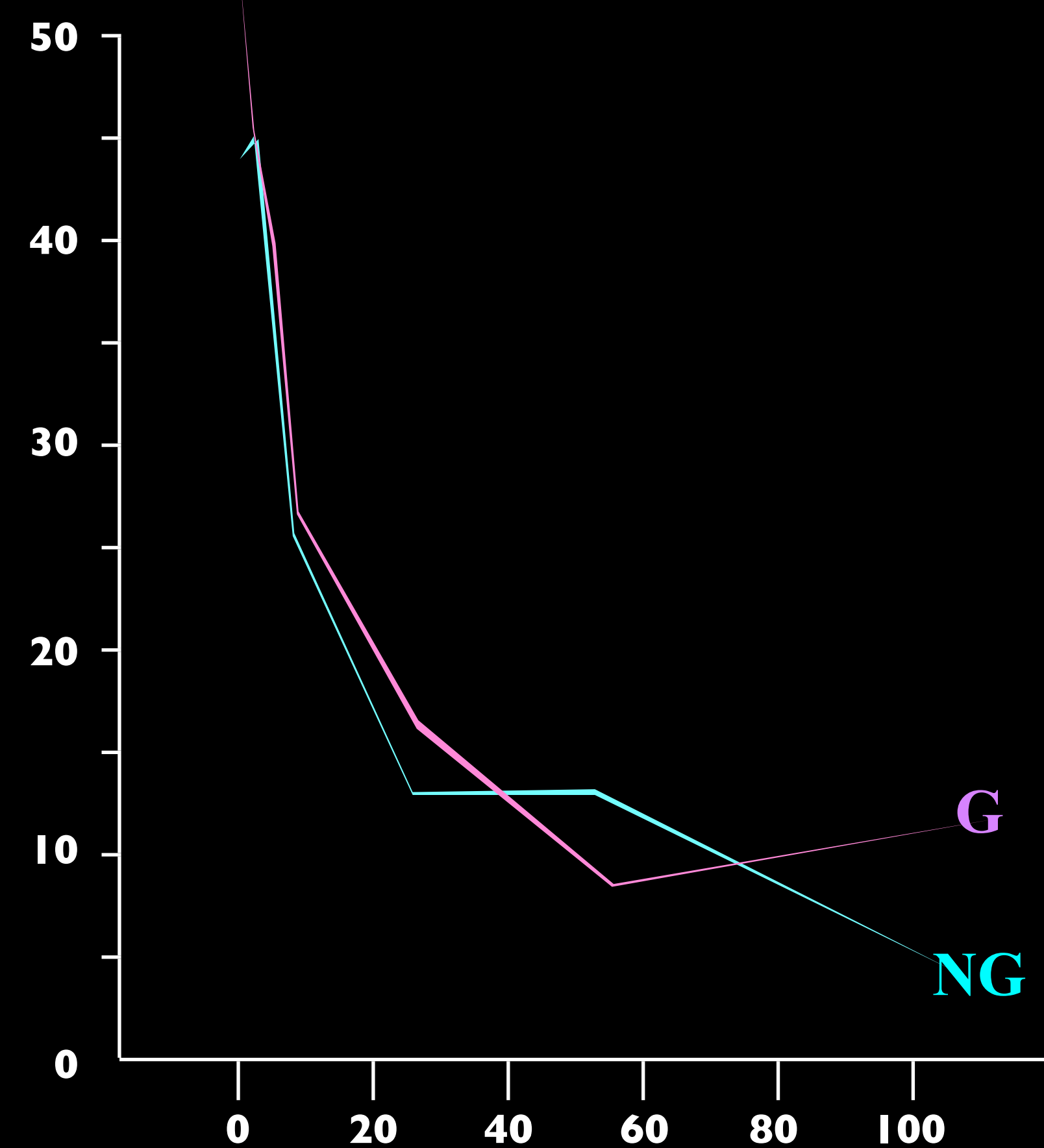
Range of Motion  
Strength  
Fracture-healing  
Bone density

Significant  
improvement  
( $p < 0,001$  for all)

DASH scores



Weeks



- Improvement between one week and one year within groups

### *Radiographic Parameters Outcomes*

RI (p=0,4)

RH (p=0,6)

VT (p=0,2)

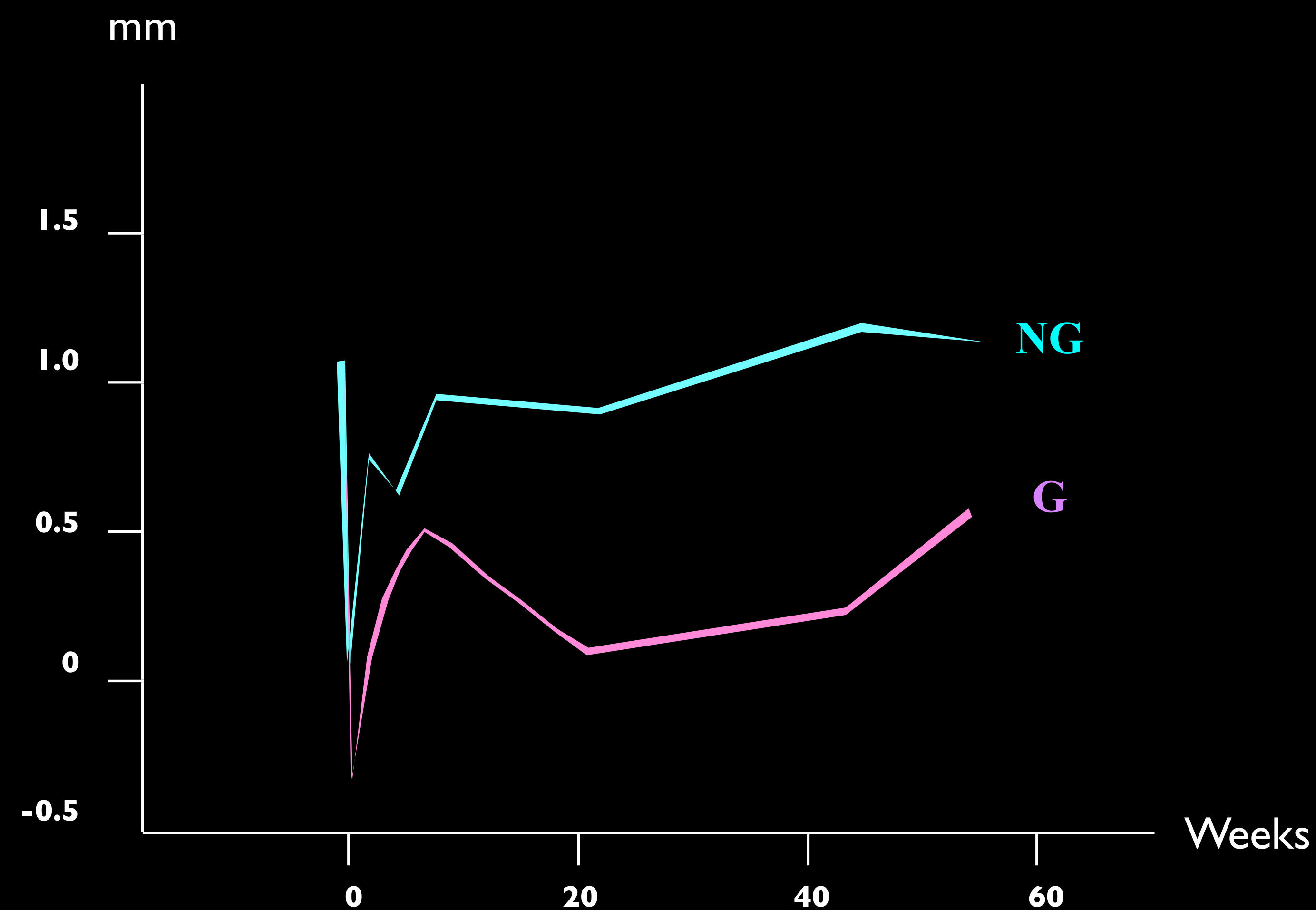
No significant changes

UV (p<0,001)

TD\* (p=0,04)

Significant changes

→ Progressive radial crush in both groups



## ● Complications

### *Did AlloMatrix enhance morbidity ?*

Peroperative	Graft group	No Graft group
Radial artery lesion	0	2

Postoperative	Graft group	No Graft group
Infection *	1	2
Flow of graft	1	0
CRPS I	3	1
Neurosensitive complaints	4	6
Tenderness on K-wires	3	1
Tendons rupture *	0	2
Trigger fingers	0	1
Dupuytren's disease	0	1
Wrist synovial cyst	1	0
Symptomatic malunion *	1	1

**No increase in morbidity and surgical revisions in the Graft group**

## ● Complications

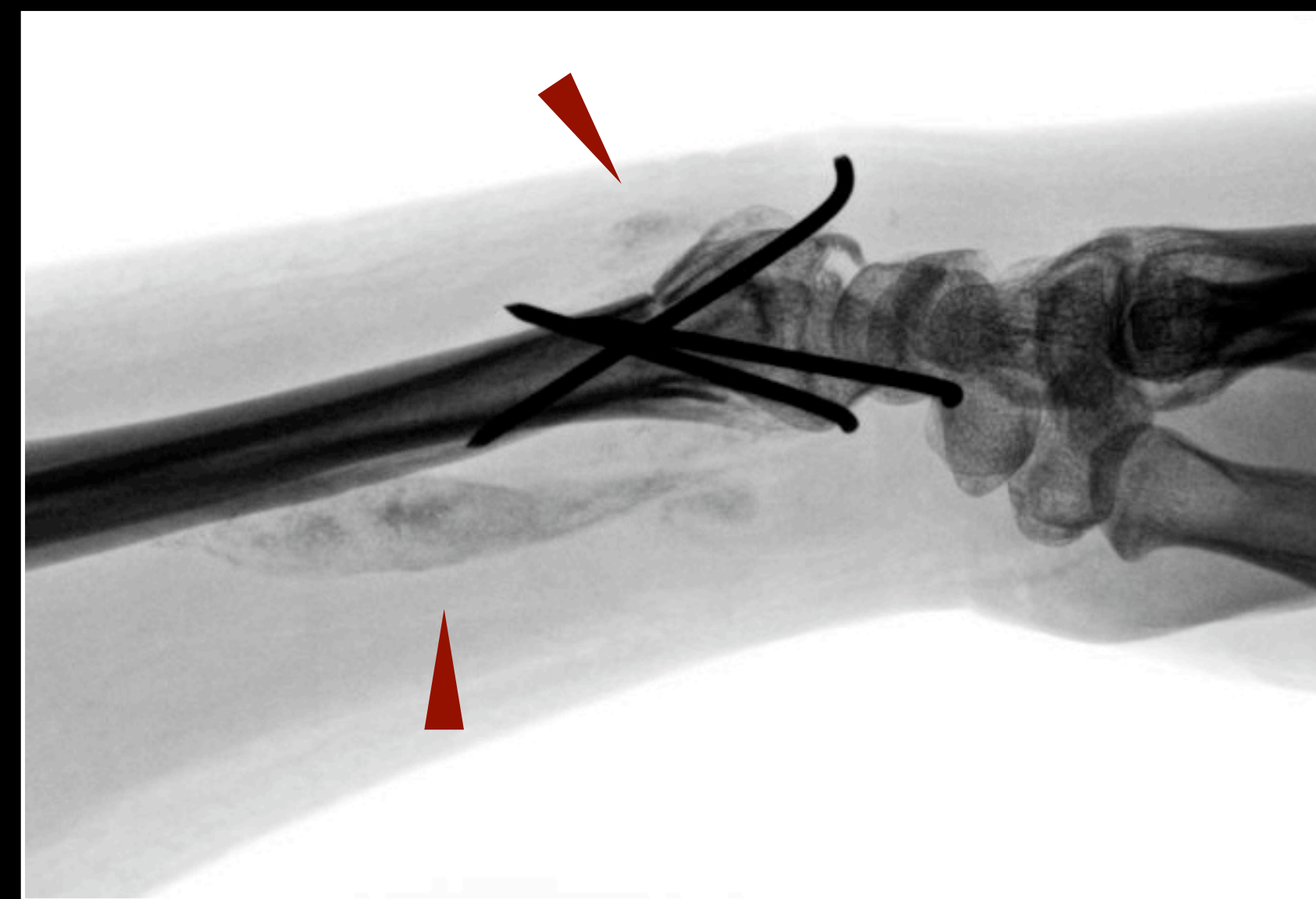
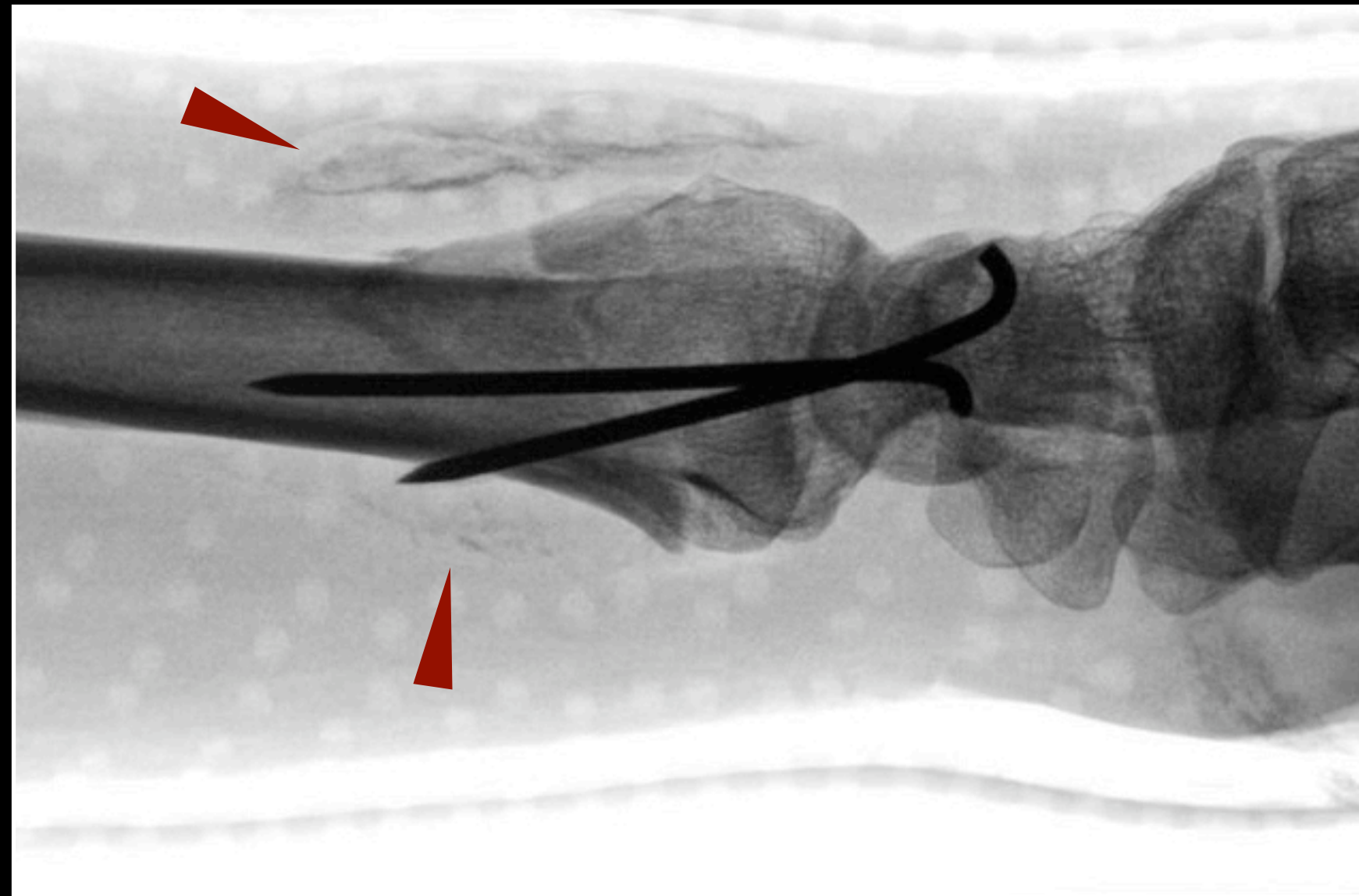
### *Did AlloMatrix enhance morbidity ?*

Peroperative	Graft group	No Graft group
Radial artery lesion	0	2

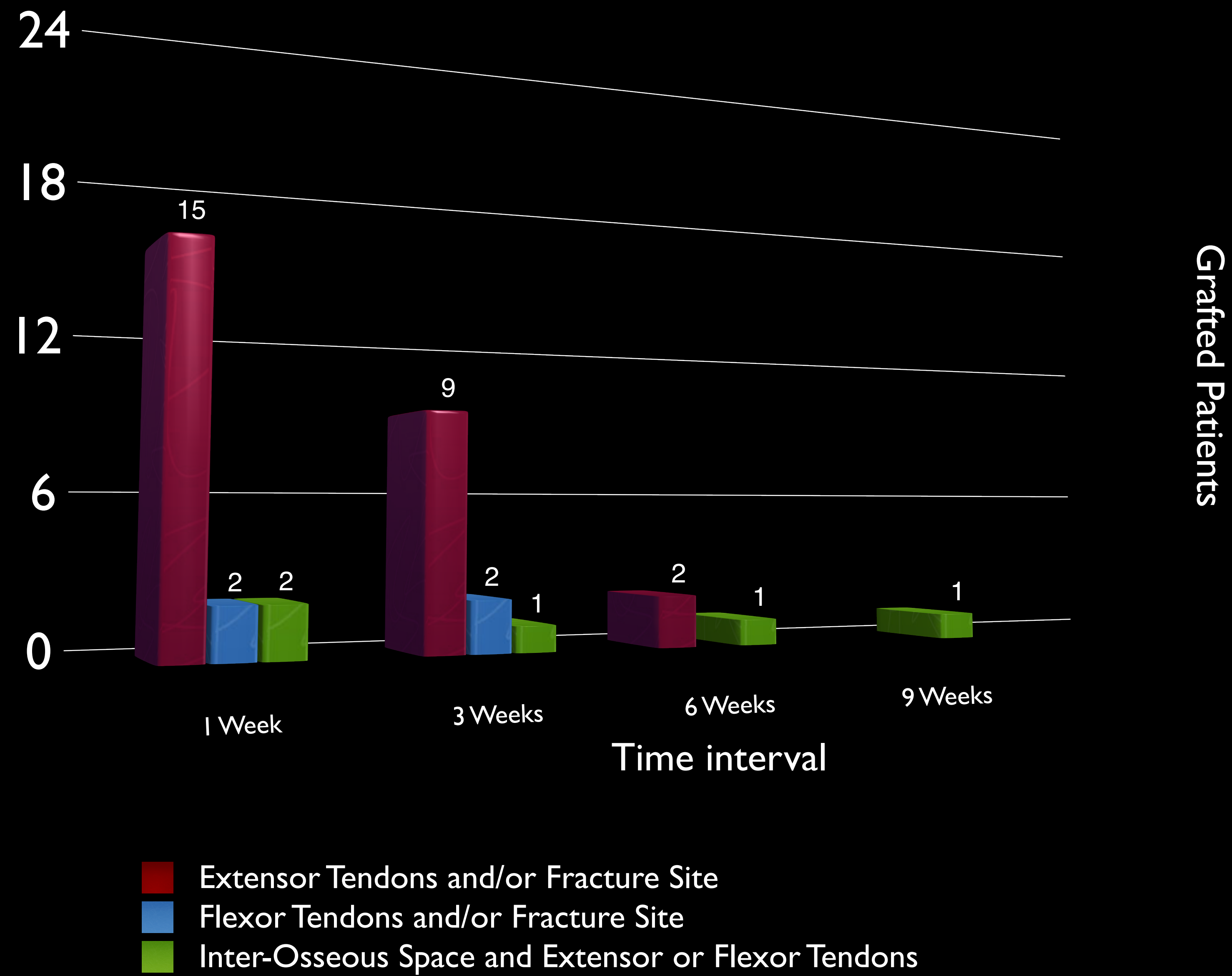
Postoperative	Graft group	No Graft group
Infection *	1	2
Flow of graft	1	0
CRPS I	3	1
Neurosensitive complaints	4	6
Tenderness on K-wires	3	1
Tendons rupture *	0	2
Trigger fingers	0	1
Dupuytren's disease	0	1
Wrist synovial cyst	1	0
Symptomatic malunion *	1	1

**No increase in morbidity and surgical revisions in the Graft group**

- **Extraskeletal AlloMatrix Deposits**



## ● Extraskkeletal AlloMatrix Deposits



Disappearance of all soft-tissue extrusions after 9W

- **Safety and Morbidity**

No adverse events observed

- **Handling**

Significant increase of surgical procedure time

Supplementary dorsal approach

➔ *Strength weakness / Dorsal wrist synovial cyst ?*

Difficulty for injection

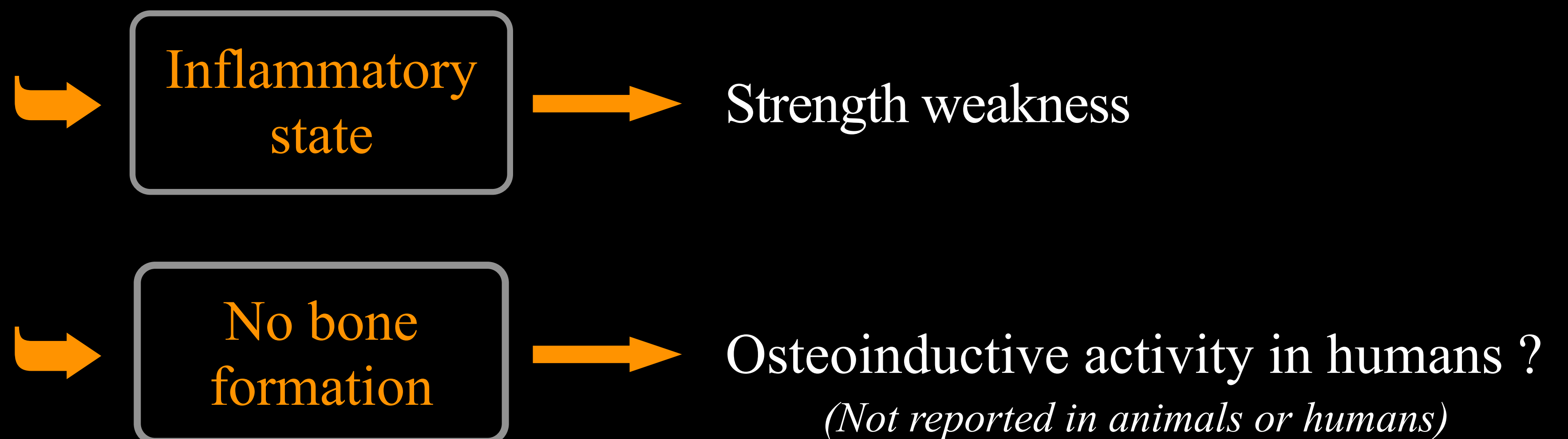
➔ *Soft tissue deposits*



- **Graft Resorption**

No significant difference in R1 zone bone density at 6W  
No extraskeletal deposits on X-rays after 9W

**RESORPTION**



- **Variability in osteoinductivity**

- ↳ **Intervariability of BMPs in DBM grafts**

Proportional osteoinduction related to [BMPs]

*Han et al., J Orthop Res 2003*

*Yoo et al., Spine J 2003*

*Edwards, IsoTis OrthoBiologics 2003*

*Atti et al., Spine J 2003*

*Peterson et al., J Bone Joint Surg 2004*

→ AlloMatrix DBM content is **40%** by weight

DBM preparation and storage methods

*Zhang et al., J Periodontol 1997*

*Han et al., J Orthop Res 2005*

*Ferreira et al., Clin Orthop Relat Res 2001*

*Alanay et al., Spine J 2008*

*Qiu et Connor, J Biomed Mater Res 2008*

*Pinholt and Solheim, Ann Plast Surg 1994*

- **Variability in osteoinductivity**

- ↳ **Intravariability of BMPs in a DBM graft**

Highest variability in [BMPs] among lots of the same DBM formulation

*Bae et al., Spine 2006*

Human cadaver donors age

Young donors enhance osteoinductivity ?

*Not supported in literature*

*Pinholt and Solheim, J Craniofac Surg 1998*

*Traianedes et al., J Biomed Mater Res B Appl Biomater 2004*

- **Variability in osteoinductivity**

- ↳ **PDGF in blood decrease DBM osteoinductivity**

- Ranly et al., J Bone Joint Surg 2005 and 2007*

- Patient blood never adjunct or mix to AlloMatrix

- **Sample size**

- Power of the analysis limitation

**No significant clinical effect of AlloMatrix demonstrated in this human model**

**Additional trials needed | to evaluate utility and potential benefits in humans  
to confirm our observations**



Baizati

# ALLO MATRUX

BELIEVE THE UNBELIEVABLE

Thank you for your attention

