

#### Orthopaedic Surgery & Musculoskeletal Trauma School of MEDICINE, University of THESSALIA, LARISSA, GREECE

#### School of Medicine

#### University Hospital

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# Pathogenesis & Diagnosis Femoral Head Osteonecrosis (FHOn)

Konstantinos N. MALIZOS Professor & Chair

# Osteonecrosis: most commonly affecting the Hip

Epidemiology of Non-traumatic OnFH in Japan (128 million) annual incidence :1.91/100,000 *Ikeuchi K. et al , Mod Rheumatol. 2014 Jul* 

Young adults: 33 (+/-15) yrs Bilateral > 80 % Untreated: ~ 90 % will collapse End stage → Joint destruction



M:**3**% F:**3.6**% of the THAs *SHipAR 2013* 







# impact of the disease

- a very large economic burden on HC Systems
- a large burden on the young patient
  - THA yields less optimal outcomes with
    - increased risk of mechanical complications
    - the majority will need at least one revision procedure during their lifetime

Hungerford DS. Osteonecrosis: avoiding THA. J Arthroplasty 2002; 17:121-4. Ortiguera CJ, et all, THA for osteonecrosis: matched-pair analysis of 188 hips with long-term follow-up. J Arthroplasty 1999; 14:21-8. Dudkiewicz I, Covo A, Salai M et al. THA after avascular FHOn: does etiology affect the results? Arch Orthop Trauma Surg 2004; 124:82-5.

# Pathogenesis



may be related to:
direct blood vessel injury (posttrauma-On)
intraluminal obliteration (vasculopathy) or
extraluminal obliteration inside the bone marrow

the final mechanism is ischemia & infarct

#### Etiology of Nontraumatic FHOn: Multifactorial

Corticosteroids, Hemoglobinopathies Thrombophilia, Dysbaric phenomena, SLE, overuse of Alcohol & Tobbaco,...



# Subchondral





Absence of collateral vessels at the subchondral zone

#### Cohort FHOn pts at Ortho-UTh, LARISSA GREECE

- 2000 2014 , n= 428 Pts , 631 hips 191 / 631 hips asymptomatic
- 299 M, 129 F, avg: 34 yrs (16 60 yrs)
- In 92 % various etiology associated factors identified
- 8 % Idiopathic



Steroid - induced FHOn during SARS epidemic in Beijing, China 2003



significant risk for multifocal epiphyseal & diaphyseal Osteonecrosis lesions

Oral corticosteroids & Idiopathic FHOn Multicenter Study Japan Sakaguchi M, et al J Orthop Sci. 2010 Mar.

#### N=73 FHOn & 250 matched controls

→ oral Corticosteroids: <u>odds Ratio 20.3</u> vs Non-use

# ...after high-dose glucocorticoid therapy..

...FHOn is SILENTLY established very early ..! in <u>Renal Transplant</u> recipients & Connective tissue disease FHOn present on MRI within 2-6 months after treatment onset <sup>Sakamoto M et al JBJS Br 1997</sup> Le Parc JM et al Rev Rhum 1996 Onuma K et al Ann Rheum Dis 2001

All Pts on steroids → a Hip <u>MRI screening</u> within 6 months from treatment onset

IF not detected within 6 months :

the risk of later detection is <u>extremely small</u> even when glucocorticoid therapy is continued Hip osteonecrosis frequently complicates treatment with glucocorticoids. When affecting ≥ 30% of the epiphyseal surface, 80% of joints collapse within 2 years, Interventions are needed to prevent this outcome.

#### CONCLUSION:

In patients age < 10 years who require prolonged glucocorticoid therapy, screening is unnecessary because their risk is low & lesions tend to heal.

In children > 10 years, early MRI screening successfully identifies extensive asymptomatic lesions for interventions to prevent or delay joint collapse.

Kaste SC et al, Utility of early screening magnetic resonance imaging for extensive hip osteonecrosis in pediatric patients treated with glucocorticoids. *J Clin Oncol.* 2015 Feb

# ... is FHOn part of a systemic disorder ..?

# 60 % of pts → White Matter lesions, on Brain MRI

[Asymptomatic (?)\_but :45% emotional distress, 40% depression..]

Hatzigeorgiou ,...Malizos et al, EJR, 2006 , Hatzigeorgiou, ...Malizos et al, JOR, 2007



M 35y multiple bilateral lesions in frontal white matter grade B

m 40y lesions in frontal white matter

m 27y multiple bilateral WMLeOn grade C

Psychological distress, personality traits &

functional disability in patients with OnFH

Mouzas O., Malizos KN, et al, J Clin Med Res. 2014 Oct

 symptoms of psychological distress associated with distinct functional clinical parameters.

# Risk factor in Sickle Cell Disease

Mukisi-Mukaza M, Orthop Traumatol Surg Res. 2011 Dec,

# Elevated Haemoglobin level : is associated with more "crisis" episodes & FHOn, from increased blood viscosity



FHOn : part of an underlying health Problem !!

 asymptomatic for an unpredictable period of months after it is established

All PHYSICIANS dealing with high risk patients

→ High index of suspicion

→ <u>Hip MRI Screening</u> &



monitoring to diagnose it "...Early..."

=>may SALVAGE the hips in YOUNG pts

# FHOsteonecrosis after an Asymptomatic course..

# Insidious onset with Mild recurent Pain at the Buttocks, Hip, & Thigh,

..aggravating in Hip Flexion & Internal rotation

## Radiographs



# Diagnosis

#### <u>MRI</u>:most sensitive 99%

## <u>X-rays</u>



Prese



prog



Bone scan:Sensitive in Multifocal On but Non specific





# for Screening & Diagnosis of early idiopathic FHOn

# in the absence of other MRI abnormalities Dynamic Contrast-Enhanced MRI (DCE-MRI)



Chan WP et al AJR Am J Roentgenol 2011

<u>Whole-body</u> STIR-MRI : in juvenile SLE & in **systemic disease** pts..



Castro TC et al Br J Radiol 2011

symptomatic hips with Bone Marrow Edema on MRI

 secondary sign of subchondral fracture indicating ARCO stage 3/4 disease with presence of articular collapse.

#### CT scan

- identifies subchondral fractures
   & FH collapse better than MR imaging
- => & helps to avoid under-staging
  - & to trigger adequate treatment.

Meier R, et al, Bone marrow oedema on MR imaging indicates ARCO stage III AVN of Femoral Head. Eur Radiol. 2014 Sep;

## Non traumatic Osteonecrosis

# Multifocal:~38 % of pts

head of Humerus,

Elbow,

Sciatic & iliac bone, Acetabulum, Femoral Head & Condyles, Talus, Scaphoid,



Patella

Femoral Head

# **GENETIC** Background investigation

Is useful for:

# Identification of high-risk pts particularly those with additional risk factors (dyslipidemia, alcohol abuse)

Evaluation & screening of pts before starting high-dose glucocorticoid therapy

#### Transient Bone Marrow Edema (TBME):a distinct clinical entity

# <u>Acute</u> pain

•T2 MRI : diffuse signal intensity
• delayed washout of gadolinium >40 sec **transient osteoporosis**: 80 %, after **3** wks

#### Spontaneous resolution

None developed FHOn in 2 yrs (n=43)





# Clear Cell Chondrosarcoma







#### Clear Cell Chondrosarcoma





#### 6 yrs post-op

Dept of Orthopaedic Surgery & Musculoskeletal Trauma School of Medicine, \* University of THESSALIA, LARISSA, GREECE

# Current Management of the Femoral Head Osteonecrosis

# - FHOn

Konstantinos N. MALIZOS Professor & Chairman



# Initially : the bone infarct remains intact

*in days or wks* => a repair front at interface with necrotic bone **resorption** & new **bone formation** 

#### serpantine line on MRI

sclerotic demarcation line on X-Rays & CT



# Osteoclastic activity weakening the trabeculae

#### Subchondral infarct

# Flattening & collapse













#### severity assessment: classification systems

4 more common ... •Ficat & Arlet •ARCO •U Pen •Japanese Orthop Association Type B Type C2 Type A Type C1

Malizos et al, SKEL RAD, 2001, & 2004

# turning point in the natural history of FHOn

- collapse of the necrotic segment
- ⇒ Painful

# → Irreversible

# →major determinant of progression to hip OA







# A collapsed articular surface at diagnosis is <u>NON</u>

#### reversible with any joint preserving procedure



# Risk factors with poor prognosis

- 1. Size & Extent of the lesion
- 2. Location of the affected area
- 3. current Glucocorticoid or Alcohol exposure
- Bone marrow edema under the necrotic segment
   & /or joint effusion on MRI
- 5. Increasing Pain

#### worst outcome

- lesions extending laterally to the acetabular edge & beyond
- **pain** : a strong sign of impending collapse
  - collapsed cases are preceded by pain of
     ~ 8 months duration

Sugano N, Atsumi T, Ohzono K et al. J Orthop Sci 2002; 7:601-5.



# lesion's size & prognosis



Large lesions > 30% FH => 95% will collapse in < 2 yrs



# lesions of different Size & Etiology

present a different natural history







observation : in very small lesions away of the articular surface

# 11 yrs f-up

Steinberg E.M, 1993, Sugano et al., 1993, Takaori et al., 1993, Kim & Kuon 1996, Urbaniak et al, 1998. O-utilition

# fate of small asymptomatic lesions

# Delay of Collapse can happen & clinical improvement can follow without need for intervention for **5** yrs..

Nishii T, Sugano N, Ohzono K et al. CORR, 2002:149- Hungerford DS, Jones LC. CORR, 2004:124- Koo KH, Kim R. J Bone Joint Surg Br 1995;77:875- Nishii T, Sugano N, et al. J Orthop Res 2002; 20:130- Yoshida T, Kanayama Y, Okamura M et al. Clin Exp Rheumatol 2002; 20:525-.

# 11 years f-up : 88 % of hips became symptomatic 73% collapsed, Hernigou P, et al, JB J S Am 2004; 86-A:2589- Fate of very small asymptomatic stage-I osteonecrotic of the hip. All required surgical intervention



#### protected weight-bearing

## meta-analysis:**n=**819pts **65**% @pre-collapse stage p.w.b. **78**% operated in 2yrs f-up



# reduced weight bearing: **only temporary NO place in definitive management of painlful FHOn**

Mont MA, Carbone JJ, Fairbank AC Core decompression versus nonoperative management for osteonecrosis of the hip. COOR 1996
Non-operative treatment of FHOsteonecrosis

search other joints for ON & quit smoking , alcohol

Bisphosphonates :stage-I or II (ARCO) of medium to large necrotic area, did not prevent collapse Evidence for prevention of THR & reduction of FHOn progression still remains controversial

Agarwala et al., JBJS (Am), 2009, Chen CH, et al, Alendronate in the prevention of collapse in nontraumatic FHOn: 2year multicenter, prospective, randomized, double-blind, placebo-controlled study. Arthritis Rheum.2012 64:1572-1578. Nonoperative treatment of Early stage FHOn

randomized clinical trials are necessary with long term f-up to determine effectiveness

- how much is the natural history affected ?
- cost-benefit value ?
- appropriate indications:
  - which patients qualify for such treatments ?
  - At what stage ?
  - What are the contraindications ?

### Surgery with Joint preserving procedures

- Core drilling or "Decompression"
- Osteotomies (varus or rotational )
- Grafting (Bonfiglio, "Trap door", Steinberg)
- trabecular metal Rod or Pegs
- Vascularized Fibula grafting

1979 : Gilbert – Judet, Urbaniak, Brunelli, Yoo, Fujimaki,

### Core Drilling or "Decompression"- CD

Variety of techniques & Selection criteria :Lesion Size & Extent, Cystic vs Sclerotic

## **3-4 spread drill holes** with a **<u>4 mm smooth pin</u>** create microfractures & induce bone formation



Best results: Prior to collapse, small & sclerotic lesions with Intact lateral pillar

## Core Drilling varies in

surgical approaches,
number of drillings,
trephines diameter





### highly cost-effective if it delays THA 5 yrs or longer

Marker DR, et. Al, Clin Orthop 2008, Al Omran , Arch Orthop Trauma Surg. 2013 May, Soohoo NF, et al, Cost-effectiveness analysis of core decompression. J Arthroplasty. 2006;21:670-681.

## Core Decompression outcomes

patient cohort studies	<b>Prior to 1992,</b> n= 1337	<b>1992 - 2007</b> n=1268
Avg f-up months:	65 (3–216!)	63 (1–176…!)
THA :	41 %	30 %
Radiographic failure :	44 %	<b>37</b> %

Marker DR, et. Al, Clin Orthop 2008

#### Trans-trochanteric Rotational Osteotomy - Modified Yoon T. R. et al, CORR 2008,



promising in young patients with Stage II or III OnFH

Anterior Rotational Osteotomy in pts with Lupus

N=16 pts (25 hips) 20-40 yrs, Motomura G, et al ,Lupus. 2010

8 pts 12 hips, avg hip survival : 24.6 yrs (20 - 27) 3 pts 6 hips died of unrelated causes without any subsequent operation.

Kaplan-Meier: hip survival at 25 yrs  $\rightarrow$  73 %

Transtrochanteric Rotational Osteotomy n=113 hips , F-up: 51 months => 24 % collapsed <u>RISK factors</u> : Stage & extent of FHOn, Age, BMI, unsatisfactory clinical results & THA ( 12 % )

Ha YC, et al. JBJS Am. 2010 Feb

### Curved intertrochanteric osteotomy



#### **18**/20 hips with **no collapse at 4 yrs** Sakano et al., JBJS(Br), 2004

subsequent THA : more demanding technically & complicated



## 15 yr outcomes after TRO for FHOn are unfavorable because OA changes occur after 5 yrs post-op

Morita D. et al, Long-term outcomes of transtrochanteric rotational osteotomy for non-traumatic osteonecrosis of the femoral head. Bone Joint J 2017;99-B:175-83

### TRABECULAR Tantalum implants

=>*st*ructural advantages over bone graft without the associated risk of autograft harvest morbidity



F-up: 76 m

St. II, HHS:100

Shuler MS et al J Arthroplasty 2007, Veillette CJ et al JBJS Am 2006

Tsao AK et al JBJS Am 2005 Varitimidis . Malizos Acta orthopaedica 2008

### 1/3 of the cases collapsed in <5 years

e-o





collapse in 30 months

#### m. 40yrs S.T. idiopathic bilateral FHOn





Malizos KN, et all, J Bone Joint Surg Br. 2012, Feb.

## 42 yrs M steroids for Optical n. neuritis Painful hip in 6 months











## Vascularized bone grafting - Fibula (1979)



91% Yoo et al 78% Brunelli et al 82% Urbaniak et al 83% Malizos et al 87% Sotereanos et al







vascularized iliac crest:

67% Leung et al , 54% Mayer et al





cortical graft NO vessels

Vascularized Fibula

#### Vascularised Fibula



callus formation osteogenesis onto the dead trabeculae

9mo's after

Malizos et al in book : Osteonecrosis AAOS,, 1996,

Ex vivo Arteriogram: => Graft + Fem. Head Vessels function as a unit

## Ideal indication for vascularized Fibula:

## Medium size lesions prior to collapse





### A. M. 38 female Idiopathic FHoN prior to collapse



# Non-contained vs Contained







### Still..an indication for Vascularised Fibula..?

F, 32 yrs, contained lesion, recent & mild collapse





Pt's age, systemic disease, immunosupression,

& multiple lesions

Crucial for treatment selection ...!

### Hip SALVAGE with Vascular Fib.Grafting

**n=149** hips 1990-2010 age 17 - 52 yrs (avg: 34) f-up: 5 - 22 yrs



#### 18 yrs f-up

results

	HHS Good - Excellent
st II	<b>86</b> %
	65 %
IV	50 %
V	40 %

## 19 yrs,M, contained No collapse



### steroid induced FHOn







6y post-op

#### 9y post-op

#### 12yrs post-op





Long-term f-up of Vascularised Fibula Graft.. N=110 pts - 124 hips : @ 14 yrs (10 -24) f-up → 11% failed to THA HIP survival influenced by : Lesion's Size, Age Location,

89 %  $\rightarrow$  maintain joint function & delay THA.

Yoo MC, et al . CORR. 2008 May

in pre-collapse FHOn
 → patient selection & technical expertise
 have an important impact on the results

# "the DUKE experience" 646 hips mean f-up 7 yrs

Hips without collapse: success rate 89 % Urbaniak JR, Harvey EJ, JAAOS, 1999



### N= 329 <u>collapsed</u> hips 43 % converted to THA in 4 -14 yrs f-up 57 % postponed THA for ~ 5 yrs Urbaniak JR et al, JBJS Am

CRITICAL: Acetabular coverage on hip survival after FVFG for FHOn

Brannon JK. J B J S Am. 2007;89:448-49; author reply 448-49;.

## Acetabular coverage + lesion size & failure rates

#### 5 studies 163 hips

Study/year/design T	Technique	Hips	Lesion location							
			A		В		CI		C2	
			Hips	Failures	Hips	Failures	Hips	Failures	Hips	Failures
Lieberman et al. [26] (2004) (R)	CD/BMP	17	3	0 (0%)	7	1 (14.3%)				
Nagoya et al. [39] (2004) (R)	VIG	35					17	4 (23.5%)	18	15 (83.3%)
Onodera et al. [40] (2005) (R)	TTRO	37					19	9 (47.4%)	18	6 (33.3%)
Atsumi et al. [2] (2006) (R)	PRO	35	11	0 (0%)	20	0 (0%)	4 hips	, 2 failures*		
Seyler et al. [46] (2008) (R)	CD/NVG/OP1	39	8	1 (12.5%)	12	5 (41.7%)	12	2 (16.7%)	7	5 (71.4%)
Total		163	22	1 (4.6%)	39	6 (15.4%)	48	15 (31.2%)	43	26 (60.4%)





The **larger** the Lesion & the more Extensive the Articular surface involved the **worst** the prognosis

Lieberman JR et al CORR 2012

Best Hip preserving procedures: No consensus

younger patients without collapse by: VBGs, Avascular grafts, BMPs, Stem Cells, or combinations or Rotational Osteotomies

Lack of level 1 evidence for Optimal treatment Intervention prior to collapse critical for joint preservation **collapsed Hip : THA is** preferred option.

Zalavras CG, Lieberman JR. J Am Acad Orthop Surg. 2014 Jul.

## metal-on- metal resurfacing

#### idiopathic bilateral ON



adverse biomechanical effects in large FHOn lesion & excessive varus or valgus implantation Sakagoshi D et al J Arthroplasty 2009

patient function & pain relief may not be as predictable as after THR & is NOT proposed today

Mont MA et al JBJS Am 2006 Revell MP et al JBJS Am 2006

57 yr m,

## FHOn : Outcomes of THA

67 reports <u>N = 3,277</u> hips (2,593 pts) • <u>Revision rates Lower</u>: Idiopathic, SLE & Heart Transplant,

 <u>significantly</u> <u>Higher rates</u>: Sickle Cell Disease, Gaucher's, Renal failure &/or transplant

> FHOn is **not associated with poor** outcomes in THA <u>except..?</u>

Johannson HR, et al. Int Orthop. 2010 Feb, Systematic review.

FH On patients : similar outcomes after THA

as the general population.

# <u>survivorship</u> at mean : 17.3 yrs f- up **98% stem & 85% cementless cup** common reason for revision : cup wear or loosening

# worst outcomes in: renal failure &/or transplant & sickle cell disease

Kim YH, et all, J Bone Joint Surg Am 2011; 93: 1806 Ilyas I, Moreau P. J Arthroplasty 2002; 17: 441

Treatment of FHOn in US: 16-yr Analysis of Nationwide

Inpatient Sample Johnson AJ, et all, JBJS 2013 Aug 14

**1992: 3570 hip operations/yr**, **75%** THAs (n = 2678) *increased to* 

**2008**: 6400 hip operations /yr, **88**% THAs (n = 5632)

Joint-preserving procedures decreased from 25 to 12%

Improved awareness, diagnosis & treatment

•The # of procedures for FHOn increased,

•THA: incorporated into the practice patterns.

### THA for FHOn with Sickle Cell Disease

N= 312 THA in 244 pts, mean age 32 yrs f-up mean: 13 yrs (5-25). Infection : 3 % at 11 yrs (7-15) Aseptic loosening : 8 % cups : 5 % stems at 14 yrs (5-25) Orthopaedic complications : 13 % medical complications : 27 %

in patients with Sickle Cell Disease, **THA carries a high risk of complication** 

Hernigou P, et all. CORR . 2008 Feb

### THA in Chronic Renal Failure

poor results in Dialysis dependent Pts 10 - 20 X higher mortality vs < 6 % in all FHOn 2X more complications <u>better after successful renal transplantation</u> Ponnusamy KE et all, J Bone Joint Surg Am. 2015 Aug

> In Renal transplant recipients N=93 cemented f-up 10-20 yrs Loosening 10 yrs =1.2%, 20 yrs = 36 % Revision 20 yrs : 21 % stems, 33 % cups

> > Gofin et. all ., Nephr. Dial. Trans. 2006

## Patients with THA in FHOn

- is an heterogenous group
- varying long term survival due to comorbidities:
   Idiopathic
  - steroids &/or alcohol
    - renal transplant

#### > SLE

- > Sickle Cell Disease
- pts < 50 yrs: Higher dislocation rate

## Ortho-UTh series avg age 34 yrs (16 - 52 )

FVFG	31	
Drilling	36	
b.g. + BMP-7	15	
Tantalium rod	28	
Tantalium pegs	29	
osteotomy	3	
THA	181	(67 %)
observation + Bisphosfonates	39	

Early Diagnosis & Surgery  $\rightarrow$  may delay or prevent collapse

- •No Consensus regarding Best procedure
- •No single treatment is sufficient for all hips
  - •Lesion's Size, Extend & Location:
  - as important as the operative procedure
  - After collapse → hip preservation associated
     with high failure rates
### "...new years bring new promises &

opportunities, but some old demons remain..."



#### ancient theater @ Larissa, Greece 320 BC - 330 AC,







primary THA in HIV-infected pt group with FHOn •extented implant survivorship, clinical & radiographic •outcomes improving as a result of better medical management •minimal complications at midterm f-up. •late infections are potential complications. No difference in the rate of infections between Cemented & uncemented stems.

Bone, Kimona Issa et all JBJS 2013 Oct 16

Autologous Non-vascularised fibular grafting with rhBMP-7 for treatment of FHOn: preliminary report. Papanagiotou M1, Malizos KN, Vlychou M, Dailiana ZH. Bone Joint J. 2014 Jar

- n=7 hips of 6 pts. 5 Steinberg st II, 2 st III early consolidation of ANVFG
- prevented collapse 5/7 hips,
- safe & effective for HIP preservation
- operative time & post-operative rehabilitation : much shorter compared with FVFGs

### Lesion's size & failure rates

core decompression with Vasc. Graft or Non-VG

### • small < 15% of FH → 14 - 25 %

### • large > 30% of FH → 42-84 %

Study/year/design	Technique	Hips	Small (<15%)		Medium (15%-30%)		Large (>30%)	
			Hips	Failures	Hips	Failures	Hips	Failures
Yoon et al. [63] (2001) (R)	CD	39	14	2 (14.3%)	7	4 (57.1%)	19	16 (84.2%)
Steinberg et al. [52] (2001) (P)	CD/NVG/EStim	312		14%		48%		42%
Israelite et al. [19] (2005) (R)	UCD	124		14%) <sup>†</sup>		48% <sup>†</sup>		42% <sup>†</sup>
	BCD	152						
Mont et al. [38] (2004) (R)	CD/SD	45		:			12	7
Yoo et al. [61] (2008) (R)	VFG	124	27	0 (0%)	38	3 (7.89%)	59	10 (16.9%)
Kawate et al. [20] (2007) (R)	FVFG	71	19	10 (52.6%)			15	11 (73.3%)
Berend et al. [5] (2003)* (R)	FVFG	224	(21.1%	)	(38.2%)		(38.2%	)

### more systematic

# Research on

### Osteonecrosis

prevention

in high risk

individuals

is Urgent necessity

KALYPSO canyon @ Mount OSSA, Thessalia, Greece

#### You are ALWAYS WELCOME to GREECE



### Association Research Circulation Osseous

#### ARCO INTERNATIONAL CLASSIFICATION OF OSTEONECROSIS

STAGE	0	1	2	3	4
FINDINGS	All present techniques normal or non-diagnostic	X-ray and CT are normal at least ONE of the below mentioned is positive	NO CRESCENT SIGN! X-RAY ABNORMAL: sclerosis, osteolysis, focal porosis	CRESCENT SIGN! on the X-ray and/or flattening of articular surface of femoral head	OSTEOARTHRITIS! joint space narrowing, acetabular changes, joint destruction
TECHNIQUES	X-ray, CT Scintigraph MRI	Scintigraph MRI *QUANTITATE on MRI	X-ray, CT Scintigraph MRI *QUANTITATE MRI & X-ray	X-ray, CT ONLY * QUANTITATE on X-ray	X-ray ONLY
SUBCLASSIFICA- TION	NO	LOCATION	central	lateral	NO
QUANTITATION	NO	QUANTITATION % AREA INVOLVEME? minimal A < 15% moderate B 15% - 30% extensive C > 30%	NT LENGTH $\%$ : of CRESCENT DC A < 15 % B 15 % - 30 % C > 30 %	SURFACE COLLAPSE & ME DEPRESSION	NO

# loaded surface of the FH

### articular surface =120% of Hemisphere

the acetabulum covers

75 % of a Hemisphere





→60% of FH's articular surface continous contact with acetabulum



Rab, JBJS Br 1991

### Cementless THA in renal transplant pts

Lim, Byung-Ho, et al, Hip Int 2012;

N= 45 cementless THAs in 30 pts with advanced AVN after renal transplantation. Mean 44 years (22 - 68). F-up 7.2 years (2 to 13)

Compared to 96 sex & age-matched AVN hips in 72 pts without organ transplantation or long-term steroid therapy (controls).

HHS :48 preop → 94 last follow-up (p<0.05).</li>
3 hips revisions for PE wear massive osteolysis
1 hip revision for recurrent dislocation at 11 years postop.

#### No inter-group differences in overall

complications or revisions were observed.

F. 30yrs



Young-Hoo KIM, et al. JBJS Am 2011 Oct

n=98 pts (148 hips) f-up : 17.3 yrs

- revision rates
- •\_Femoral component : 2 %
- Acetabular >> :15-17 %

<u>Wear & periacetabular osteolysis :</u> the cause of failure in Hips requiring revision alumina-on-alumina ceramic THA in young pts

n= 93 hips ON, 64pts < 45ys f-up 11.1y (10-13)

No aseptic loosening or revision no acetabular or femoral osteolysis (x-rays & CT)

Kim YH et al Int Orthop 2009

### alumina-on-highly cross-linked PE

n= 73 FHOn,71 pts < 50 ys f-up 8.5y (7-9)

Mean PE linear penetration 0.05 +/- 0.02 mm/y

no hip aseptic loosening or osteolysis

Kim YH et al J Arthroplasty 2010

### THA for FHOn

#### \* in SLE f-up 5 yrs : 91% success rate

#### 10 yrs : 81% >> rate

Hansen & Cabanella, 1996

# treatment algorithm

Radiographic stage	symptoms	procedure
Prior to collapse	(	observe, pharmacological
		drilling ± bone grafting
No collapse	++ Va	scularized Fibula grafting
		or drilling ± bone grafting
Small lesions mild collapse	++	SAME ± TMT pegs
Arthritis	+++	THA

Lieberman JR , Urbaniak JR et al JBJS Am 2002

### Hemiarthroplasty is used less today

Author	Year	Number of Hips	Procedure	Follow-up [months]	Clinical Success
Auno	1.4.4.				624
Vomana at al	2004	29	Bipolar hemiarthroplasty	144	02.0
fallano er en	2000	48	Bipolar hemiarthroplasty	137 (84-216)	(5%)
no et al.	2000	28	Bipo ar hemiarthroplasty	77 (48-144)	89%
Chan et al.	1006	26	Bipolar hemiarthroplasty	55 (25-84)	57%
Sarjay et al.	1990	20	Bipolar hemiarthroplasty	40 (24-71)	95%
Grevitt et al.	1990	22	Bipdiar hemiarthroplasty		86%
Takaoka et al.	1992	02	Dipolar hemiarthroplasty		77%
Cabanela	1990	28	Bipciar nemiart inopiasty	22	48%
Lachiewicz et al.	1988	31	Bipolar nemiarthroplasty	55	4070
Krockmu of al	1004	21	TARA	48 (36 84)	86%
Reduktive Bildi.	1007	25	TARA	37 (25-60)	84%
Scott et al.	1301	25	Inter		A STORE OF STREET
TARA. Tota articula	ar replaceme	nt arthroplasty.	Pellegr	rini VD, Mont MA	et al ICL AAOS 2008

STATISTICS.		Number of	Age	and where a state of the state of the	Follow-up	1000
Author	Year	Hips	[years]	Frocedure	[months]	Clinical Success
		and the second second	Service	and which the second state of the	Station and	12
A-Mousawi et al.	2002	35	28 (19-42)	THA in patients with AVN secondary to SCD	114 (60-180)	80%
Zangger et al.	2000	26	46 (21-71)	THA n patients with AVN secondary to SLE	55 (21-124)	
Lieberman et al.	1995	46		THA in patients with AVN and chronic renal failure	54	19%
Schneider et al	2004	57		Cementiess THA		82%
Kim et al	2003		47 (26-55)	Cemented / Cementless THA	122	98% 98%
Xenakis et al	2001	36	51 (28-65)	Cementless THA	136 (120-180)	93%
Taylor et al.	2001	70		Cementless THA	77	
Hartev et al.	2000	55	31 (21-40)	Cementiess THA	117 (-)	79%
Eve et al.	1998	72	(-)	Cementless THA	(-)	94%
Stulberg et al.	1997	98	41 (21-69)	Cementless THA	87 (31-134)	75%
D'Antonio et al.	1997	53	41 (22-73)	Cementless THA	82 (60-96)	75%
Xenakis et al.	1997	29		Cementless THA	91	96%
Kim et al.	1995	78	48 (20-73)	Cementless THA	86 (72-108)	79%
Nakai et al.	2000	17	36		102	
Fyda et al.	2002	53		Cemented THA	>120	83%
Ortiguera et al.	1999		58	Cemented THA	214 (120-304)	82%
Weietal	1999	22	54	Revision THA	>24	62%

#### Mont MA & Seyler TM ICL AAOS 2006

### metal-on- metal resurfacing

- n= 116 hips ON vs n=1023 hips OA, f-up= 24 months. Stulberg BN et al Bull NYU Hosp Jt Dis 2009
- Survival NS different, FHOn:95.8%, OA:95.9%

good results for ON, taking into consideration implant size, pt gender, size of femoral deficiency

## treatment algorithm



Marker D et al ,J Bone Joint Surg Am. 2008

### GlucoCorticoids & FHOn

### Osteoblasts & osteocytes -> apoptosis

Zalavras et al, Crit. Rev. Eukryot Gene Expr. 2003

• The replicative capacity of osteocytes is significantly <u>reduced</u> in femur with On

Gangji et al. J Reumatol. 2003, Calder JD et al JBJS Br 2004, Suh KT et al CORR 2005

mechanisms of intraluminal obliteration

> fat embolism

glucocorticoid therapy & dyslipidemia

>fat or cholesterol emboli formation do

not consistently lead to ON
sickle cell crisis

hypercoagulability

Lafforgue P Joint Bone Spine

Bone is a closed compartment &...

adipocyte hypertrophy from glucocorticoids alcohol abuse or dyslipidemia

edema

nitrogen bubbles (Caisson's disease)

proliferation of histiocytes (Gaucher disease)

bleeding within the bone marrow

Lead to <u>extraluminal</u> obliteration of FH vessels

 better outcome in pts without radiological. abnormalities at baseline Е ΣТ time to articular surface collapse usually within > 2 yrs from diagnosis after 3rdzyear the risk of radiological deterioration is LITTLE worst in pts diagnosed after collapse

А

В

#### Systematic review



#### Lieberman JR et al CORR 2012



## ON occurs immediately or shortly

...after exposure to risk factors

...but the <u>date of ON onset</u> is usually unknown since there is <u>no pain</u> initially

in:

Trauma, Barotrauma, Glucocorticoid therapy time of the onset <u>can be</u> determined

www.ortho-uth.org

the

# Racial genetic risk profile for ON may differ among ethnic groups

In Korean population:

MTHFR polymorphisms play no significant role in susceptibility to ONFH

Kim TH et al Mol Cells 2010

#### a pig model

#### HIF-1α activates Sox9 expression & enhances Sox9-mediated transcriptional activity

### $\rightarrow$

HIF-1α upregulation of Sox9 activity may have a chondroprotective role following femoral head ischemia

Zhang C et al Bone 2011

in rat model

transient extreme oxidative stress induces ON

rats were injected with the pro-oxidant Buthionine sulfoximine(BSO)500mg/kg intraperitoneally only once

Ichiseki T et al Arthritis Rheum 2011

In Bone specimens:

from 34 ONFH pts underwent THA & from 10 femoral neck fracture pts

Increased Dickkopf-1 (DKK1) expression accelerates bone cell apoptosis in ONFH



### Genetics traits of ONFH

In Korean population: specific genes FLJ40296, CYP27C1, CTDP1

FLJ40296 & CYP27C1 highest frequency (55.6%) in idiopathic ON

FLJ40296 high frequency (44.4%) & CYP27C1 relatively low frequency (33.3%) in alcoholic ON

CTDP1 high frequency (55.6%) in alcoholic ON & low frequency (22.2%) in idiopathic ON

Hwang JT et al Orthopedics 2011

### steroid-induced ONFH

in rabbit model

Vitamin E administration significantly inhibited steroidinduced oxidative stress

suggest that the administration of vitamin E may be a novel & simple method to prevent the development of steroid-induced ON

> Mikami T et al J Orthop Sci 2010 Kuribayashi M et al Acta Orthop 2010

### steroid-induced ONFH

in vitro

human bone marrow adipocytes:

simvastatin may exhibit preventive effects against steroid-induced ONFH

by suppressing PAI-1 secretion

Sakamoto K et al BMC Musculoskelet Disord 2011

### <u>steroid-induced ONFH</u>

in rat model:

upregulation of gene alpha-2-macroglobulin (A2M)

→ A2M may a potential marker & a treatment target for early steroid-induced ONFH

> Amin Kerachian M et al Arthritis Res Ther 2010
J Arthroplasty. 2010 Camporesi et all. Level IV

<u>unilateral FHN :</u> Ficat stage II, N = 20 pts

→ 30 treatments for 6 wks : compressed O<sub>2</sub> (HBO) vs compressed air (HBA)

F-up MRI: Pretreatment, 1 & 7 yrs

pain & ROM improvement for HBO

7 yrs later: All patients pain-free, none with THA.

Substantial radiographic healing in 7 of 9 hips.

Hyperbaric O<sub>2</sub> might be a viable treatment modality in pts with Ficat II FHOn...??