

3

1

2

: MRI 3 가 , MRI 2
 : 3 14
 MRI
 MRI , 3 MRI 3
 ' fluid displace -
 ment method ' . MRI 2 3
 : MRI 2 Spearman 0.657
 , MRI 3 Spearman 0.952
 가 , $p < 0.05$
 : 가 MRI 3 MRI 2

(5, 8).
 가 MRI (6, 8-12),
 2 가
 . 30-50 , 50-80%
 (1).
 가 가 ,
 가 MRI (13, 14)
 (total hip replacement) (1). 3 가 (15, 16).
 MRI 3
 (stage) 가 MRI 2
 (2, 3). Ficat
 가 (3).
 가
 가 가 (4-
 7). 2002 4 6 3
 MRI

2, 54 (32 - 67) . 14
8, 6, 3
. 11
29 (3 - 60)
가 5 (46%),
가 3 (27%), 3 (27%)
가 14
Ficat stage III가 5 (36%), stage
IV가 9 (64%) . 12 1 MRI
, 2 99 (3) 419
(1) MRI
MRI 1.5 T (Signa; GE Medical Systems, Milwaukee,
WI, U.S.A.) (body coil)
T1 TR 350 - 700 msec, TE 8 - 16 msec
(axial), (coronal), (sagittal)
T2 TR 4200 - 5900 msec TE 105 - 108 msec
STIR TR 4000 -
5000 msec, TE 24 - 30 msec, TI 150 msec
STIR 4 mm, 1 mm
mm (matrix size) 512 × 256
(field of view; FOV) 34 - 38 cm
(supine position)
MRI 2 Koo (11)
T1
가
a, b (Fig. 1),
(necrotic fraction) $(a/180) \times (b/180) \times 100 (\%)$
(11). MRI 3 20
T1 (digital
imaging and communications in medicine; DICOM) 3
(Rapidia, Infinitt, Seoul, Korea)
T1

(serpiginous line)
(Fig. 2A). (total
volume of femoral head on MRI; VtMRI) 20
(region of interest; ROI)
(Fig. 2B, D). MRI 3
(volume of osteonecrosis on MRI;
(freehand technique)
(Fig. 2C, E).
가 2
가 (VonMRI/ VtMRI)
 $\times 100 (\%)$
(trochanter)
(osteotomy)
76
0 - 4
' fluid
(17). ' Fluid
displacement method ' 200 mL
가
가
(volume of osteonecrosis in
specimen; VonS) (total volume
of femoral head in specimen; VtS)
(volume of normal area in specimen; VnS)
(VonS = VtS - VnS). VtS
, VnS (ronger)
3 ' fluid displacement
method '
가

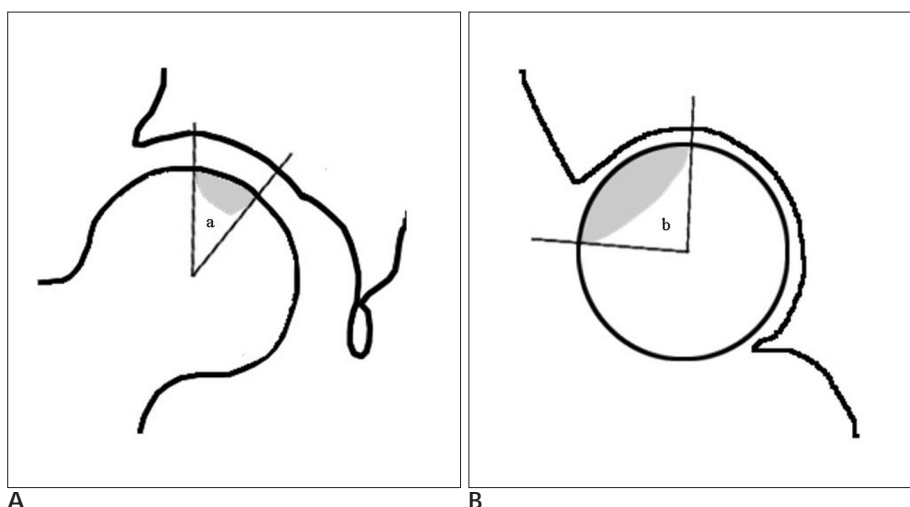


Fig. 1. MRI 2D quantitative analysis in assessment of the necrotic fraction in osteonecrosis of the femoral head. ' a ' is the angle of necrotic portion (gray colored area) in the midcoronal image (A) and ' b ' is the angle of necrotic portion in the midsagittal image (B). The necrotic fraction = $(a/180) \times (b/180) \times 100 (\%)$.

$$\frac{[(VtS - VnS) / VtS] \times 100(\%)}{\text{MRI 2} \quad \text{MRI 3}}$$

Table 1. Necrotic Fractions of the Femoral Head by MRI 2D Quantitative Analysis, MRI 3D Quantitative Analysis, and Quantitative Analysis of the Specimen

Cases	Necrotic Fraction by MRI 2D Method (%)	Necrotic Fraction by MRI 3D Method (%)	Necrotic Fraction of the Specimen(%)
1*	52.10	30.97	26.48
2	53.70	20.11	15.93
3*	63.50	38.36	32.07
4	57.50	46.36	37.59
5	69.20	53.93	40.19
6	20.20	18.49	11.72
7	25.10	15.21	9.98
8	63.90	42.33	30.86
9	47.10	25.71	20.65
10	38.00	24.96	18.47
11	42.30	38.56	30.39
12	57.40	48.70	41.52
13	35.70	44.15	38.23
14	40.30	28.15	15.22

* In case 1 and case 3, MRI were obtained at 419 days and 99 days before operation, while in other cases at 1 day before operation.

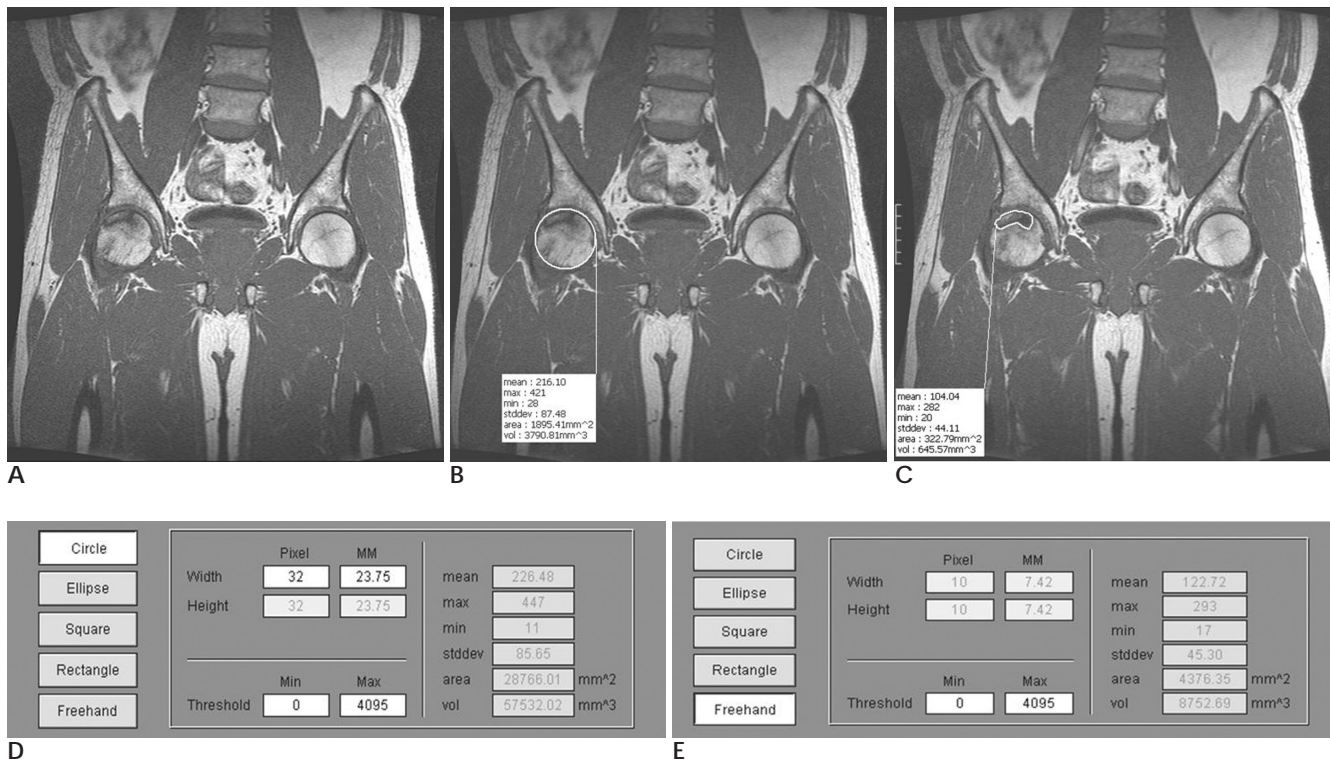


Fig. 2. Measurement of necrotic fraction by MRI 3D quantitative analysis.

A. Coronal T1WI in a 61-year-old man with osteonecrosis in right femoral head.

B. Circular ROI along the entire femoral head is outlined on continuous coronal T1WI.

C. Freehand ROI along the necrotic interface line is drawn.

D. Summary of volumetric measurement of total femoral head after processing shown in (B). Automatically calculated total volume of the femoral head is 57532.02 mm³.

E. Summary of volumetric measurement of osteonecrosis after processing shown in (C). Automatically calculated volume of necrosis is 8752.69 mm³.

MRI 2 MRI 3

(Spearman correlation analysis) . SPSS
version 11.0 (SPSS, Chicago, Ill, U.S.A.)

(correlation coefficient) r 0.7
(strong) , 0.3 - 0.7
(moderate) , 0.3 (weak)
, p 0.05

MRI 2 , MRI 3
Table 1 Fig. 3

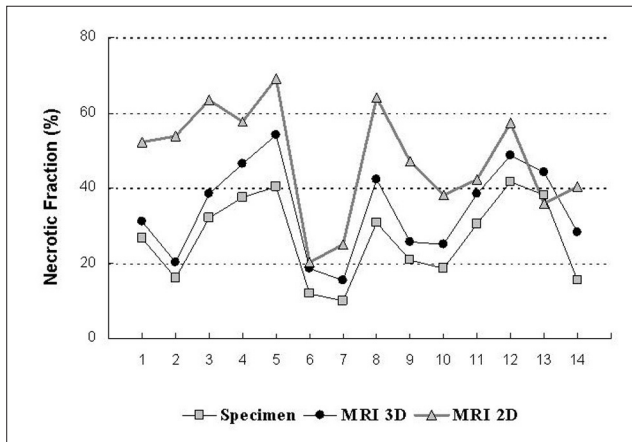


Fig. 3. Comparison of necrotic fractions of the femoral head measured by MRI 2D quantitative analysis, MRI 3D quantitative analysis and necrotic fraction of the specimen. Number of X axis represents each case. Number of Y axis represents percentage of necrotic fraction.

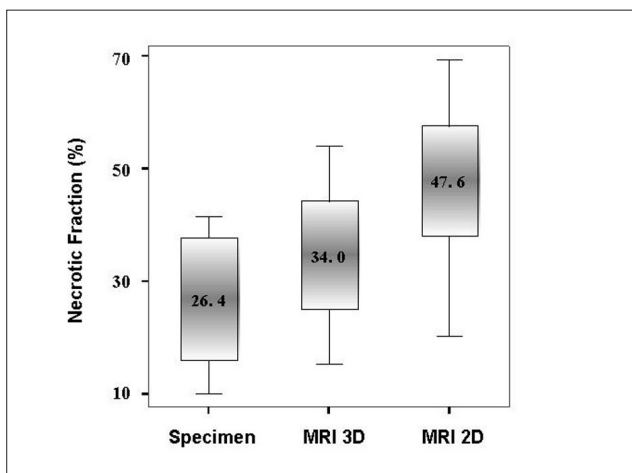


Fig. 4. Comparison of mean value of necrotic fractions of the femoral head measured by MRI 2D, 3D quantitative analysis, and necrotic fraction of the specimen. Data within the box represent mean value of necrotic fractions.

MRI 2 MRI 3

47.6% , MRI 3 34.0%
26.4% (Fig. 4).

MRI 3
7.6% MRI 2
21.2% (Fig. 4).

, MRI 2
Spearman 0.657
(Fig. 5), MRI 3
Spearman 0.952
 $p < 0.05$ (Fig. 6).

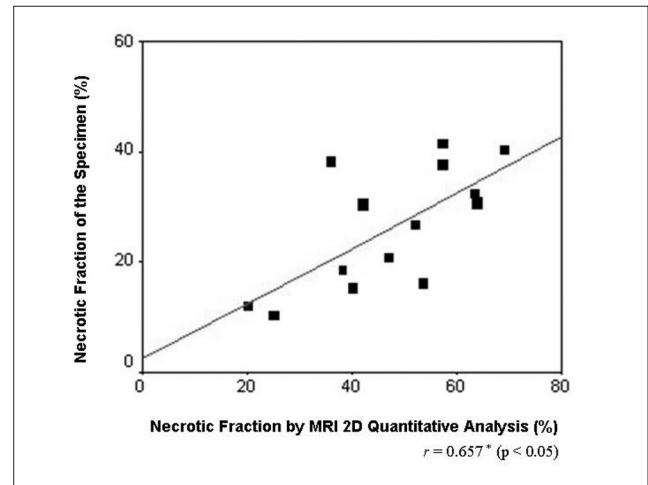


Fig. 5. Correlation between necrotic fraction by MRI 2D quantitative analysis and necrotic fraction of the specimen.

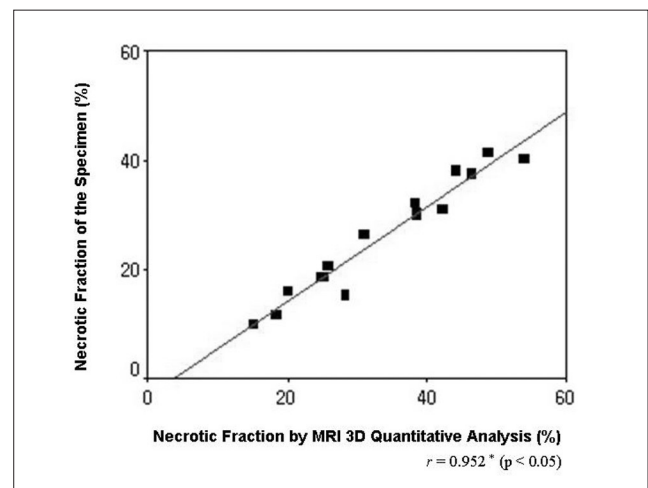


Fig. 6. Correlation between necrotic fraction by MRI 3D quantitative analysis and necrotic fraction of the specimen.

99Tc-MDP bone scan, MRI, CT

Ficat system (3), Japanese Investigation Committee (JIC) system (5, 7), Steinberg system (8), Association Research Circulation Osseous (ARCO) system (1), Steinberg system ARCO system grade A (<15%), grade B (15-30%), grade C (>30%)

(hemiarthroplasty)

(18). (core decompression), (bone grafting), (osteotomy) (joint preserving surgery) (4, 19). 53-72%

(4),

(cutoff value) (5-8, 15).

frog-leg, Sugano (7) frog-leg, Steinberg (8)

MRI 가 T1

MRI 2 가 가 T1 가 MRI 가

Shimizu (6) Kubo (12) 가 2 가

3 4 15% 30% 가 가 가

Theodorou (20) 4-5 mm T1 5

가 가

Koo (11) T1 MRI 2 (Fig. 1). 가 MRI 2 Koo MRI 2 가 0.657 (Fig. 5). MRI 3 MR 3 가 MRI 가

21.2%

3 MRI CT 2 2 3 (slab thickness) 가 3 가

Nishii (15) Kishida (16) MRI 3 1 mm (three-dimensional spoiled gradient-echo sequence; 3D-SPGR) (Adobe Photoshop, Adobe Systems, San Jose, CA) 가 가 1 mm 40 2

(8, 20).

:

3

MRI 2 13.6% 가 MRI 3
가

Koo MRI 2
가

T1 T2

가

가

MRI 3

가

가

MRI 8%

가 (8), MRI 12.6%

(20).

2 mm

T1

. 3

MRI

MRI

(VonMRI)

가 mm³

, 2 mm MRI

4 - 5 mm

(freehand technique)

가 가

T1

. MRI

가

,

, 3

2

MRI

가

, 가

MRI T1

가

가

가

가

가

(17).

' fluid displacement

method '

(17),

가

3

(6, 10, 15)

가

가

가

가

MRI

. 2 mm

T1

MRI 3

가

MRI 2

MRI 3

가

3

. MRI 2

T1

MRI 3

, MRI 3

MRI 3

MRI 2

가 가

MRI 3

7.6%

가

가

, MRI 3

Koo

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The Usefulness of 3D Quantitative Analysis with Using MRI for Measuring Osteonecrosis of the Femoral Head¹

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Purpose: We wanted to evaluate the usefulness of MRI 3D quantitative analysis for measuring osteonecrosis of the femoral head in comparison with MRI 2D quantitative analysis and quantitative analysis of the specimen.

Materials and Methods: For 3 months at our hospital, 14 femoral head specimens with osteonecrosis were obtained after total hip arthroplasty. The patients preoperative MRIs were retrospectively reviewed for quantitative analysis of the size of the necrosis. Each necrotic fraction of the femoral head was measured by 2D quantitative analysis with using mid-coronal and mid-sagittal MRIs, and by 3D quantitative analysis with using serial continuous coronal MRIs and 3D reconstruction software. The necrotic fraction of the specimen was physically measured by the fluid displacement method. The necrotic fraction according to MRI 2D or 3D quantitative analysis was compared with that of the specimen by using Spearman's correlation test.

Results: On the correlative analysis, the necrotic fraction by MRI 2D quantitative analysis and quantitative analysis of the specimen showed moderate correlation ($r = 0.657$); on the other hand, the necrotic fraction by MRI 3D quantitative analysis and quantitative analysis of the specimen demonstrated a strong correlation ($r = 0.952$) ($p < 0.05$).

Conclusion: MRI 3D quantitative analysis was more accurate than 2D quantitative analysis using MRI for measuring osteonecrosis of the femoral head. Therefore, it may be useful for predicting the clinical outcome and deciding the proper treatment option.

Index words : Hip, necrosis

Magnetic resonance (MR), volume measurement

Magnetic resonance (MR), three-dimensional

Femur

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