Prevalence of osteoporosis and preoperative screening using X-ray indices in female patients undergoing total hip arthroplasty

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INTRODUCTION:
Osteoporosis is one of the risk factors leading to complications in patients undergoing total hip arthroplasty (THA), and adequate diagnosis and treatment before and after surgery are important to achieve favorable outcomes. The prevalence of osteoporosis in patients undergoing THA is reported to vary depending on patient background (e.g., older age and low body weight), with rates of up to 23% [1]. Importantly, many patients remain undiagnosed and untreated, indicating the importance of clarifying the prevalence in each patient cohort and establishing a method to effectively screen for osteoporosis.
Usually, osteoporosis is diagnosed through the measurement of bone mineral density (BMD) using dual-energy X-ray absorptiometry (DXA). However, not all patients undergoing THA receive DXA examination due to its cost and restricted accessibility. Consequently, several researchers have attempted to use X-ray indices measured on anteroposterior (AP) hip X-rays for osteoporosis screening, and the effectiveness of some indices (e.g., canal-bone ratio (CBR) and canal-bone area ratio (CBAR)) has shown its clinical utility. However, only limited information has been provided regarding the optimal X-ray indices [2]. Therefore, we aimed to 1) investigate the preoperative prevalence and treatment rate of osteoporosis in patients undergoing THA at our institution, and 2) evaluate and compare the diagnostic performance of X-ray indices in this cohort.

METHODS:
This retrospective study initially included 434 female patients who underwent primary THA at our institution. After excluding 62 patients who had prior hip surgery, fracture, or insufficient data, 372 patients were first analyzed to investigate the prevalence and treatment rate of osteoporosis (Figure 1). The diagnosis of osteoporosis was defined as a T-score ≤ -2.5 in the proximal femoral region (i.e., the femoral neck or total region) of the surgical side measured by DXA (Hologic Horizon). Treatment history was reviewed using each patient's electronic medical records, including prescription records and medical history.
For the analysis of the X-ray indices, diseases that affect BMD and who had already been treated for osteoporosis were excluded. Specifically, 103 patients who had corticosteroid use, and a history of rheumatoid arthritis or osteoporosis, were excluded, leaving 269 female patients (269 hips) to be analyzed (Figure 1). From the preoperative AP hip X-ray image, canal flare index (CFI), morphological cortical index (MCI), CBR, and CBAR at 2 cm, 7 cm, and 10 cm distal to the tip of the lesser trochanter were measured (Figure 2). Then, the diagnostic performance of each index was evaluated using receiver operating characteristic (ROC) curve analysis, and the area under the curve (AUC) values were compared across the indices using the Delong test. All statistical analyses were performed using JMP Pro 17 (SAS Institute Japan, Tokyo, Japan) and MATLAB v9.10 (MathWorks, Natick, MA, USA). Statistical significance was considered at $p < 0.05$.

RESULTS:
Osteoporosis was identified in 104 patients (28.0%), of whom 22 (21.2%) were receiving osteoporosis treatment. The AUC values were highest in the following order: CBAR2–7, CBAR7–10, CBR7, CBR2–10, CBR10, CBR2, CFI and MCI, with values of 0.801, 0.798, 0.798, 0.785, 0.766, 0.740, 0.697 and 0.654, respectively (Figure 3). The diagnostic performance of CFI and MCI was significantly lower than that of all other X-ray indices except for CBR2 (all $p < 0.01$). CBAR2–7 and CBAR2–10 had higher AUCs than CBR2, and CBAR7–10 also had higher AUCs than CBR10 (all $p < 0.01$). No significant differences were observed for other comparisons.

DISCUSSION:
In this study, we investigated the prevalence and treatment rate of osteoporosis in female patients scheduled for THA and compared the diagnostic performance of eight commonly used hip X-ray indices in patients without a prior diagnosis of osteoporosis.
In the analysis, the prevalence of osteoporosis was 28.0%, but only 21.2% of these patients received treatment, supporting the importance of an effective osteoporosis screening tool for such patients. When compared to previous studies, the prevalence was higher, and the treatment rate was lower. These discrepancies may be explained by a previous study that reported the prevalence of osteoporosis in Japan was higher than that in the United States and Europe [3].
When X-ray indices were used to screen for osteoporosis, CFI and MCI showed lower diagnostic performance, whereas CBR (except CBR2) and CBAR showed higher AUCs. These findings were consistent with previous studies that reported AUCs of 0.544–0.800 for CFI and MCI [2,4–6] and AUCs of 0.732–0.821 for CBR and CBAR. When compared across X-ray indices, the diagnostic performance of CBAR was higher than that of CBR2 and CBR10, and the proximity of CBR2 to the lesser trochanter may have contributed to its reduced accuracy. While CBAR tended to enhance screening accuracy, it must be noted that CBR7 showed an AUC comparable to those of CBAR (all AUCs > 0.78), and that measurement of CBAR requires more time and effort than CBR Given its simplicity and ease of measurement, CBR7 may serve as a useful screening index in clinical practice.

SIGNIFICANCE/CLINICAL RELEVANCE:
In the present cohort of female patients undergoing THA, the prevalence of osteoporosis and treatment rate were 28.0% and 21.2%, respectively. In patients without a history of osteoporosis, CBR7 demonstrated diagnostic performance for osteoporosis comparable to that of CBAR, suggesting its potential utility as a simple screening tool for osteoporosis.

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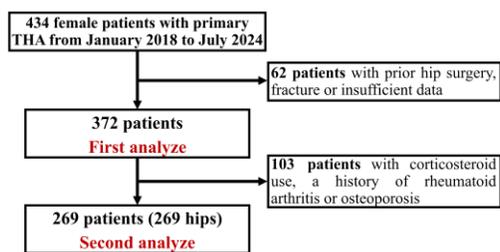
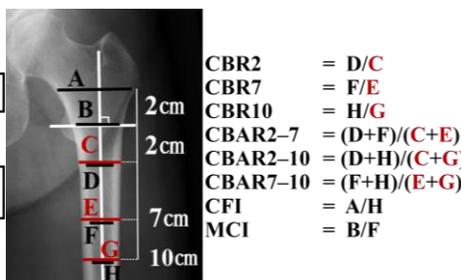**Figure 1.** The flowchart of patient selection.

Figure 2. Parameters measured from an anteroposterior hip X-ray.

CBR2 = D/C
CBR7 = F/E
CBR10 = H/G
CBAR2–7 = (D+F)/(C+E)
CBAR2–10 = (D+H)/(C+G)
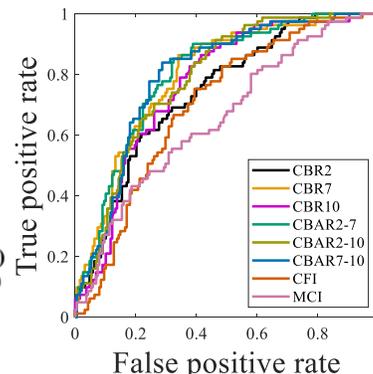CBAR7–10 = (F+H)/(E+G)
CFI = A/H
MCI = B/F

Figure 3. The ROC curves of eight X-ray indices for osteoporosis screening.