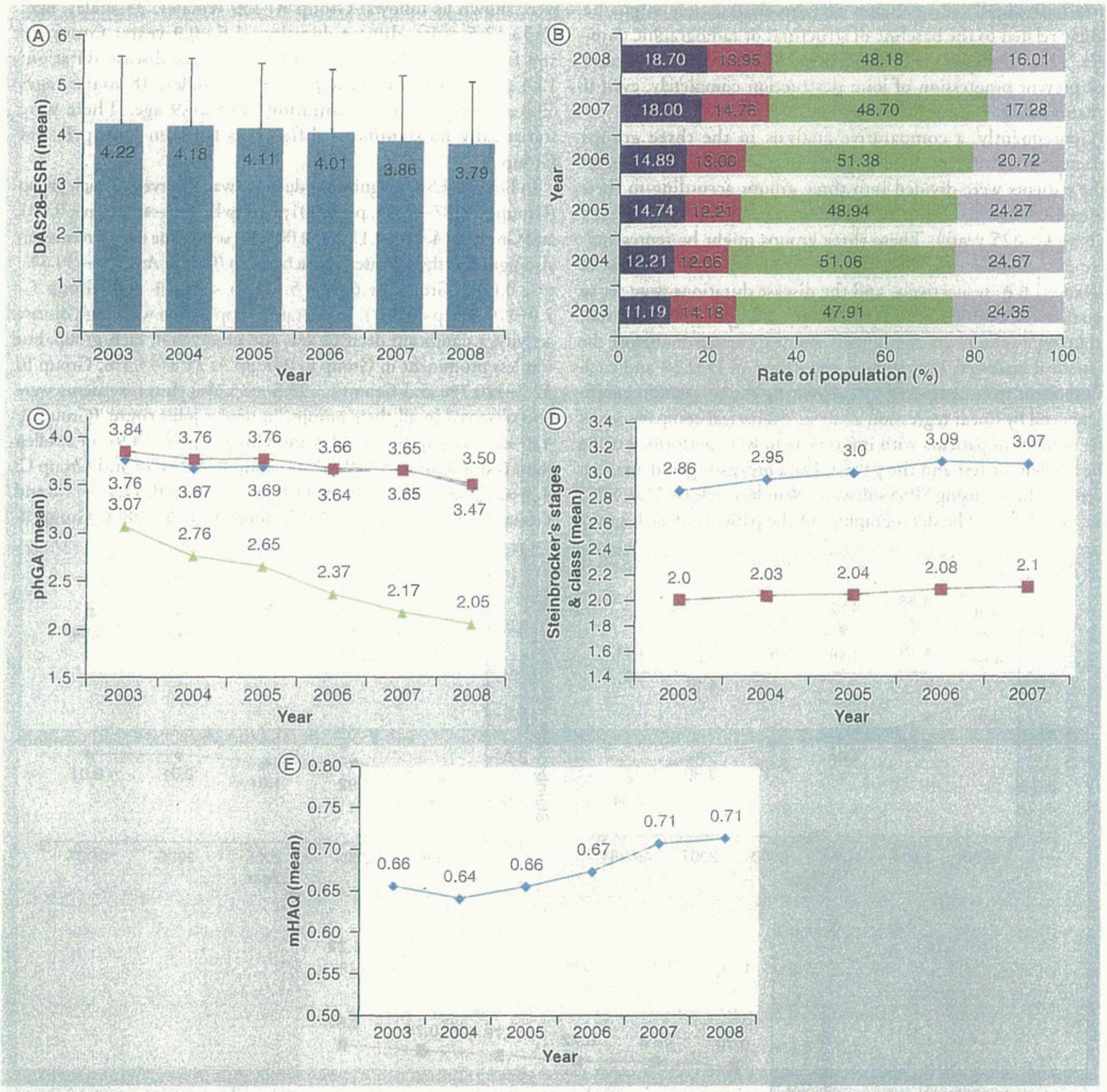

Figure 5. Changes in outcomes by longitudinal analysis from the National Database of Rheumatic Diseases by iR-net in Japan. (A) Disease activity score 28-erythrocyte sedimentation rate (mean), **(B)** disease activity score 28-erythrocyte sedimentation rate, **(C)** physician's global assessment value by visual analog scale indicated by green, patient's global assessment value by visual analog scale indicated by blue, patient's pain assessment value by visual analog scale indicated by red, **(D)** stages (indicated by blue) and class (indicated by red) according to Steinbrocker's criteria and **(E)** modified health assessment questionnaire. The rate of missing data was less than 5% in each year. The data were not analyzed by using last observation carried forward method. The missing data were omitted.
DAS: Disease activity score; mHAQ: Modified health assessment questionnaire; phGA: Physician's global assessment value.

that of cross-sectional analysis; however, both radiographic and functional stages in Steinbrocker's criteria and mHAQ showed a gradual progression. Thus, there is a dissociation between the results of cross-sectional analysis and those of longitudinal analysis regarding structural and functional aspects. In Figure 4E, the result was obtained from a cross-sectional analysis. So, it is possible that the later registered patients might be less sick functionally and the population of the less sick patients might be increasing in the whole RA patients. However, in Figure 5E, the result was obtained from longitudinal analysis and the data were compared intra-individually. Progression of joint destruction might be closely related to the baseline of structural or radiographic damages. Thus, aggressive treatments using MTX or biologics could not prevent progression of joint destruction completely, even if inflammation is controlled completely.

Consequently, a comparative analysis in the three groups selected with different disease duration was carried out (Figure 6). The patients were divided into three groups according to their disease duration (Group A: ≤3 years, Group B: 10–15 years, Group C: ≥25 years). These three groups might be representative of as that of early RA, that of established RA and that of advanced RA, respectively, and the disease durations were set to equalize the number of the patients in each group. In addition, grouping was done unintentionally and was carried out before the statistical analyses. In statistics, the values of DAS28 and each component were compared by calculating the correlation coefficients and by linear regression analysis. Statistical comparisons of the number of patients with improvement were performed using the Student's t-test and the χ^2 test. Data processing and analyses were conducted using SPSS software (Windows release 11.0; SPSS Inc., IL, USA). The demographics of the patients of each group were shown as follows: Group A: 139 females, 35 males, age: 57.3 ± 12.6 years, disease duration: 1.6 ± 0.9 years; Group B: 189 females, 28 males, age: 59.1 ± 11.3 years, disease duration: 12.4 ± 1.5 years; and Group C: 167 females, 18 males, age: 63.3 ± 9.0 years, disease duration: 33.4 ± 6.9 age. There were statistically no significant differences between Group B and Group A.

In DAS28-ESR, a significant decrease was observed in each group (Group A: 3.87→3.04, $p < 0.001$; Group B: 4.46→4.06, $p < 0.001$ and Group C: 4.43→4.11, $p < 0.001$; Figure 6A). The rate of remission also significantly increased in each group (Group A: 19.0→39.6%, $p < 0.001$; Group B: 6.5→15.5%, $p < 0.001$ and Group C: 7.0→10.2%, $p < 0.001$). In the rate of population with high disease activity, a significant decrease was also observed in each group, but was less prominent in Group C (Group A: 21.8→5.5%, Group B: 32.7→20.7% and Group C: 28.3→23.3%). Improvements were also observed in all three groups, in tender joint count (Group A: 4.8→2.1, Group B: 6.1→4.4 and Group C: 6.3→4.9), in swollen joint count (Group A: 3.0→1.4, Group B: 4.8→3.4 and Group C: 4.3→2.7), in CRP (Group A: 11.8→6.0, Group B: 17.4→11.8 and Group C: 15.6→9.0), in ESR (Group A: 37.5→28.4, Group B:

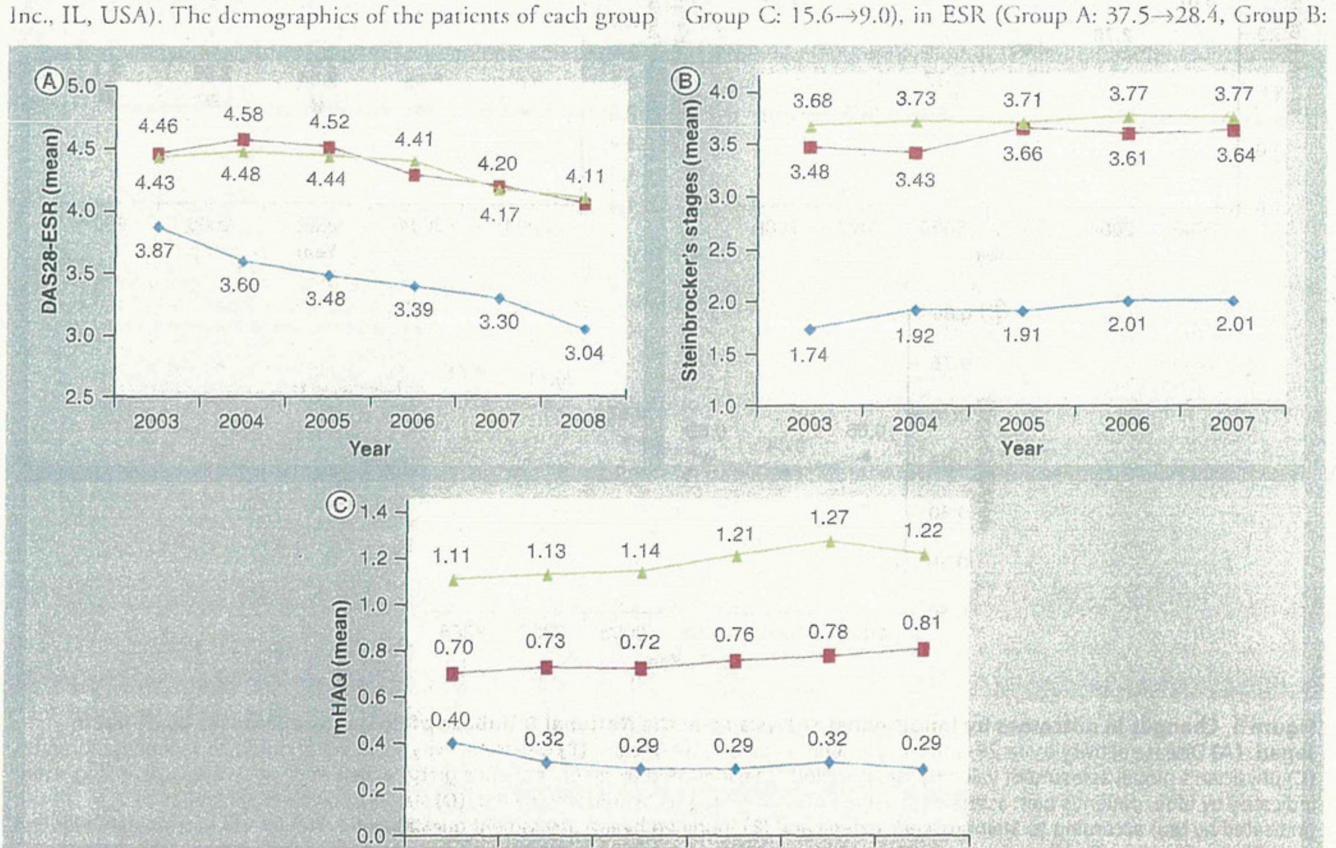

Figure 6. Changes of outcomes by comparative analysis in three subgroups with different disease duration. (A) Disease activity score 28-erythrocyte sedimentation rate, **(B)** stage of disease according to Steinbrocker's criteria and **(C)** modified health assessment questionnaire. Group A: disease duration ≤3 years indicated by blue, Group B: disease duration 10–15 years indicated by red and Group C: disease duration ≥25 years indicated by green. The rate of missing data was less than 5% in each year.
DAS: Disease activity score; mHAQ: Modified health assessment questionnaire.

46.0→37.6 and Group C: 44.4→37.9) and in physician's global assessment value (Group A: 2.4→1.3, Group B: 3.4→2.4 and Group C: 3.8→2.6). However, significant improvements were also observed in Group A and B but not in C; in patient's pain assessment value, Group A: 3.1→2.1, Group B: 4.2→3.7 and Group C: 4.4→4.3 and in patient's global assessment value, Group A: 3.1→2.3, Group B: 4.3→3.8 and Group C: 4.5→4.5).

Regarding radiographic stages indicated by Steinbrocker's stages (mean) (Figure 6B), some progression was observed in each group (Group A: 1.74→2.01, Group B: 3.48→3.64 and Group C: 3.68→3.77). The rate of patients at Stage I was reduced from 43.7 to 32.7% even in Group A. A significant functional improvement indicated by mHAQ (Figure 6C) was observed only in Group A (0.40→0.29), but not in Group B (0.70→0.81) and Group C (1.11→1.22).

In the results of the longitudinal analysis, it was revealed that both disability and joint destruction became worse, despite the reduction of disease activity. Although the method of radiographical assessment using the Steinbrocker's criteria was crude, this suggested that the treatment of RA during this decade in Japan was not enough to prevent progression of the disease completely. Despite the progression in stages of the disease, some functional improvement indicated by mHAQ was observed only in Group A. The degree of joint destruction at the time of registration in Group A (<Stage II: 85.1%) was significantly milder than in other groups (Group B: <Stage II 49.7% and Group C: <Stage II 8.6%). Baseline joint destruction might affect subsequent progression of disability, suggesting the importance of earlier therapeutic intervention and tight control.

Safety

In the NinJa, the data of incidence of hospital admission and causes of death have been collected annually (Box 1). By viewing the data, the changes of safety issues were summarized. In 2010, 69 of the total enrolled patients (7,254 patients) were dead. They included 24 males and 45 females. The mean age and disease duration were 73 ± 9.9 and 18.9 ± 13.4 years, respectively. The leading causes of death were infections, malignancies and cardiovascular diseases. The main cause of death was infection and the number of the patients that succumbed to this was 24 out of 69. In particular, pneumonia, including two cases of *Pneumocystis carinii* pneumonia, constituted 24.6%. Malignancies constituted 18 cases, including four lung cancers and three colon cancers. In addition, four cases of interstitial pneumonia were reported. Overall, the mean age of the deceased patients and the proportion of both infections and malignancies tended to be increased.

Expert commentary & five-year view

In drug therapy, the use of MTX has increased consistently, and as such it has established a place as an anchor drug in the treatment of RA among nonbiologic DMARDs, although the dosage is still significantly less compared with that of western countries. In 2011, MTX was approved for use as a first-line drug and its upper dosage has also been officially raised to 16 mg/week in Japan. Therefore, MTX may continue to keep a place as an anchor drug among nonbiologic DMARDs, and both the use-rate and dosage will increase for some time before the advent of another drug that could replace the role of MTX.

TAC is characteristically unique compared with other DMARDs, and therefore, it may be stably used as a concomitant drug with other nonbiologic DMARDs (especially MTX), or biologics.

In biologics, the rate of their use in Japan has become close to that seen in western countries. In fact, almost 20% of the patients with RA in Japan have been administered biologics to date. In addition, various types of new biologics with different therapeutic targets have been recently emerging [2]. Thus, treatment options in biologics will be extended greatly. However, because of some disadvantages, especially its high costs and serious adverse effects, such as severe infections, considerable care is needed when judging the indications. The use-rate of patients who are administered with biologics may reach a peak in the near future. In support of this, in recent years, the increase of the use-rate of biologics has begun to plateau. In fact, the economic burden due to a rapid increase of biologics use has already become one of the vexing problems in Japan.

However, with the growing number of biologics available for the treatment of RA, clinicians have faced difficult decisions concerning the choice of the most optimal biologic. Recently, intense investigations have been performed to seek the predictors for efficacy or adverse effects [33]. If found, these will enable clinicians to easily choose an optimal antirheumatic drug and to avoid its adverse effects. It may also be useful in the realization of personalized therapy for RA [34].

Recent data from large-scale clinical trials have emphasized the importance of both early therapeutic interventions and tight controls in the treatment of RA [35–37]. Both early intervention and tight control have been practiced in Japan and western countries. In the near future, these trends may become more apparent. Therefore, the indication for biologics may be expanded to the cohort of patients with short disease duration. In these situations, the possibility of drug-free remission, especially concerning biologics, should be considered. In addition, recent clinical trials have shown an excellent efficacy of some new oral drugs [38–40]. In particular, janus kinase inhibitors have received much attention, and they will probably be filed for new oral agents in the treatment of RA shortly [39]. If approved, these agents may have the potential to change the map of DMARDs, including biologics.

In another aspect, the rate of elderly persons has been rapidly increasing in Japan preceding that of any other countries. Elderly RA patients may have more age-related complications. In addition, their physiological functions, such as immunity, decrease evidently. Therefore, the treatment of RA in elderly patients is of special interest and needs extreme care [41].

In surgical treatment, as described, the number of joint surgeries related to RA has decreased due to recent rapid advances of drug therapy. In the near future, this trend may continue. Further advances in drug therapy and management could reduce the severity of bone-joint destruction directly related to RA. This may accelerate the decrease in joint surgery numbers related to RA, especially joint replacements. The increase in the number of elderly patients will increase surgical operations related to aging. In addition, surgical treatments for the purpose of functional or cosmetic improvements may increase.

Further advances in RA treatment and strategy, including earlier diagnosis, earlier therapeutic intervention and realization of tight disease control, could undoubtedly improve outcomes. Remission could be expected as a realistic therapeutic goal in the near future.

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Key issues

- Recent changes in both treatments and outcomes of rheumatoid arthritis (RA) in Japan were analyzed by viewing the 'National Database of Rheumatic Diseases by iR-net in Japan' registry, one of the largest clinical databases for RA patients.
- There were two main changes in drug therapy during the past decade. First, the use of methotrexate has increased consistently and it has now established a place as an anchor drug. Second, the use of biologics has become popular in Japan, as well as in western countries.
- The changes in drug therapy have enabled us to control RA disease activity more tightly and have brought marked improvement both clinically and functionally.
- Overall rates of joint operations related to RA, especially joint replacement and synovectomy, have shown a significant decrease continuously in the past decade.

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BASIC RESEARCH

Anatomic Mapping of Short External Rotators Shows the Limit of Their Preservation During Total Hip Arthroplasty

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Abstract

Background The direct anterior approach in THA requires no detachment of muscle insertions. However, damage to the short external rotator muscles may occur when attempting to elevate the femur for exposure. Although the anatomic insertions of these muscles are approximately known, there are no quantitative data regarding their locations.

Questions/purposes We therefore asked where and how the tendons attach to the inner aspect of the greater trochanter.

Methods In 20 cadaveric hips we identified the attachments of the short external rotator tendons on the medial aspect of the greater trochanter. Mapping of the attachment site was performed by defining coordinate axes; the total width and height of the greater trochanter represented 100% and distances of the attachment from the anteroinferior reference point were given.

Results The mean anterior border location of the conjoined tendon (obturator internus, gemellus superior, and gemellus inferior) attachment was located at 29% (13 mm from the anteroinferior reference point), its posterior border at 53% (23 mm), its mean superior border at 70% (15 mm), and its mean inferior border at 24% (5 mm). The mean anterior border of the piriformis tendon attachment was located at 57% (25 mm), its mean posterior border at 78% (34 mm), its mean superior border at 64% (17 mm), and its inferior border at 55% (12 mm). There was considerable variation in these attachment sites among individuals.

Conclusions The insertion of the conjoined tendon extends to the anterosuperior aspect of the greater trochanter. Together with the considerable variation of the attachment site, external rotator muscles remain at risk of being damaged during the capsular release.

Each author certifies that he or she, or a member of their immediate family, has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.
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Each author certifies that his or her institution either has waived or does not require approval for the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

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Introduction

Minimally invasive THA (MIS-THA) that minimizes soft tissue dissection reportedly reduces blood loss [3], does not increase complication rates [3, 6, 13], and improves early walking ability compared with conventional THA [3, 4]. Among the MIS-THA methods, the direct anterior approach (DAA) was modified from the Smith-Petersen approach and has become one of the standard procedures for primary THA [5, 13]. The DAA, which uses an intermuscular plane among the sartorius, rectus femoris, and tensor fasciae latae, does not dissect muscles around the hip and conserves the posterior tissue to a large extent, leading to improved stability and a reduced postoperative dislocation rate [6, 8, 11–13]. As a consequence, reduction of the dislocation rate and early postoperative functional recovery can be expected [10].

When performing DAA, detachment of the joint capsule at appropriate sites is indispensable to obtain a clearer visual field during surgery [8, 11]. However, despite careful capsular release and rasping, damage to muscles may occur [9], possibly eliminating one of the advantages of the approach. Furthermore, because of the limited surgical visual field in MIS-THA, there is a risk of prolonged operation time, unexpected soft tissue injury, unfavorable implant placement position, and fracture [1]. Anterior elevation of the proximal femur for a clearer visual field and femoral rasping may minimize these complications, and releasing of the posterolateral capsule or superior capsule has been advocated [7, 11]. However, such capsular dissection and femoral rasping may pose a risk of damaging the short external rotators. Therefore it is essential for surgeons to have detailed anatomic knowledge of the muscle attachment sites to minimize soft tissue damage during the anterior approach. Although the anatomy of the short external rotator muscles is approximately known [15], there is no detailed quantitative information regarding the location of their tendon insertions.

We therefore asked where and how the tendons attach to the inner aspect of the greater trochanter on defined horizontal and vertical axes.

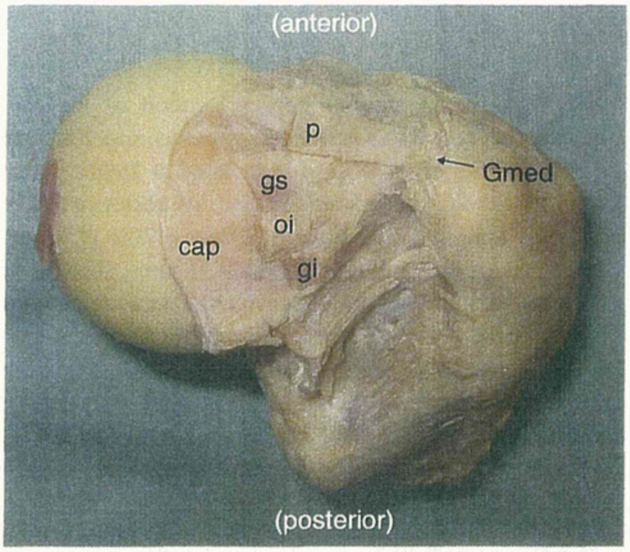

Fig. 1 A posterosuperior view of the cadaveric dissection of the right hip shows the short external rotator muscles. p = piriformis; gs = gemellus superior; oi = obturator internus; gi = gemellus inferior; Gmed = gluteus medius; cap = capsule.

Materials and Methods

We obtained 20 hips (11 right hips and nine left hips) from 16 embalmed cadavers (11 males and five females) donated for medical education and research. The cadaver specimens had a mean age of 84 years (range, 61–100 years) at the time of death and had no history of hip disease. Details of the antemortem weight and mobility status were not available, but the estimated height was 168 ± 8 cm for the male and 149 ± 6 cm for the female cadavers. Measured collodiaphyseal angle and neck anteversion were 126.0° ± 6.0° and 12.3° ± 5.1°, respectively. We removed the skin, fat, and soft tissues until only the gluteus medius, gluteus minimus, piriformis, obturator internus, obturator externus, gemellus superior, gemellus inferior, and capsular structures remained. After arthrotomy around the acetabular rim, the femur was disarticulated and the muscles were dissected so as to leave sufficient structures at the femoral insertion (Fig. 1). We then dissected the gluteus medius, obturator internus, gemellus superior, gemellus inferior, obturator externus, and remaining capsule with special attention to the connection between the tendons (Fig. 2A). When the tendons were integrated close to the insertion sites, the tendons were identified and separated

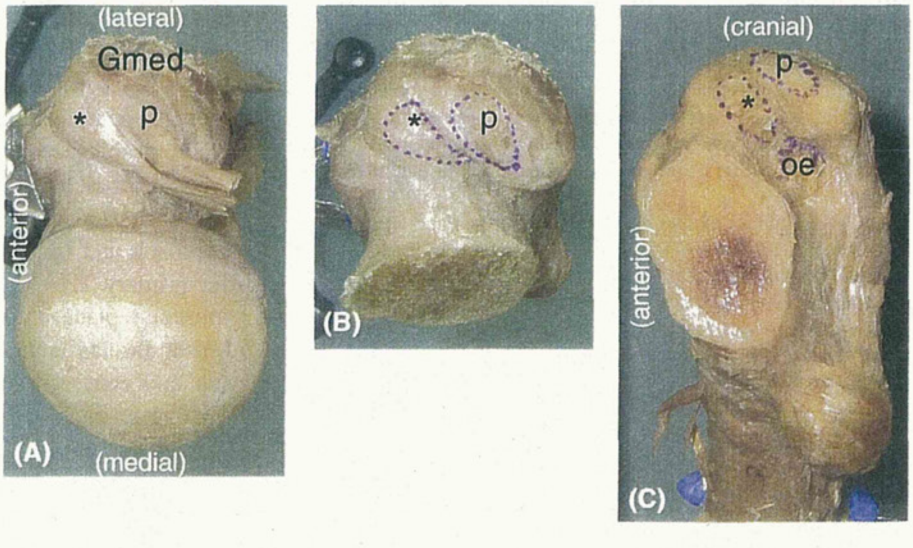

Fig. 2A–C The attachment site of the short external rotator muscles indicates their relative localization. (**A**) A superior view, (**B**) superior view and footprint of the tendon insertion, and (**C**) mediolateral view and footprint of the tendon insertion are shown. *Conjoined tendon of the gemellus superior, obturator internus, and gemellus inferior; p = piriformis; oe = obturator externus; Gmed = gluteus medius.

bluntly based on their fiber orientation down to the attachment on the greater trochanter or trochanteric fossa. Subsequently, we partially cut the tendons with scissors to identify their footprints at the insertion and their peripheries were carefully marked with a pen. Osteotomy of the femoral neck at the saddle then was done (Fig. 2B-C).

We measured the major and minor axes of the elliptical or scaphoid-shaped footprint of the tendon attachment using calipers. We then took high-resolution scaled digital photographs of each dissected specimen in a mediolateral direction from 50 cm away at a right angle to the femoral shaft. We determined eight points (anterior, posterior, superior, inferior, and midpoints between each of them) on the contour of the attachment footprint and recorded them using Adobe Photoshop CS2 software (Adobe Systems Inc, San Jose, CA, USA). In the mediolateral view of the femur, the proximal shaft axis was defined as the proximal femoral axis (Fig. 3A). At the level of the femoral neck saddle, an axis perpendicular to the proximal femoral axis was defined as the X-axis (AP axis). We defined an axis at the anterior border of the greater trochanter on the saddle level, parallel to the proximal femoral axis, as the Y-axis (vertical axis) (Fig. 3B). Their intersection was defined as 0. For mapping of the tendon attachment, the AP position was expressed in percentages with the anterior border as 0% and the posterior border as 100%. The vertical position of the tendon attachment was expressed with the saddle height as 0% and the vertex of the greater trochanter as 100% (Fig. 3B). The distance of each border in millimeters from the 0 reference point also was measured and the value was standardized with the mean width and height of the greater trochanter of the cadavers.

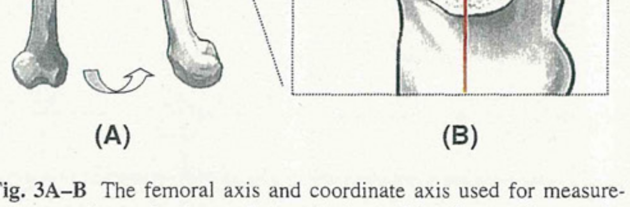

Fig. 3A–B The femoral axis and coordinate axis used for measurement are shown. In the mediolateral view of the femur, the anterior border of the greater trochanter parallel to the proximal femoral axis was defined as the Y-axis and its perpendicular axis at the saddle level was defined as the X-axis. (**A**) An AP view of the right femur is shown on the left and a mediolateral view is shown on the right. (**B**) The coordinate axis for measurement of tendon attachment is shown.

We used Spearman's rank correlation to identify relationships among the anterior border of the tendon attachment site, neck anteversion angle, and the width and height of the greater trochanter.

Results

Three muscles of the short external rotators, obturator internus, gemellus superior, and gemellus inferior, formed a conjoined tendon and attached anteriorly of the medial aspect of the greater trochanter. On the coordinate axes, the anterior border of the conjoined tendon attachment site ranged from 19% (9 mm) to 43% (23 mm), the posterior border ranged from 39% (18 mm) to 60% (30 mm), the superior border ranged from 48% (8 mm) to 86% (21 mm), and the inferior border ranged from 4% (1 mm) to 40% (9 mm) (Table 1). The footprint of the conjoined tendon insertion was elliptical or scaphoid-shaped with a mean size of 12.8 (± 2.5) mm × 4.3 (± 1.2) mm. As shown in the superimposed drawing of the attachment site of each specimen (Fig. 4A), there was variation in the position of the conjoined tendon attachment in the horizontal and vertical directions. The attachment site of the piriformis was posterosuperior to that of the conjoined tendon. On the coordinate axes, the anterior border of the piriformis attachment site ranged from 42% (16 mm) to 77% (36 mm), the posterior border ranged from 59% (23 mm) to 97% (46 mm), the superior border ranged from 65% (10 mm) to 99% (24 mm), and the inferior border ranged from 34% (7 mm) to 79% (17 mm) (Table 1). The size of the attachment footprint was 10.3 (± 1.6) mm × 4.7 (± 1.1) mm and the superimposed attachment sites indicated the degree of their variation (Fig. 4B). The obturator externus attached independently to a fossa located posteroinferior to the other short external rotator muscles (Fig. 4C). Its

Table 1. Mapping of attachment sites

Tendon	Attachment border		Mean ± SD (range) (%)
Conjoined tendon*	X axis	Anterior	29.1 ± 6.4 (18.8–43.2)
		Posterior	52.8 ± 5.1 (38.9–59.9)
	Y axis	Superior	70.2 ± 8.4 (48.1–85.7)
		Inferior	24.3 ± 10.1 (3.8–40.2)
Piriformis	X axis	Anterior	57.4 ± 10.2 (42.1–76.9)
		Posterior	78.4 ± 11.9 (59.4–97.3)
	Y axis	Superior	64.3 ± 9.4 (64.9–98.5)
		Inferior	55.1 ± 11.3 (34.3–74.8)
Obturator externus	X axis	Anterior	61.3 ± 6.5 (48.6–70.1)
		Posterior	75.9 ± 5.8 (65.6–83.0)
	Y axis	Superior	10.6 ± 12.7 (−19.0–33.3)
		Inferior	−18.7 ± 18.6 (−59.0–6.3)

* Obturator internus, gemellus superior, and gemellus inferior.

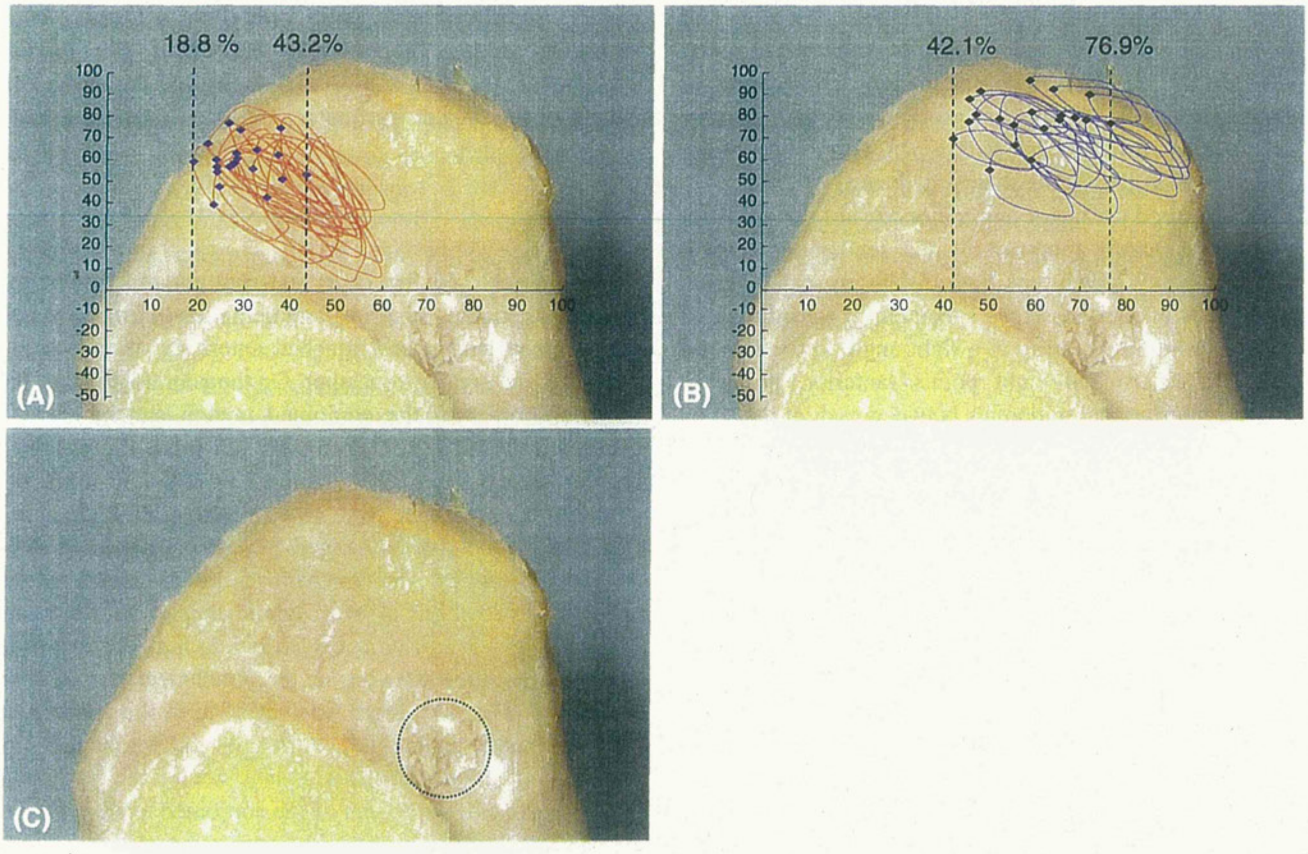

Fig. 4A–C Superimposed footprints of the attachment of the short external rotator muscles on the inner aspect of the greater trochanter are shown. (**A**) The attachment of the conjoined tendon (obturator internus, gemellus superior, and gemellus inferior) for 20 hips is shown. The plot highlights the most anterior part of the attachment in each specimen to show its variation of 18.8% to 43.2% from the anterior border of the greater trochanter. (**B**) The attachment of the piriformis for 20 hips is shown. The plot highlights the most anterior part of the attachment in each specimen. (**C**) The dotted line indicates the attachment site of the obturator externus to a fossa.

attachment site was relatively constant; on the coordinate axes, the anterior border ranged from 49% (20 mm) to 70% (34 mm), the posterior border ranged from 66% (23 mm) to 83% (39 mm), the superior border ranged from −19% (−2 mm) to 33% (7 mm), and the inferior border ranged from −59% (−7 mm) to 6% (1 mm) (Table 1).

No significant correlation was found between the anterior border (X value) of the conjoined tendon attachment and neck anteversion angle ($p = 0.12$), the width of the greater trochanter ($p = 0.25$), or the height of the greater trochanter ($p = 0.82$). In addition, the anterior border (X value) of the piriformis attachment did not show significant correlation with neck anteversion angles ($p = 0.73$), the width of the greater trochanter ($p = 0.74$), or the height of the greater trochanter ($p = 0.36$).

Discussion

Detailed knowledge of the anatomy of tendon attachment is a prerequisite for less invasive THA and attempts should be made to preserve soft tissue, including the short external rotator muscles. MIS-THA using an intermuscular approach has been reported [2, 13]. However, unless capsular dissection and femoral rasping are performed carefully, the short external rotators might be injured. It therefore is important to have improved knowledge of the anatomic positions of the tendon attachment sites.

Readers should know the limitations of our study. First, our study was limited by sample size as a result of the difficulty in obtaining a large number of embalmed cadavers. Second, we did not have detailed information regarding body size and could not correlate quantitative anatomy with body size. However, the position of the tendon attachment site, when shown as a relative value on the coordinate axes, apparently was not influenced by skeletal size difference. Third, with a smaller sample size of female and bilateral hip cadavers, our study was underpowered to analyze possible gender differences or intraspecimen variance. Additional study is needed to investigate such variance, if any. Fourth, the study is limited to the measurement of morphologic hip features in

Japanese subjects. It is possible that ethnic difference in bony geometry may be associated with variation of the tendon attachment. However, we believe these quantitative data supplement what generally is known about the locations of the short external rotator muscle attachments.

The general gross anatomy and approximate insertion of the short external rotator muscles to the greater trochanter have been approximately known, but detailed quantitative locations of the attachment sites are not known. Standard anatomy textbooks only indicate the insertion to be the upper medial side of the greater trochanter [15] and do not provide specific information regarding the attachment site. Windisch et al. [17] provided details regarding the anatomy of the musculotendinous junction and fusion of short external rotator muscles. Solomon et al. [14] reported that the piriformis inserted onto the greater trochanter through a conjoint tendon with the obturator internus. Nevertheless, the location of the attachment of each tendon on the inner aspect of the greater trochanter still remained obscure. Our observations show the accurate location of the greater trochanteric attachments of the short external rotator muscles (a conjoined tendon, piriformis, and obturator externus) and their positional relation for the first time.

We found both attachment sites of the conjoined tendon and piriformis were considerably more variable among individuals than had been thought. Based on the mapping data, the conjoined tendon of the short external rotators may attach as anteriorly as 19% (or 9 mm from the anteroinferior reference point) of the horizontal width of the greater trochanter and as low as 4% (1 mm) of the medical height of the greater trochanter from the saddle in certain individuals. These observations suggest preservation of the short external rotator muscles may not always be possible during capsular release in the DAA. The piriformis also can be damaged depending on its attachment variation during capsular release or femoral rasping. This is consistent with the study of Meneghini et al. [9] that showed the need for transection of the piriformis or the conjoined tendon of the obturator internus and gemelli in 50% of the cases during the anterior Smith-Petersen approach.

Thus, the short external rotators, especially the conjoined tendon, are at a high risk of being damaged and their detachment might be inevitable during the superior and/or posterior capsular release that is necessary to mobilize the femur during DAA in certain cases. The importance of preservation of the short external rotators for postoperative hip stability has been documented for other approaches such as the posterior approach [16]. The question remains whether a partial release of the short external rotator muscle during DAA would affect the postoperative stability of the hip. In addition, further study is needed to see the potential influence of morphologic features of a diseased hip, such as coxa vara and valga, on alteration of anatomic tendon attachment.

We report the quantitative locations of the anatomic attachment of the short external rotators of the hip. We showed that the tendons are at a risk of being damaged during capsular release. Improved anatomic knowledge of the short external rotators will assist surgeons in accurately locating these structures.

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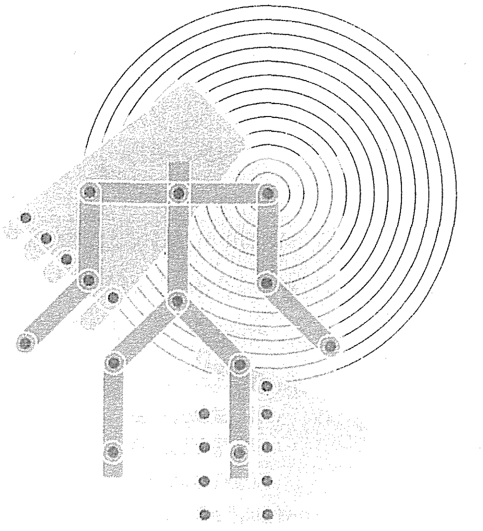
手術療法の実際
各関節における手術



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メトトレキサート（MTX）と生物学的製剤の出現により，関節リウマチ（以下RA）の薬物療法はいちじるしく進歩しましたが，外科的治療がRA患者の日常生活動作（ADL）と生活の質（QOL）を維持するために重要な治療法であることに変わりはありません。

RAに対する手術は，関節の破壊の程度や関節の部位により多岐にわたります。おもな手術法は滑膜切除術，関節形成術，人工関節置換術，関節固定術ですが，薬物療法の進歩により滑膜切除術の頻度は減少しつつあります。一方薬物療法が進歩したとはいえ，関節破壊の進んだ症例に対しては，薬物療法のみでは関節症状やADLを改善させることが困難なことが多く，人工関節を含んだ関節形成術が有用です。

本稿では，四肢の各関節に対する手術方法について，治療ガイドライン[1)2)]をふまえて概説します。

RA関節のX線画像評価

手術のタイミングや術式の選択には，関節のX線写真において関節破壊の程度を6段階に分類したLarsen分類（表1）[3)]が有用であり，判定に際してはstandard filmを参照しながら行うとよいでしょう。一般的にLarsen分類のグレード0～IIで関節破壊がないか，あっても軽度の場合は，滑膜切除術が選択されることが多く，関節破壊の進行したグレードIII～Vでは人工関節を含んだ関節形成術が選択されています。

手関節

保存的治療にもかかわらず疼痛が6カ月以上持続し，前腕の回内外制限を有する場合は

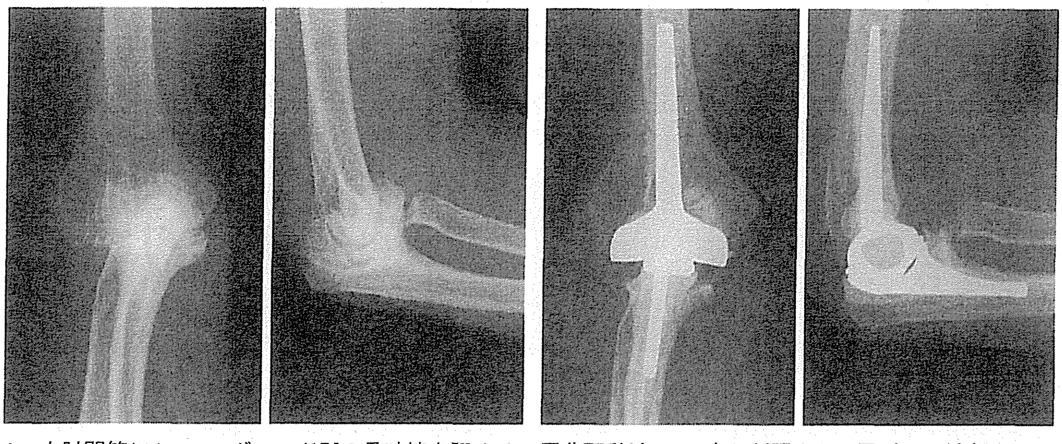
表1　X線像のLarsen分類

グレード0	正　常	変化があっても関節炎とは関係ないもの
グレードI	軽度の異常	関節周囲の軟部腫脹，関節周囲のosteoporosis，軽度の関節裂隙狭小化のうち一つが存在する
グレードII	初期変化	びらんと関節裂隙狭小化。びらんは非荷重関節では必須
グレードIII	中等度の破壊	びらんと関節裂隙狭小化。びらんはすべての関節で必須
グレードIV	高度の破壊	びらんと関節裂隙狭小化。荷重関節では骨変形
グレードV	ムチランス変形	関節端が原型をとどめないもの

〔文献3より引用，一部改変〕

図1　人工肘関節置換術（60歳，女性）

A．術　前　　　　B．術　後



A：右肘関節に Larsen グレードⅣの骨破壊を認める。屈曲可動域は70度と制限され，両手での洗顔はできなかった

B：屈曲可動域は120度に改善し，顔に手が届くようになった

手術の適応となります[1)]。疼痛がいちじるしくない場合は，手関節固定装具などを使用して経過をみてもよいですが，手関節の炎症が長期に及ぶと伸筋腱の断裂を合併するので注意を要します。断裂した状態を放置しないように，外来では手指の自動伸展を確認することを勧めます。

手術方法としては，手関節形成術（滑膜切除術と併用）と手関節固定術が行われます。手関節形成術には尺骨遠位端を切除する Darrach 法があります。術後の橈骨手根関節に不安定性を危惧される場合は，尺骨遠位端を温存し，橈骨の尺側に棚を形成する Sauve-Kapandji 法や橈骨月状骨間を固定する部分固定術が有用です。手関節破壊が高度で亜脱臼・脱臼をともなっている場合は，手関節固定術の適応です。

指関節

MCP 関節，PIP 関節に滑膜炎が持続する場合で，Larsen 分類グレード 0～II の関節に対しては滑膜切除術が行われますが，その有効性には疑問も多いです。グレードIIIまたはIVの MCP 関節に対しては Swanson インプラントなどを用いた人工関節置換術が行われます。除痛と変形矯正が得られることから患者の満足度も高いですが，術後の屈曲不良，インプラントの沈み込み，折損などの問題があります。

母指ダックネック変形は頻度の高い変形で，つまみ動作が困難な場合には MCP 関節または IP 関節の固定術が行われます。

手指の関節は，外見上の変形や X 線の骨破壊が高度であっても，日常生活では大きな障害なく手指を使用していることが多いです。手術適応は ADL の評価を十分に行ったうえで慎重になされるべきです。

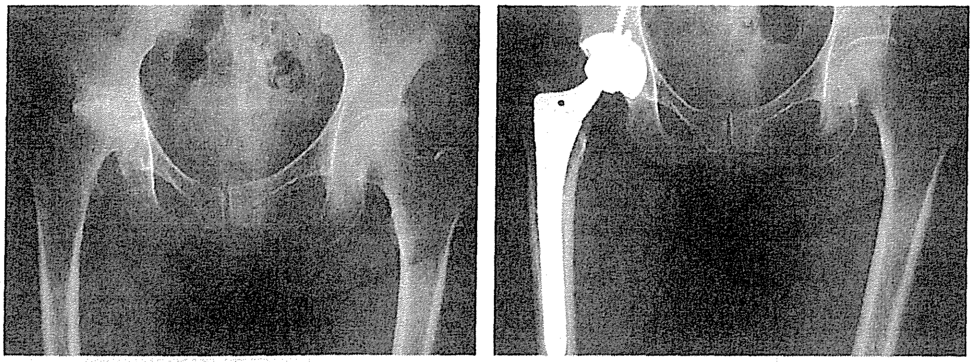
肘関節

6カ月以上つづく耐えがたい肘関節痛と可動域制限による ADL 障害を認める場合は，外科的治療が選択されます[1)]。

手術療法としては Larsen 分類グレード 0 から破壊がやや進行したグレードIIIまでが滑膜切除術の適応となります。滑膜切除術の成績は比較的安定しており，術後の除痛は十分期待できます。橈骨頭の関節軟骨が残存し，回内外制限が軽度な場合は橈骨頭を温存し，

図２　人工股関節置換術（61歳，女性）

A. 術　前　　B. 術　後



A：右股関節にLarsenグレードⅣの骨破壊を認め，歩行困難であった
B：右股関節の疼痛は消失し，歩行障害は改善した

滑膜切除を行いますが，橈骨頭の骨びらんがいちじるしく回内外制限がある場合は，切除したほうがよいでしょう。

グレードⅢ～Ⅴの肘関節で屈曲可動域が制限されている場合は，人工肘関節置換術[4]（図１）の適応となります。術後除痛と可動域の改善が期待できますが，伸展制限は残存します。

肩関節

保存的治療に抗して６カ月以上つづく耐えがたい自発痛，運動時痛があるときには外科的治療が選択されます[1]。方法としては，滑膜切除術と人工骨頭置換術（または人工肩関節置換術）が行われます。

滑膜増殖が高度で，関節破壊がLarsen分類グレード０～Ⅱの軽度の場合，滑膜切除術が行われます。完全に滑膜を取り除くことはむずかしく，短期成績は悪くないですが，術後の関節破壊の進行を予防する効果は乏しいです。

グレードⅢ以上の肩関節に対しては，人工骨頭置換術または人工関節置換術が適応となります。十分な除痛は得られますが，グレードⅢ以上の場合，腱板損傷を合併することが多く，挙上機能の改善は得られにくいと考えられます。術後コンポーネントのゆるみ，移動などの問題も無視できません。

股関節

RAにおいて股関節は，いったん破壊が生じると強い疼痛のため歩行障害が生じます。X線画像上で関節裂隙が消失した場合，疼痛による歩行障害は，保存的治療では軽快することは期待できません。手術方法としては人工股関節置換術（THA；図２）がよい適応です[2]。RA股では，手術のタイミングが遅れると手術操作ばかりでなく，術後のリハビリテーションにも難渋します。

近年，術後の機能回復の点から最小侵襲手術（MIS）が注目されていますが，骨萎縮の強いRA症例では術中骨折などの合併症も危惧されるため，RA股に対するMISを用いたTHAの適応は慎重であるべきです。

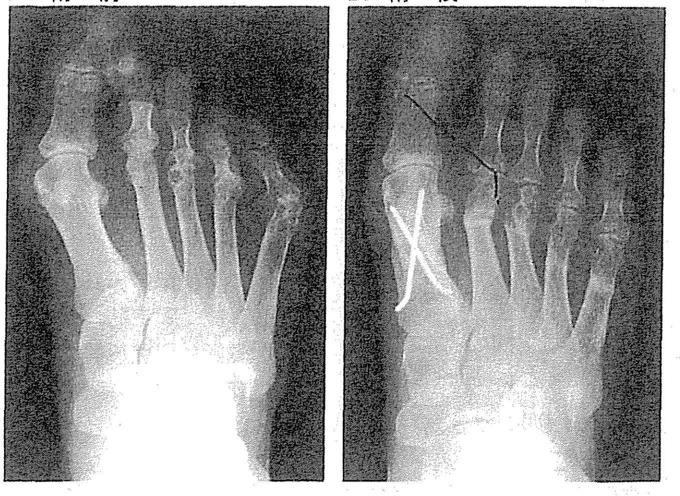
膝関節

膝関節の外科的治療には，滑膜切除術と人工膝関節置換術（TKA）が一般的に行われています。

滑膜切除術の適応は，保存療法にもかかわらず６カ月以上滑膜炎が持続し，関節裂隙が

図 3　外反母趾矯正骨切り術とⅡ～Ⅴ足趾の短縮骨切り術（30歳，女性）

A. 術　前　　　B. 術　後



A：外反母趾と第Ⅱ～Ⅴ足趾の claw toe 変形のため歩行時痛を訴えていた
B：変形は改善し，歩行時痛は消失した

十分保たれている場合と考えられています[2]。術後早期の除痛効果はおおむね満足できるものですが[5]，関節裂隙の消失した症例に対して良好な成績は期待できません。

TKA の適応は，関節裂隙が消失し疼痛が強く歩行困難な場合です[2]。可動域制限，屈曲拘縮などが生じると手術は困難となり，術後の可動域もあまり期待できなくなります。

TKA においても MIS が注目されていますが，変形が高度で骨粗鬆症が強い場合は術中骨折や骨の圧壊の危険性もあり，いたずらに MIS に固執することは避けねばなりません。

足関節

滑膜切除術の適応は，保存的治療に 6 カ月以上抵抗性の持続する滑膜炎で，関節裂隙が温存されている症例です[2]。滑膜切除術の成績は比較的良好で，15年で10％の滑膜炎の再発をみるのみですが，骨破壊抑制効果は乏しいです。

足関節固定術は，薬物療法，装具療法に無効な距腿関節の破壊にともなう強い疼痛があり，歩行障害がいちじるしい場合に適応となります。無痛性，支持性，変形の矯正が得られるため，患者の満足度は高いです。足関節固定術には近年，フィン付き髄内釘が用いられており，骨癒合率や後療法の点で有効な治療法です[6]。

一方，人工足関節置換術は，関節が破壊され頑固な疼痛が 6 カ月以上つづく場合適応になりますが，15° 以上の内外反変形や高度の骨欠損を有するムチランス型，60歳未満の症例には使用を避けるべきです。RA に対する人工足関節の長期成績はけっして良好とはいえません。

前足部

外反母趾，槌趾変形，鷲爪趾変形により有痛性胼胝（べんち）を形成し，歩行障害や履物の制限を訴え，装具療法が無効な場合，手術の適応となります[2]。

RA の外反母趾変形に対しては，母趾 MTP 関節の切除関節形成術，人工関節によ

る関節形成術，固定術があります。なかでも関節固定術は除痛効果が高く，踏み返し力の低下を予防でき，外反変形の再発がないなどの利点があります。

II～V足趾の中足骨の足底脱臼に対しては，切除関節形成術が有効です。骨頭を含め中足骨の末梢を切除するLelievre法がよく用いられてきました。

近年われわれは，薬物療法により滑膜炎が沈静化した前足部変形に対し，関節温存を目的とした外反母趾矯正骨切り術と，II～V足趾の短縮骨切り術を行っており（図3），短期ではありますが，良好な成績を得ています。

＊

現在一般的に行われているRA四肢関節の手術法について概説しました。各手術方法の詳細は専門書を参照していただければ幸いです。

RAの手術療法は，手術材料と手術方法の改良に加え，薬物療法の進歩により良好な成績が期待できるようになってきましたが，手術の適応，タイミングが適切でなければADL・QOLを十分改善することはできません。一方で，タイミングの遅れを危惧するあまり，生活指導や薬物療法，装具療法などの保存的治療を十分に行わず，いたずらに局所療法である手術を優先することはあってはなりません。RA患者の関節炎と機能障害を総合的に判断し，十分保存的治療を行ったうえで，適切な手術療法をタイミングよく実施していくべきです。

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関節リウマチの画像診断

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Abstract　薬物療法の急速な進歩に伴い，関節リウマチ(RA)の治療目標は“寛解”となったが，この目標を現実化するためには早期診断・早期治療，さらには厳密な管理が必須である．画像検査はRA領域において極めて有用なツールであり，画像診断を有効に活用することで，寛解はより達成可能な目標となる．超音波検査やMRIは理学所見だけではとらえることができない滑膜炎を検出することができるため，RAの超早期診断の一助となる．また，これらの検査を用いて画像的寛解を維持することができれば，炎症に引き続き出現する骨破壊を阻止することも可能になるであろう．それぞれの画像検査の特徴を把握し臨床の場に有効活用していくことで，RA患者の機能予後はさらに向上することが期待される．

Key words　関節リウマチ(rheumatoid arthritis)，画像診断(diagnostic imaging)，単純X線検査(radiography)，超音波検査(ultrasonography)，MRI(magnetic resonance imaging)

はじめに

“寛解”が関節リウマチ(RA)の実現可能な治療目標に設定されて以降，RA診療はさらなる変革期に入ってきている．RAを寛解に導くためには，早期診断・早期治療が重要であり，さらには疾患活動性の厳密な管理が求められる．診断から寛解に至る道筋において画像検査はRA診療において欠くことができない診察ツールであり，有効に活用することで寛解は間違いなく身近な目標になり得る．

近年，RAの画像診断としてMRIや超音波検査などの進歩は目覚ましいものがある．一方，単純X線検査は再現性が高く簡便で骨表の変化がとらえやすいため，今なおRA診療には欠くことができない重要な画像検査である．各画像検査の特徴を十分に把握したうえで，それらを有効に活用することで，RA診療の質は間違いなく向上する．

本稿では単純X線検査，関節超音波検査およびMRIに焦点を当て，検査の実際と読み取るべき所見について述べる．

画像検査の特性と比較

表1に関節評価における単純X線検査，関節超音波検査およびMRIの特性を示す．単純X線検査は撮像時間が短く，複数の関節を撮像することが可能である．骨病変の描出に優れており再現性は高い．超音波検査については，X線検査と同様複数の関節を撮像することが可能ではあるが，関節数が増えると撮像時間は長くなる．滑膜病変や骨表の骨びらんの描出に優れており，確認したい部位を任意の方向で撮像することが可能である．MRIは撮像時間が比較的長く検査が高額である．また，複数の関節評価には不向きである．しかし，X線写真や超音波検査では確認することができない骨髄内の変化(骨髄浮腫)を読み取ることができる利点がある．

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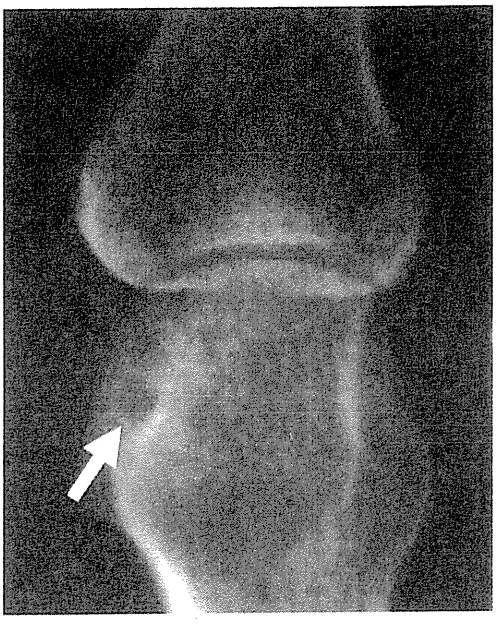
表 1. 関節評価における単純 X 線検査・超音波検査・MRI の比較

	単純 X 線検査	超音波検査	MRI
費用	安価	安価	高価
撮影時安静の必要性	あり	なし	あり
造影剤の必要性	なし	なし	使用が望ましい
放射線被曝	あり	なし	なし
撮像時間	短	撮像関節数による	比較的長い
複数の関節評価	可能	可能	困難
滑膜病変の描出	不可	可能	可能
骨病変の描出	優れている	骨表のみ描出可能	骨髄まで描出可能
動的評価	不可	可能	不可
説明しながらの撮像	不可	可能	不可
検者による画像の違い	ほぼなし	あり	ほぼなし
検者による再現性	あり	熟練を要する	あり
読影者による評価の違い	あり	あり	あり



◀図 1.
中手骨遠位部(MCP 関節)の dot sign(矢印)
(文献 3 より引用)

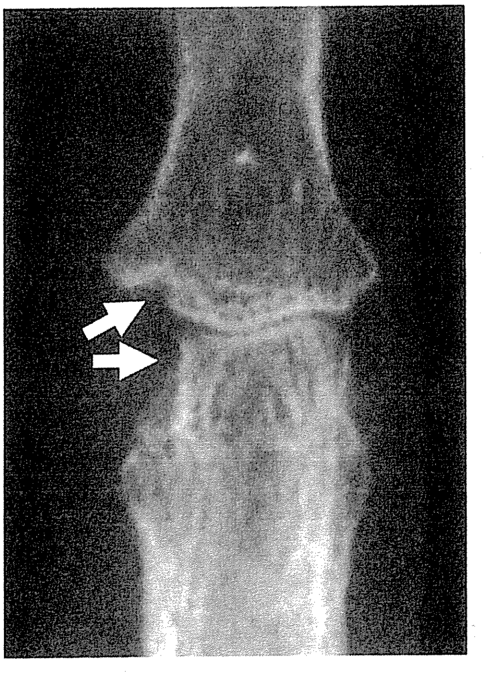


図 2. ▶
PIP 関節の bare area に出現した骨びらん(矢印)

単純 X 線検査

1. 読み取るべき所見

初期病変として，関節周辺の軟部組織の腫脹，関節近傍の骨萎縮が確認される．進行とともにポケット状骨びらん，関節裂隙の狭小化，関節表面の粗糙化が出現し，さらに geode，関節変形，関節強直が観察される．また，近年薬物療法の進歩により関節破壊の修復像も散見されるようになってきた．

1) 軟部組織の変化

関節液貯留，滑膜炎，関節周囲の浮腫などが軟部組織陰影の拡大として認められる．

2) 骨萎縮

早期から関節近傍の骨萎縮像が認められる．点状の骨透亮像である dot sign(図 1)も見逃さないようにしたい．

3) 関節裂隙の狭小化

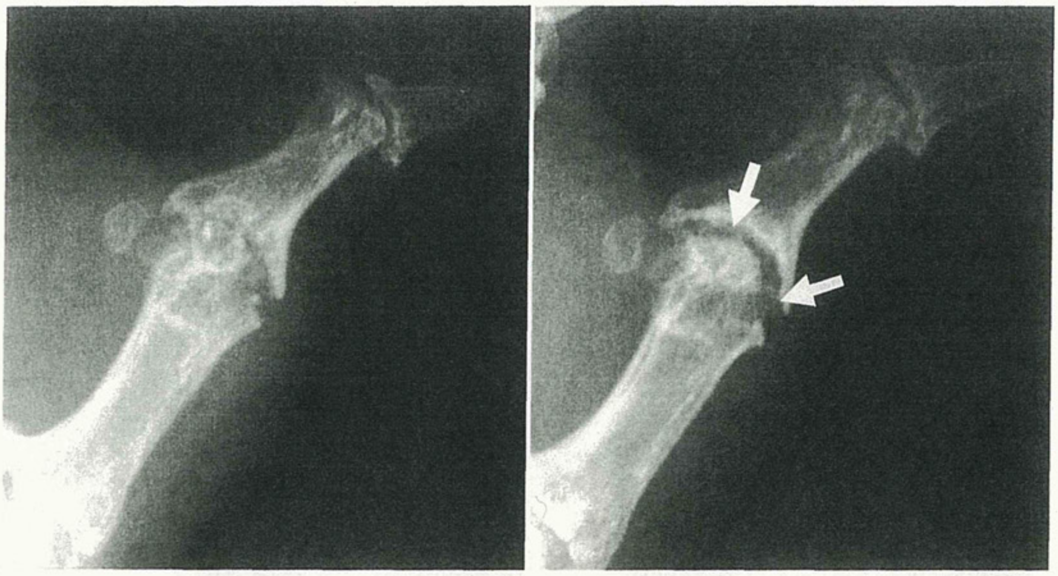
関節軟骨が破壊されると，関節裂隙は減少する．変形性関節症(OA)とは異なり，全体が均一に狭小化することが一般的である．

4) 骨びらん

早期には関節内の辺縁で骨が軟骨に覆われていない bare area に生じることが多く，時にポケット状骨びらんとして確認される(図 2)．

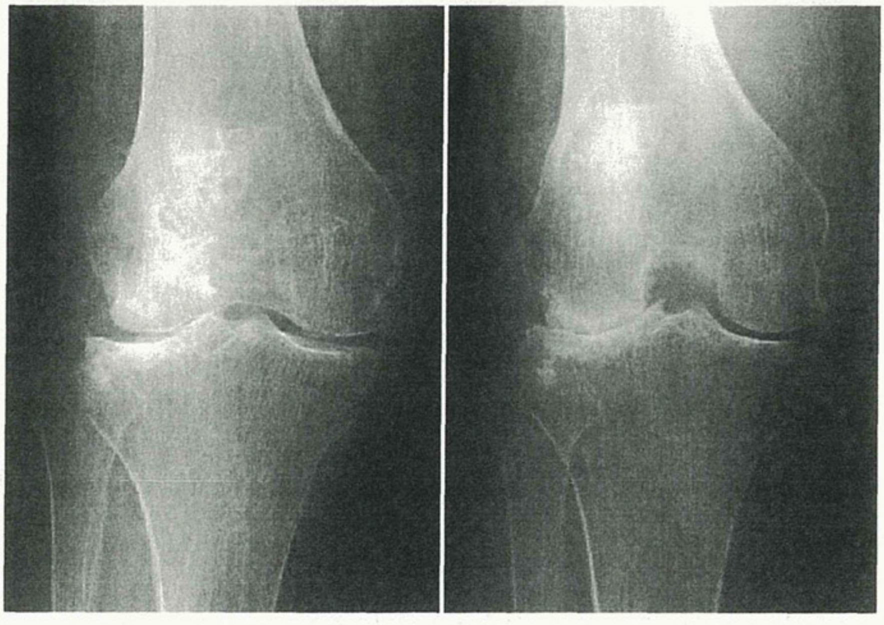
5) Geode

炎症性肉芽組織が軟骨下に形成されて，X 線像で骨嚢腫のようにみえる．単純 X 線写真のみでは geode の広がりを把握しにくいことがあり，確認には CT が有用である．



a|b

図 3.
骨破壊の修復
a：拇指 MCP 関節に骨びらんが存在していた.
b：治療開始後に骨びらんの filling と皮質骨の再出現(矢印)が確認された.
(文献 3 より引用)



a|b

図 4.
単純 X 線膝関節臥位正面像と立位荷重位正面像
a：臥位正面像
b：立位荷重位正面像にて関節裂隙が狭小化している.

6）関節破壊・変形

骨破壊に関節支持組織の破綻が加わり，特徴的な変形が各関節に生じる.

7）関節強直

骨・軟骨破壊の結果，関節は線維性ないし骨性に癒合する．手根部や足根部などに出現することが多い.

8）関節の修復

Rau ら[1]は骨びらんの縮小，皮質骨の再出現を関節の修復所見として提唱した(図 3)．生物学的製剤が出現して以来，小関節のみならず大関節の修復所見[2]がしばしば確認される.

2．各関節における撮影と読影のポイント

1）頚椎

環軸椎亜脱臼は頚椎側面像で評価するが，前屈のみで出現する場合があるため機能撮影はぜひ撮影しておきたい[3].

2）肩関節

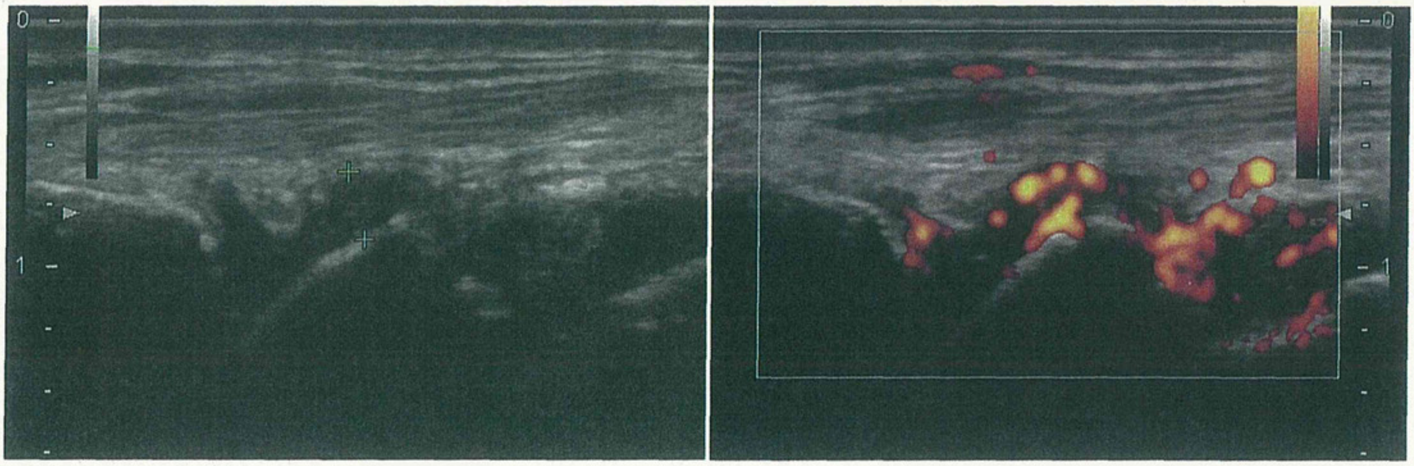
基本的には肩関節正面写真で評価する．関節裂隙の狭小化や関節面の粗糙化が出現する前に，大結節近位の腱板付着部に骨びらんを確認することがある．上腕骨頭が上方偏位する所見は腱板破綻のサインである.

3）肘関節

2 方向撮影が基本であるが，進行例では屈曲拘縮があるため正確な正面像をとることが難しい．時に，上腕骨軸と前腕骨軸のそれぞれで撮影する必要がある.

4）手関節・手指

最も早期に骨びらんが生じやすい部位である.



a．Bモード法で関節内に低エコーの滑膜肥厚が確認できる．　b．同部位にPDシグナルが認められる．

図 5． 手関節の関節滑膜炎

手根骨や中手骨基部の観察が不十分だと骨びらんを見逃すことがあるので注意が必要である．

5）股関節

正面写真が多くの情報を与えてくれる．骨梁構造の不鮮明化は骨萎縮の所見である．進行すると臼底に向かって骨頭が偏位する中心性脱臼を呈する．

6）膝関節

臥位での撮影では関節裂隙の狭小化が過小評価されるため，立位荷重位での撮影が必要である[3]（図4）．

7）足関節・距骨下関節・ショパール関節

足関節においては通常は2方向撮影が行われる．正面撮影で足関節を約20°内旋すると内外の関節裂隙が描出される．足関節部の疼痛が距骨下関節やショパール関節に起因することも多く，これらの関節は側面写真で評価する[3]．

8）足部・足趾

手指同様骨びらんが生じやすい部位である．RAを疑った場合には症状の有無にかかわらず必ず撮影するようにする．

関節超音波検査

1．使用する機器と撮像条件

関節超音波検査で最も大切なものはプローブであり，リニア型を使用する．一般的に大関節（膝関節など）は5～10 MHz，小関節（手指，足趾など）は10～20 MHzの周波数プローブを使用する．検査方法にはBモード（グレースケール）法とパワードプラ（PD）法がある．Bモード法では画面が暗くならないようにゲインを設定し，フォーカスを観察したい関節の表層に合わせる．PD法による血流評価にはPRF（pulse repetition frequency）を低め（500～1,300 Hz）に設定し，低速血流を検出するようにする．ドプラゲインはノイズが出るまでゲインを上げた後に，徐々に絞ってノイズが見えなくなる最大のところで観察する必要がある．

2．描出可能な病態

1）滑液

関節内で低エコーあるいは無エコーを示す．プローブで圧迫すると容易に圧縮されて移動する．PDシグナルは陰性である．

2）滑膜肥厚と滑膜内血流

関節内で低エコー（時に中エコー）を示し，移動性・圧縮性に乏しい．活動性の滑膜炎の場合PDシグナルは，陽性となる（図5）．PDシグナル陽性の滑膜炎は，その後の骨破壊の進行を予見する重要な所見と考えられている[4]．

3）腱鞘滑膜肥厚と滑膜内血流

縦断・横断の2方向で観察される腱近傍の肥厚した組織で低エコーを示す．時に無エコーの液体貯留を伴うことがある．PDモードでは肥厚した腱鞘に一致してPDシグナルが陽性になる場合がある（図6）．プローブからのビームが腱の走行に垂直に入らないと，アニソトロピー（異方性）により腱内部のエコー輝度が低下する．腱鞘滑膜肥厚を過大に評価しないためにプローブの角度を調整