Differentiating Nutrient Artery Canals of the Femur versus Fracture Lines in Patients with Total Hip Arthroplasty on Plain Radiographs

Abstract

Background: Nutrient artery canals of the femur are often visible on plain radiographs as radiolucent lines which may mimic fracture lines. The purpose of this study was to distinguish nutrient artery canals from fracture lines on plain radiographs. **Materials and Methods:** Ninety-three patients (102 hips) with an average age of 65.6 years were included in the study. We retrospectively analyzed nutrient artery canals of the femur on pre and postoperative anteroposterior (AP) and cross-table lateral (CTL) hip radiographs in patients with cementless total hip arthroplasty. The shape, number, location, direction of obliquity, length of nutrient artery canal, and the distance between the tip of the greater trochanter and the proximal end of the nutrient artery canal were measured. **Results:** Nutrient artery canals were determined in 54 hips (53.0%) on preoperative radiographs. The numbers of nutrient artery canals were entirely found to be one for each hip. The nutrient artery canals of the femur were the most frequently seen in the cortex on CTL radiographs with 32 hips (31.4%), whereas nutrient artery canals were not seen at all in the cortex on AP radiographs. All nutrient artery canals in the cortex on CTL radiographs coursed upward obliquely. Comparing to fracture lines, nutrient artery canals show less radiolucency, smaller diameter, and blunted ends in both the cortex and medullary cavity, show sclerotic walls in the cortex and have the less straight course in the medullary cavity. **Conclusions:** Based on the results of this study, there are clearly distinguishable differences between nutrient artery canals of the femur and fracture lines on plain radiographs.

Keywords: *Cementless femoral stem, fracture line, nutrient artery canal, periprosthetic fracture, total hip arthroplasty*

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Introduction

The incidence of intraoperative periprosthetic fractures during total hip arthroplasty (THA) are becoming more common given the increased use of cementless femoral stem fixation,[1] which may cause bursting of the femur required to achieve a press-fit and intimate contact with the bone.[2] Plain radiographs have been mostly used to evaluate the pre and postoperative general status of THA patients including to detect periprosthetic fractures due to their simplicity, availability, and minimal expense.

Nutrient artery supply 70%–80% of the nutrients and oxygen to a long bone[3,4] and nutrient artery canal is a normal structure that carries a nutrient artery.[5] Nutrient artery of the femur originates from perforating branches of the deep femoral artery. After entering nutrient foramina, nutrient artery canal of the femur keeps on the course through the cortex and extends into the medullary cavity.[6] Nutrient artery canals are often visible on plain radiographs like to other anatomical structures[7,8] as oblique or longitudinal radiolucent lines which may mimic fracture lines.[9-12]

Nutrient arteries and their canals have been studied by observing the dry bones[3,4,13] or perfused bones,[14,15] radiological study,[14] and multidetector computed tomography (MDCT).[11,16] However, there have been few relevant data on differentiating nutrient artery canals from fracture lines on plain radiographs. In an effort to improve our understanding of this issue, we retrospectively analyzed nutrient artery canals of the femur on pre and postoperative plain radiographs in patients with primary cementless THA and compared them with fracture lines of intraoperative periprosthetic femoral fractures. The present study addresses the following questions: (1) How frequently are nutrient artery canals of the femur seen on plain radiographs and what

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are their morphological and topographic features; (2) How to distinguish nutrient artery canals from fracture lines on plain radiographs; and (3) Whether clinical significance of nutrient artery canal of the femur in patients with THA is evident or not.

Materials and Methods

From March 2010 to December 2013, 158 patients (186 hips) underwent THA at one institution by a single surgeon. The study was approved by our Institutional Review Board. The exclusion criteria for this study were: (1) cemented femoral stem, (2) previous metal implant or deformity in the proximal femur (3) revision cases, and (4) <12 months postoperative follow-up. After applying exclusion criteria, 93 patients (102 hips) with an average age of 65.6 ± 4.2 years (range 30–82 years) were included in this study. The mean follow-up is 3.9 ± 2.4 years (range 1–7.9 years). Eighty-one of the hips analyzed were in men and 12 were in women. Forty-four THAs were on the right side, 40 on the left, and 9 on both. Cementless hemispherical acetabular components were used in all patients. All femoral stems used (55 hips by Corail®, 32 hips by Bicontact®, and 15 hips by Summit®) had a similar design in which a double-wedged, tapered, whose upper one-third was coated. An average stem length was 138 mm (range 110–170 mm).

Pre and postoperative anteroposterior (AP) and cross-table lateral (CTL) plain digital hip radiographs were taken with the use of a previously described protocol.[17] AP and CTL radiographs were performed such that every patient was supine and the femurs are held in 15 degrees of internal rotation. The X-ray beam is centered at the midpoint between the superior margin of the symphysis pubis and the midpoint between the anterior superior iliac spines in AP radiographs and is directed parallel to table, oriented 45° cephalad from inferomedial to superolateral, and centered at the femoral head in CTL radiographs. In both radiographs, the source-to-image distance was 120 cm. AP films of 330 mm × 430 mm and CTL film of 430 mm × 330 mm, including proximal one-third diaphysis of the femur, were used for evaluation. Patients were followed postoperatively at initial, 3 days, 2 weeks, 4 weeks, 3 months, 6 months, 1 year, and then yearly thereafter. Plain radiographs were undertaken preoperatively and 3 days postoperatively were evaluated retrospectively.

Nutrient artery canal of the femur on plain radiograph was defined with modification of Schiessel and Zweymuller's definition[18] as an oblique radiolucent line which is seen traversing the cortex or a longitudinal radiolucent line traversing the medullary cavity. The shape, number, location, the direction of obliquity, length of the nutrient artery canal, and the distance between the tip of the greater trochanter and the proximal end of the nutrient artery canal was measured.

We classified visible patterns of the nutrient artery canals in the cortex between pre and postoperative radiographs into four groups as follows:

- Group I: A nutrient artery canal was seen preoperatively and postoperatively
- Group II: A nutrient artery canal was seen preoperatively but was not seen postoperatively
- Group III: A nutrient artery canal was not seen preoperatively but was seen postoperatively
- Group IV: A nutrient artery canal was not seen preoperatively and postoperatively.

Using the implant tip as a reference, Group I and III were subdivided into three subgroups as follows:

A: Both ends of the nutrient artery canal were distal to the implant tip. B: Upper end of the nutrient artery canal was proximal to the implant tip. C: Both ends of the nutrient artery canal were proximal to the implant tip.

We classified visible patterns of the nutrient artery canal in the medullary cavity between pre and postoperative radiographs into five groups as follows:

- Group I: A nutrient artery canal was seen preoperatively and postoperatively
- Group II: A nutrient artery canal was seen preoperatively but was not seen postoperatively
- Group III: A nutrient artery canal was not seen preoperatively but was seen postoperatively
- Group IV: A nutrient artery canal was not seen preoperatively and postoperatively
- Group V: A nutrient artery canal was seen preoperatively and was visible postoperatively, but its proximal end was not defined.

We had experienced one case with undiagnosed periprosthetic femoral fracture [Figure 1], and another case with a nutrient artery canal misdiagnosed periprosthetic femoral fracture [Figure 2] before this study. After that, we underwent postoperative MDCT (Sensation 16, Siemens Medicals, Erlangen, Germany) in every hip which showed a Group III visible pattern of the nutrient artery canal [Figure 3] and had new or additional radiolucent lines seen postoperatively [Figure 4]. Nutrient artery canal on CT was defined as a hypodense line having all of the three properties in the cortex (an outer ostium, an uninterrupted course and an inner ostium) using the previous definition[11] [Figure 3].

Two sets of measurements were obtained by two independent observers, who were unaware of the study design with an interval of 1 month between measurements. All the observers were skillful at applying all tools of image adjustments. The intraclass correlation coefficient for measurements ranged from 0.91 to 0.99 [Table 1].

All statistical analyses were performed with SPSS software, version 18.0 (SPSS Inc, Chicago, USA). For the descriptive analysis, mean values and differences were expressed in

Figure 1: Anteroposterior hip radiographs of a 63-year-old male (a-d). (a) No radiolucent line is seen preoperatively in the femoral diaphysis. (b) A displaced periprosthetic femoral fracture is seen in the proximal one-third of the femur postoperatively. In addition, a longitudinal radiolucency (fracture line) in the medullary cavity is observed from the implant tip. (c) New displaced periprosthetic fracture is developed through the radiolucency seen in (b) due to insufficient fixation of the fracture (c). (d) Reoperation with plate fixation is underwent

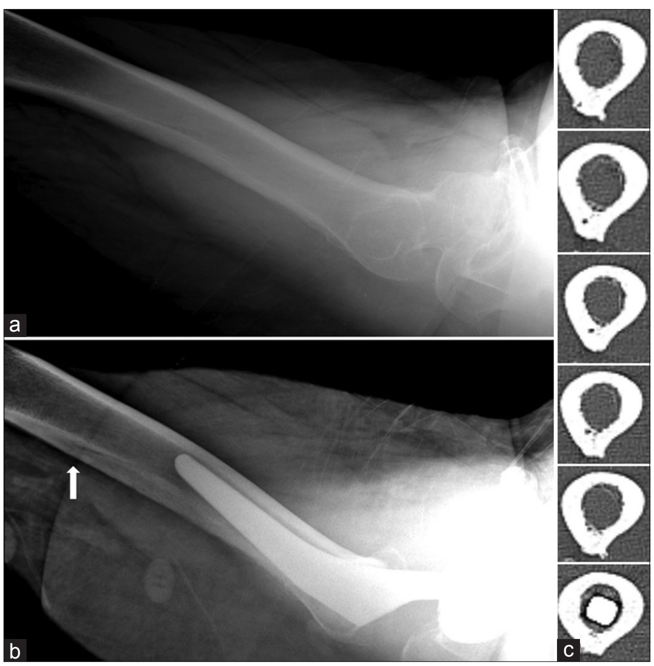

Figure 3: Cross-table lateral hip radiographs of a 68-year-old female (a and b). (a) No radiolucent line is seen in the femoral diaphysis preoperatively. (b) At below the implant tip, oblique radiolucent line (white arrow) is seen postoperatively. (c) Subsequent 6 axial computed tomography images from distal to proximal shows a nutrient artery canal in the posterior cortex (the ostium of nutrient artery canal on the outer cortex, the course through the cortex, and the inner ostium)

degrees and included standard deviation or 95% confidence interval, respectively. A paired *t*-test was used to compare the reproducibility of the nutrient artery canal between pre

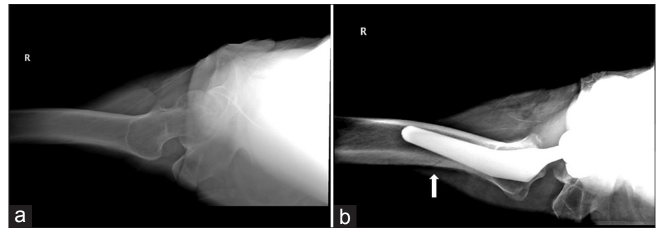

Figure 2: Cross-table lateral hip radiographs of a 70-year-old male (a and b). (a) No radiolucent line is seen in the femoral diaphysis preoperatively. (b) At proximal to the implant tip, oblique radiolucent line (white arrow) is seen postoperatively. This patient was misdiagnosed as intraoperative periprosthetic femoral fracture and was treated by conservative treatment with protective weight-bearing and serial radiological examination

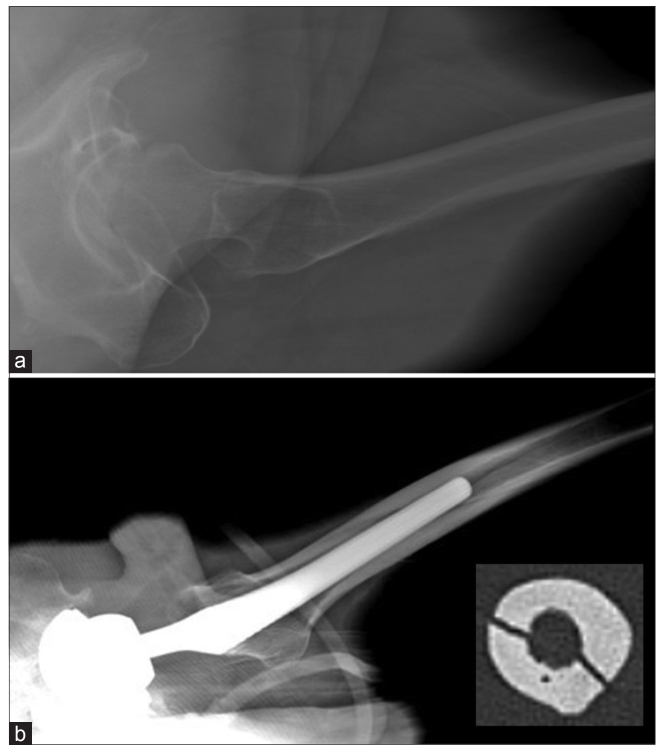

Figure 4: Cross-table lateral hip radiographs of a 53-year-old male (a and b). (a) No radiolucent line is seen in the femoral diaphysis preoperatively. (b) Around the implant stem tip, a smaller oblique radiolucent line with blunted ends in the posterior cortex and a sharply configured, larger longitudinal radiolucent line in the medullary cavity are seen postoperatively. An axial computed tomography image shows a nutrient artery canal and fracture lines in the femoral diaphysis

and postoperative radiographs. $P < 0.05$ was considered to be statistically significant.

Results

Nutrient artery canals were determined in 54 of 102 hips (53.0%) on preoperative radiographs. The numbers of nutrient artery canals were entirely found to be one for each hip. The basic measurement results for nutrient artery of the femurs in the preoperative radiographs were summarized in Table 2. Nutrient artery canals were the most frequently seen in the cortex on CTL radiographs with 32 of 102 hips (31.4%), whereas nutrient artery canals were not seen at all in the cortex on AP radiographs. All nutrient artery canals in the cortex on CTL radiographs coursed upward obliquely.

Visible patterns of nutrient artery canal of the femur between the pre and postoperative radiographs were summarized in Tables 3 and 4. There were statistically significant differences in the reproducibility of the nutrient artery canal in the cortex on CTL radiographs (31/32, 97%) in comparison with in the medullary cavity on AP radiographs (9/17, 53%) and CTL radiographs (3/5, 60.0%) ($P < 0.05$). The length of stems which fully masked nutrient artery canals in the medullary cavity on postoperative plain radiographs were at least 150 mm or longer. In cases of 4 hips (3.9%) in the cortex on CTL hip radiographs and 2 hips (2.0%) in the medullary cavity on AP and CTL radiographs, nutrient artery canals were newly seen on postoperative radiographs.

Among 11 hips (6 hips; Group III visible pattern of the nutrient artery canal, 5 hips; new or additional radiolucent line was seen postoperatively) which were underwent MDCT postoperatively, all of 5 hips (4.9%) which had showed new or additional radiolucent lines postoperatively were Type B1 intraoperative periprosthetic femoral fractures according to the modified Vancouver classification.[19]

Table 1: Intra and interobserver reliability for measurements of the nutrient artery canal of the femur on plain radiographs

Radiographs	Intraobserver A		Intraobserver B		Interobserver A-B	
	ICC	95% CI	ICC	95% CI	ICC	95% CI
AP/C*	0.99	0.98-0.99	0.97	0.96-0.98	0.94	0.92-0.96
CTL/C†	0.96	0.95-0.97	0.97	0.96-0.98	0.95	0.93-0.96
AP/M‡	0.91	0.88-0.94	0.92	0.89-0.95	0.93	0.90-0.95
CTL/M§	0.94	0.92-0.96	0.93	0.90-0.95	0.91	0.88-0.93

*Nutrient artery canal of the femur in the cortex on AP hip radiograph, †Nutrient artery canal of the femur in the cortex on CTL hip radiograph, ‡Nutrient artery canal of the femur in the medullary cavity on AP hip radiograph, §Nutrient artery canal of the femur in the medullary cavity on CTL hip radiograph. AP=Anteroposterior, CTL=Cross-table lateral, ICC=Intraclass correlation coefficient, CI=Confidence interval

Comparing to fracture lines in five intraoperative periprosthetic femoral fractures [Figures 4 and 5], nutrient artery canals were encountered only in one part of the cortex, mostly posterior cortex and showed less radiolucency, smaller diameter, traversing with regular widths, and blunt ends in both the cortex and medullary cavity showed sclerotic walls in the cortex, and had less straight course in the medullary cavity [Figures 2, 5 and 6]. We treated two Type B1 fractures by additional internal fixation with a single or multiple cables [Figure 5] and three Type B1 fractures by conservative method with protective weight-bearing and serial radiological examination [Figure 7]. There was no subsequent surgery in our cases, and all of the fractures were united at last followup [Table 5].

Discussion

Understanding the morphological and topographic features of nutrient artery canals on plain radiographs is important in various clinical situations such as evaluation for the

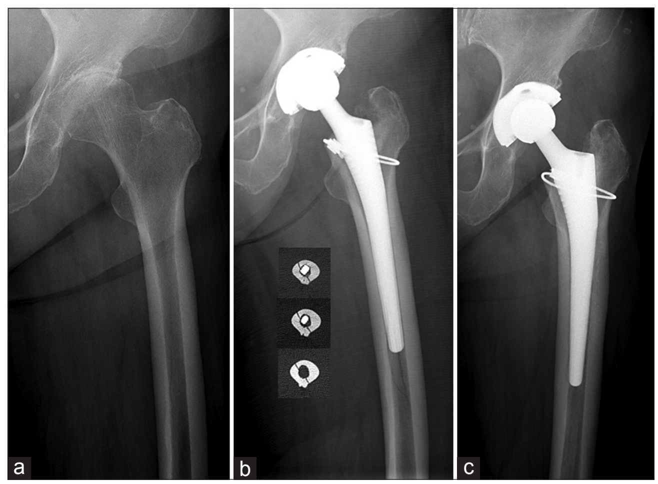

Figure 5: Anteroposterior hip radiographs of a 76-year-old female (a-c). (a) A blunted configured, longitudinal radiolucent line is seen in the medullary cavity of the proximal one-third of the femur preoperatively. (b) A previous longitudinal radiolucent line is superimposed by the implant. At below the implant tip, two sharply configured, radiolucent lines are newly appeared in the postoperative radiograph. A Vancouver Type B2 intraoperative periprosthetic femoral fracture is diagnosed by computed tomography. (c) Postoperative 1-year radiograph shows complete disappearance of fracture lines

Table 2: Visible patterns of nutrient artery canals of the femur on preoperative radiographs

	AP/C*	CTL/C†	AP/M‡	CTL/M§
Visibility (%)	0/102 (0)	32/102 (31.4)	17/102 (16.6)	5/102 (4.9)
Location		Posterior (32/32)		
Direction of obliquity		From posterodistal to anteroproximal (32/32)		
Length (mm)		32.6±13.9 (10.2-70.6)	23.6±8.8 (10.2-55.3)	23.5±6.7 (9.4-34.9)
Distance A (mm)‖		130.1±15.8 (83.3-181.1)	105.1±13.4 (73.9-157.2)	102.5±7.4 (86.7-116.4)

Values are expressed as mean±SD with range in parentheses. *Nutrient artery canal of the femur in the cortex on AP hip radiograph, †Nutrient artery canal of the femur in the cortex on CTL hip radiograph ‡Nutrient artery canal of the femur in the medullary cavity on AP hip radiograph, §Nutrient artery canal of the femur in the medullary cavity on CTL hip radiograph, ‖The distance between the tip of the greater trochanter and the proximal end of nutrient artery canal. SD=Standard deviation, AP=Anteroposterior, CTL=Cross-table lateral fracture lines.[11,18] Nutrient artery canals may erroneously suggest fractures on account of their topography. It was the objective of this study how to differentiate nutrient artery canals from fracture lines on plain radiographs. Our findings showed that comparing to fracture lines, nutrient artery canals show less radiolucency, smaller diameter, and blunted ends in both the cortex and medullary cavity, show sclerotic walls in the cortex and have less straight course in the medullary cavity. We also found that nutrient artery canals of the femur are most frequently seen in the cortex on CTL radiographs, and the courses of nutrient artery canals of the femur through the cortex were always in an upward direction. These findings are consistent with the previously established reports.[11,18] Based on the results of this study, there are clearly distinguishable differences between nutrient artery canals and fracture lines in term of configuration on plain radiographs.

Table 3: Visible patterns of nutrient artery canal of the femur in the cortex between the preoperative and postoperative plain radiographs

Classification	AP/C*	CTL/C†
Group I	0	21 (A)‡, 5 (B)§, 5 (C)‖
Group II	0	1
Group III	0	2 (A), 1 (B), 1 (C)
Group IV	102	63

Values are expressed as number. *Nutrient artery canal of the femur in the cortex on AP hip radiograph, †Nutrient artery canal of the femur in the cortex on CTL hip radiograph, ‡Both ends of the nutrient artery canal were distal to the implant tip, §Upper end of the nutrient artery canal was proximal to the implant tip, ‖Both ends of the nutrient artery canal were proximal to the implant tip. AP=Anteroposterior, CTL=Cross-table lateral

Table 4: Visible patterns of nutrient artery canal of the femur in the medullary cavity between the preoperative and postoperative plain radiographs

Classification	AP/M*	CTL/M†
Group I	4	2
Group II	8	2
Group III	1	1
Group IV	83	95
Group V	5	1

Values are expressed as number. *Nutrient artery canal of the femur in the medullary cavity on AP hip radiograph, †Nutrient artery canal of the femur in the medullary cavity on CTL hip radiograph. CTL=Cross-table lateral, AP=Anteroposterior

Figure 6: Cross-table lateral hip radiographs of a 62-year-old male show a nutrient artery canal (white arrow), of which upper end was proximal to the implant tip. Shape and length of the nutrient artery canal is unchanged throughout the postoperative followup (a-d). (a) Preoperative period. (b) Postoperative 2 weeks. (c) Postoperative 6 months. (d) Postoperative 3 years

Our study is limited in several ways. First, this study is slightly limited by the lack of information on how commonly nutrient artery canals could be mistaken for fracture lines. MDCT[20] has become an accurate modality in the evaluation of cortical and medullary structures of the bones and accuracy study using MDCT would be helpful to address this issue. Second, we did not analyze the effect of age distribution, gender difference, type of femur, and bone quality on the visibility of nutrient artery canal. Finally, we could not measure the width of nutrient artery canal. In a CT study,[11] the average width of nutrient artery canal of the femur in the cortex was 1.16 ± 0.32 mm, ranged from 0.6 to 2.0 mm, and this finding may be useful in radiologic evaluation for the fracture lines.

Previous studies on the location of nutrient artery canals of the femur showed that majority of the nutrient canals are localized in middle one-third diaphysis.[4,11] On the other hand, some authors reported that half of the nutrient artery canals were in proximal one-third diaphysis.[21,22] Our study showed approximately half (53.0%) of nutrient artery canals seen on plain hip radiographs including proximal one-third diaphysis of the femur. Comparing to the visibility of nutrient artery canal of the femur in a previous study using conventional radiography (43/129 hips,

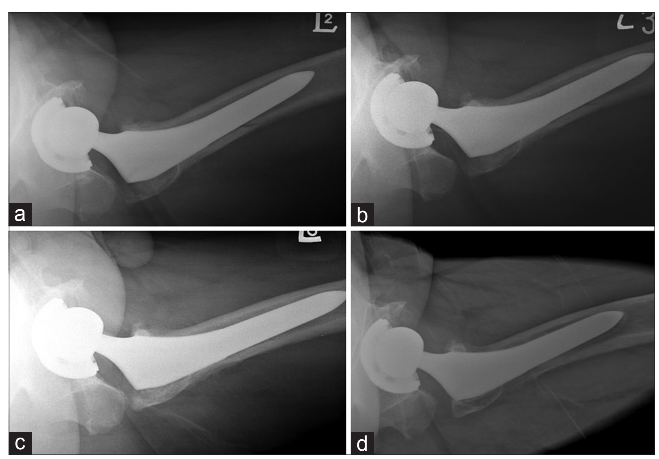

Figure 7: Cross-table lateral hip radiographs of a 62-year-old male show a Type B2 intraoperative periprosthetic femoral fracture (a-d). (a) Followup radiographs show progressive decreasing radiolucent line to the point of complete disappearance. Immediate postoperative period. (b) Postoperative 3 months. (c) Postoperative 6 months. (d) Postoperative 3 years

Table 5: Demographs of 5 intraoperative periprosthetic femoral fractures

Age/sex	Treatment	Duration between operations (days)	Preoperative HHS	Last followup HHS
72/female	Wiring	3	56	92
63/female	Conservative		62	94
67/male	Conservative		58	97
71/male	Conservative		43	93
63/male	Wiring	2	38	92

HHS=Harris hip score

33.3%),[18] our finding showed higher visibility (54/102 hips, 53.0%). It may be attributable to using digital radiography in the present study, which can improve the image quality compared to conventional radiographs.[23]

It has been commonly accepted that most of the femurs have at least one or two nutrient artery canal of the femur,[4,14,21] and if two nutrient arteries are present, the distance between upper nutrient artery canal and lower nutrient artery canal are considerable distant.[4] Similarly, our study found that none of the radiographs have more than a single nutrient artery canal.

In our study, nutrient artery canals of the femur were most frequently seen in the cortex on CTL radiographs, whereas they were not seen at all in the cortex on AP radiographs. It may be likely due to several factors. First, the medullary cavity shows more radiolucency than the cortex on plain radiograph, which may decrease the visibility in both AP and CTL radiographs. Second, it has been well known that linea aspera, invariable entrance for nutrient artery canal of the femur, is constantly located in the posterocentral portion of the diaphyseal region.[11] Therefore, nutrient artery canal of the femur in the cortex could not be visible on AP radiographs because it is completely superimposed by the anterior cortex. Finally, sclerotic walls observed in the cortex would increase the visibility for nutrient artery canal.

Several authors reported that nutrient artery canals of the femur always course in upward direction in the cortex.[3,4,11,13,14] Similarly, our study also showed that all nutrient artery canals of the femur in the cortex on CTL radiographs course upward obliquely from posterodistal to anteroproximal direction. This fact supports the suggestion of Johnson *et al*.[16] that nutrient artery canal could be used to discriminate between human and nonhuman bone.

In this study, the distance between the tip of the greater trochanter and the proximal end of the nutrient artery canal was 130.1 ± 15.8 mm in the cortex on CTL radiographs, 105.1 ± 13.4 mm in the medullary cavity on AP radiographs, and 102.5 ± 7.4 mm in the medullary cavity on CTL radiographs. None of the radiographs showed more than a single nutrient artery canal. Considering the length of nutrient artery canal in the medullary cavity (AP radiograph; 23.6 ± 8.8 mm, CTL radiograph; 23.5 ± 6.7 mm), measurements of the distance between the tip of the trochanter and nutrient artery canal clearly showed that the radiolucent lines seen on the AP and CTL radiographs correspond to one and the same nutrient artery canal.

Nutrient artery of the femur is the most apparent blood vessel of the bones[18] and nutrient artery canals are often detected as oblique or longitudinal radiolucent lines on plain radiographs, which may be mistaken as fracture lines, especially by those who are unfamiliar with their appearances and locations.[11,18] CT scan[24] would be helpful facing uncertainty regarding a fracture case. However, CT scans are expensive and expose patients to considerable radiation. Our study showed that compared to fracture lines in periprosthetic femoral fractures, nutrient artery canals (1) are encountered only in the posterior cortex;, (2) show less radiolucency, smaller diameter, traversing with regular widths, and blunt ends in both the cortex and medullary cavity; (3) show sclerotic walls in the cortex; and (4) have less straight course in the medullary cavity. These findings are consistent with the previously established studies.[11,18] This fact, combined with other findings that nutrient artery canals show several topographic features (location, number, and directionality), supports the suggestion that nutrient artery canals of the femur have several morphological and topographic features on plain radiographs to differentiate nutrient artery canal from fracture lines. Moreover, nutrient artery canals were unchanged throughout the postoperative followups [Figure 6], while fracture lines were increasingly less well defined on consecutive follow-ups to the point of complete union [Figure 7].

On postoperative AP radiographs, nutrient artery canal in the medullary cavity was completely hidden by the implant shadowing in 8/17 (47.1%) hips and partially masked by it in 5/17 (29.4%) hips. On postoperative CTL radiographs, nutrient artery canal in the medullary cavity was completely hidden by implant shadowing in 2/5 (40.0%) hips and partially masked by it in 1/5 (20.0%) hips. The length of stems which fully masked the nutrient artery canals in the medullary cavity on postoperative plain radiographs was at least 150 mm or longer. Considering a tendency to increasing use of short stems in THA, masking the effect of implant on the nutrient artery canal in the medullary cavity could be decreased. On postoperative CTL radiographs, by contrast, preoperative visible nutrient artery canal in the cortex was not superimposed by the implants.

We found that there is newly detection of nutrient artery canals postoperatively in 6 hips (5.9%). Newly detected nutrient artery canals on postoperative radiographs may be mistaken for fractures. To ensure comparability, radiographs should always be taken under standard protocol. Moreover, pre and postoperative radiographs with the same length including proximal one-third diaphysis are recommended to assess the THA as well as any abnormalities and their course.

The reported rate of intraoperative periprosthetic femoral fractures in primary cementless THA is between 1% and 5.4%.[19] In cases of undisplaced or minimally displaced Type B fractures,[19] they may be unrecognized at the time of surgery or early postoperative period due to being usually stable under the nonweight-bearing situation.[18] They must be detected because they could be unstable under loading condition, and then maybe subsequently displaced [Figure 1]. Conversely, nutrient artery canals should not be mistaken for fractures [Figure 2] as it may induce a delay in postoperative rehabilitation or make the medico-legal implication.[11,18] In the present study we detected 5 cases (4.9%) intraoperative periprosthetic Type B1 femoral fractures by in comparison with the pre and postoperative radiographs. We treated all of the cases by additional internal fixation or conservative method without subsequent surgery. Our results suggest that differentiating the nutrient artery canals from the fracture lines on plain radiographs can be important for the evaluation in patients with THA to obtain a good clinical outcome.

Conclusions

The current study demonstrated that there are clearly distinguishable differences between nutrient artery canals of the femur and fracture lines in patients with THA on plain radiographs. The knowledge of the morphological and topographic features of nutrient artery canals on plain radiographs may be useful in radiologic evaluation for fracture lines.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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