Instructional lecture

Cementless total hip replacement: past, present, and future

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Abstract Cementless total hip replacement (THR) is rapidly being accepted as the surgery for arthritic diseases of the hip joint. The bone-ingrowth rate in porous-type cementless implants was about 90% over 10 years after surgery, showing that biological fixation of cementless THR was well maintained on both the stem and cup sides. As for the stress shielding of the femur operated using a distal fixation-type stem, severe bone resorption was observed. The severe bone resorption group showed continuous progression for more than 10 years after surgery. Stem loosening directly caused by stress shielding has been considered less likely; however, close attention should be paid to bone resorption-associated disorders including femoral fracture. Cementless cups have several specific problems. It is difficult to decide whether a cup should be placed in the physiological position for the case of acetabular dysplasia by bone grafting or at a relatively higher position without bone grafting. The bone-ingrowth rate was lower in the group with en bloc bone grafting, and the reactive line was frequently noted in the bone-grafted region. Although no data indicated that en bloc bone grafting directly led to poor outcomes, such as loosening, cup placement at a higher site without bone grafting is now selected by most operators. The polyethylene liner in a cementless cup is thinned due to the metal cup thickness; however, it has been suggested that the apparent relation between the cup size and the wear rate was absent as long as a cementless cup is used. Comparative study indicated cementless THR was inferior with regard to the yearly polyethylene wear rate and incidence of osteolysis on both the stem and cup sides. Meta-analysis study on the survival rate between cement and cementless THR reported that cemented THR was slightly superior. It should be considered that specific problems for cementless THR, especially with regard to polyethylene wear, do occur.

Introduction

Although the total Japanese population is slowly decreasing, the elderly population is increasing. Elderly persons want to continue voluntary movement and exercise freely. They are positive about undergoing surgical therapy for their motor organs, and government health policy attaches a greater importance to healthy longevity than to mere expectation of life. The Japanese Orthopaedic Association (JOA) has been making efforts to respond actively to the needs of this elderly population by providing opportunities for JOA members systematically to learn the appropriate surgical techniques. Based on this background, the number of applications of total hip replacement (THR) for hip joint disorders has increased rapidly. The number of stem implants shipped in fiscal year 2006 in Japan was about 82 000, and about 72% were applied by a cementless procedure (Fig. 1). Although the use of cementless THR has been rapidly spreading, it should be remembered that problems specific for cementless THR do occur, as with cemented THR.[1–3] In this report, the history and changes (in the past) of this surgical procedure, achievements and problems of the current models (the present), and new attempts (future) are reviewed, described as the past, present, and future of cementless THR.

History of the development of cementless THR

Total hip replacement development began with cementless THR. McKee and Watson-Farrar documented an early model of an artificial hip joint between 1956 and 1960.[4] They applied it into 40 patients with hip disability. The system was cementless on both the acetabular and femoral sides. They reported 51% good or fair clinical results. THR was thus performed first using a cementless system, then followed by a hybrid system

(cemented Thompson femoral prosthesis combined with an uncemented cup) by Charnley.[5] Charnley systematically promoted THR based on the concept of low friction arthroplasty by: (1) fixation with bone cement; (2) adoption of a 22-mm femoral head; (3) adoption of ultra high molecular weight polyethylene (UHMWPE); and (4) preparation of a manual of the surgical procedure. Wroblewski et al. reported that the mean survival rates of cases in which the original Charnley cemented THR was applied were 84.7% and 74.3% at 15 and 20 years after surgery, respectively, showing favorable outcomes based on the current criteria.[6] However, the outcomes of other cemented THR procedures were markedly poor: loosening occurred in 34% at 7.4 years after surgery using the Charnley-Müller type, and 40% at 10 years after surgery using the Müller type.[7,8]

These poor outcomes of early cemented THRs were due to the implant design and cementing technique in many cases. However, at that time cement itself was considered the cause, and loosening was called "cement disease." Based on these backgrounds, cementless THR was developed, but the outcomes of cementless THR were also poor during the 1960s, although the originality and devices made by predecessors were astonishing. Figure 2 shows the Ring-type cementless THR used during the late 1960s. The same concept as the current cementless THR was adopted in many points, such as metal-on-metal articulation, adoption of femoral head with a large diameter, and cup fixation with a single screw using a direction and depth indicator, a kind of déjà vu.[9]

The surface of most cementless implants during the 1970s was smooth, for which strong adherence to bone could not be expected, and a macro lock implant with a window or fin was inserted into bone by press-fitting. The outcomes of these smooth-surface-type cementless THRs (including bipolar-type femoral prosthesis) were poor, causing aseptic loosening several years after surgery, and many cases required revision surgery.[10]
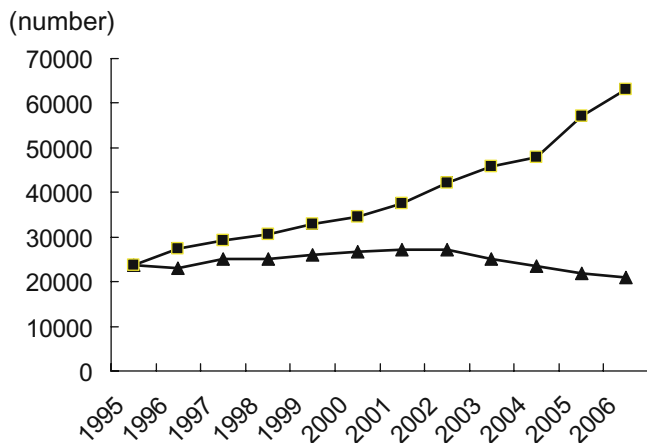

Fig. 1. Total number of stem implants used in Japan. *Squares*, cementless stems; *triangles*, cemented stems
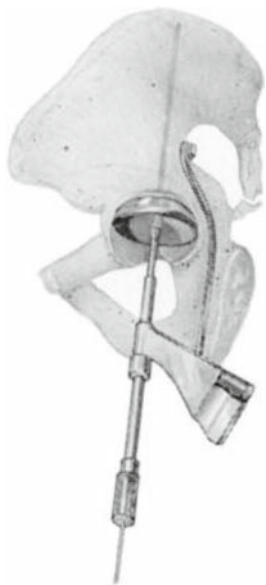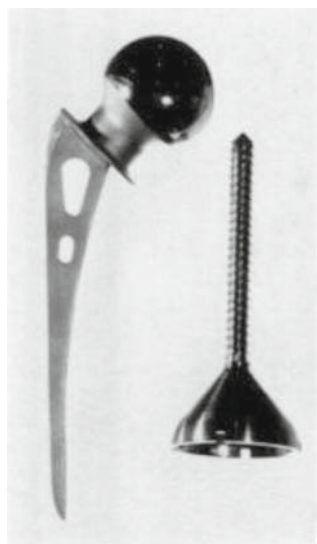
Fig. 2. Cementless total hip replacements (THRs) performed during the 1960s. Ring-type cementless THR was used during the 1960s.[9] Ring-type THR adopted many points of the same concept as the current cementless THR including metal-on-metal articulation, a femoral head with a large diameter, and cup fixation with a screw using a direction and depth indicator
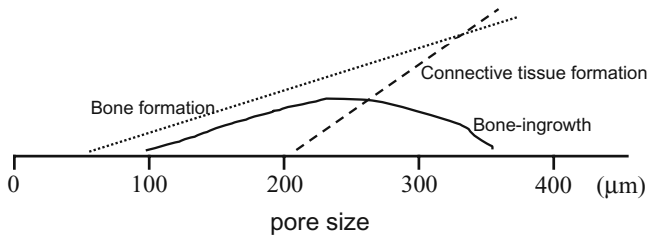
Fig. 3. Relation of bone, connective tissue formation, and total bone ingrowth with the pore size of the implant in an animal model. *Dotted line*, bone formation; *dashed line*, connective tissue formation; *solid line*, bone ingrowth

The development of material engineering during the 1980s completely changed the condition because materials that allow bone ingrowth became available. Animal experiments showed that the pore size of porous materials is important. Bone formation into the porous implant increased as the pore size increased, but the connective tissue amount also increased. Thus, the maximum bone ingrowth capability was obtained when the pore size was 100–200 μm (Fig. 3). Most of current cementless THR are bone ingrowth or bone ongrowth type. For surface processing of the bone-ingrowth type implant, titanium (Ti) fiber mesh was adopted in the Harris/Galante-type THR, cobalt-chromium (Co-Cr) beads in the AML-type THR, and Ti plasma spray in the Mallory-Head-type THR (Fig. 4).

Ti fiber mesh
Harris/Galante
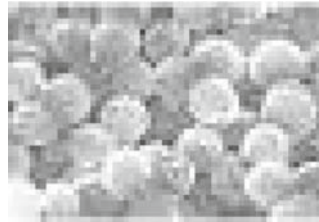
Co-Cr beads
AML

Ti plasm spray
Mallory-Head

Fig. 4. Types of surface structure in bone ingrowth cementless implants. Magnified appearances of the implant surfaces are shown at the top. *Ti*, titanium; *Co-Cr*, cobalt-chromium; *AML*, anatomical medullary locking

Clinical results and problems of current models

Biological fixation of cementless THR

X-ray radiographic results of the Anatomical Medullary Locking (AML)-A stem and Tri-Lock cup we have used were as follows: The AML-A stem is a distal fixation type with a porous structure, with a mean pore size of 275 μm in 5/8 of the stem. Based on the Engh et al. classification,[11] biological fixation at a mean of 13 years after surgery was bone ingrown in 94.7%, stable fibrous in 4%, and unstable in 1.3% (Fig. 5), showing that the distal fixation-type stem achieved excellent biological fixation for a middle term after surgery. The biological fixation of the Tri-Lock cup was bone ingrown in 88%, stable fibrous in 8%, and unstable in 4% (Fig. 6). In previous reports, the bone ingrowth rate in the AML stem was 81%–90% at 10 years after surgery,[12,13] to which our outcomes were comparable, showing that biological fixation of AML-type cementless THR was well maintained on both the stem and cup sides for at least 13 years after surgery.

Stress shielding in distal fixation-type cementless stems

Implants are fixed to the bone tissue by bone ingrowth in cementless THR. Transmission of weight-bearing stress to the femur via the cementless stem is different from that with the cement stem, and it is impossible to avoid its influence on bone tissue within in a long-term period. A typical influence is stress shielding in distal fixation-type stems. In patients who have a distal fixation-type stem, weight-bearing stress is not transmitted in the proximal femur, and bone resorption occurs.

Yoshihara et al. reported the clinical results of AML-type cementless THR applied to 67 joints in 60 patients and new radiological assessment for the bone resorption caused by stress shielding.[14] Defining apparent bone resorption as reduction of cortical bone by half on X-ray radiography, the level at which "the cortical bone thickness was ½" was measured in the X-ray AP view immediately after surgery and at the final follow-up.[14] The medial cortical thickness in the distal region of the stem on the same side was regarded as the baseline. The most distal point in the region with reduced medial

Bone-ingrown 94.7% **Stable fibrous** 4% **Unstable** 1.3%
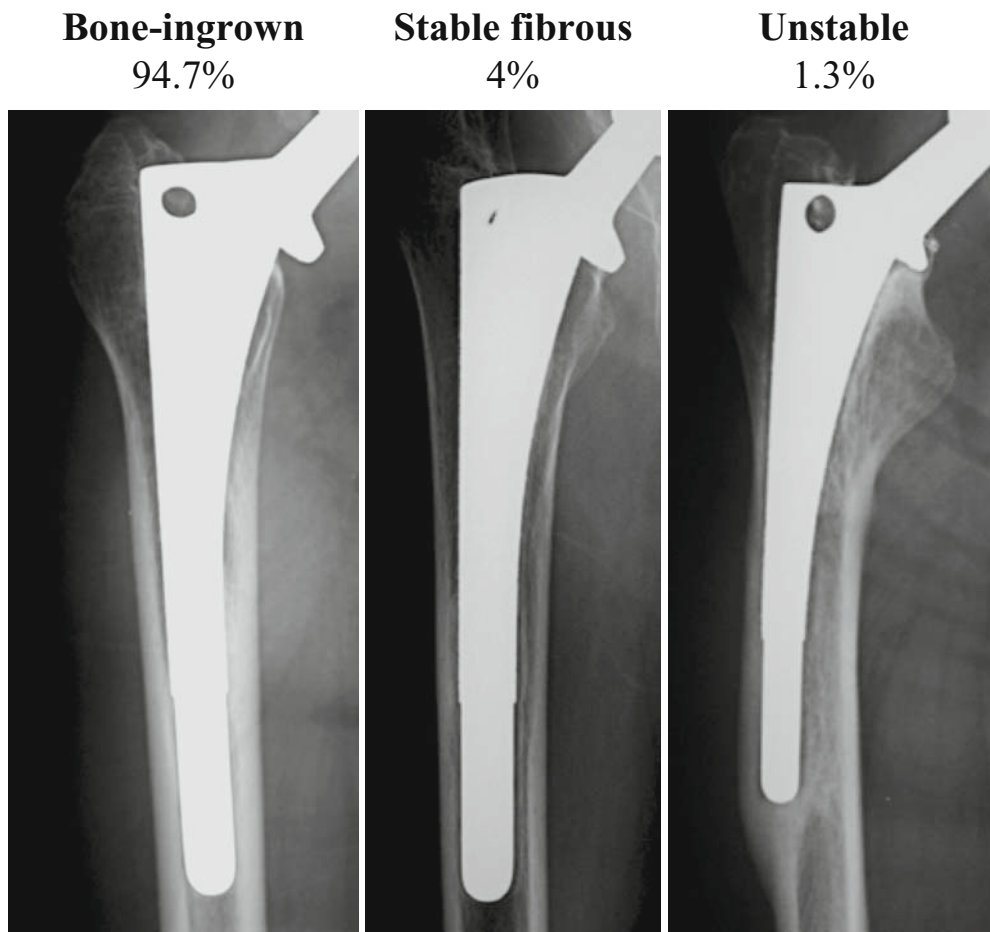
Fig. 5. Results of biological fixation of AML-A stems (average 13 years after operation). Biolological fixation of the AML-A stem implant was evaluated radiologically according to the classification of Engh et al.[11] There were 76 total joints, and the average postoperative follow-up period was 13 years

Bone ingrown
88%

Fibrous stable
8%

Unstable
4%
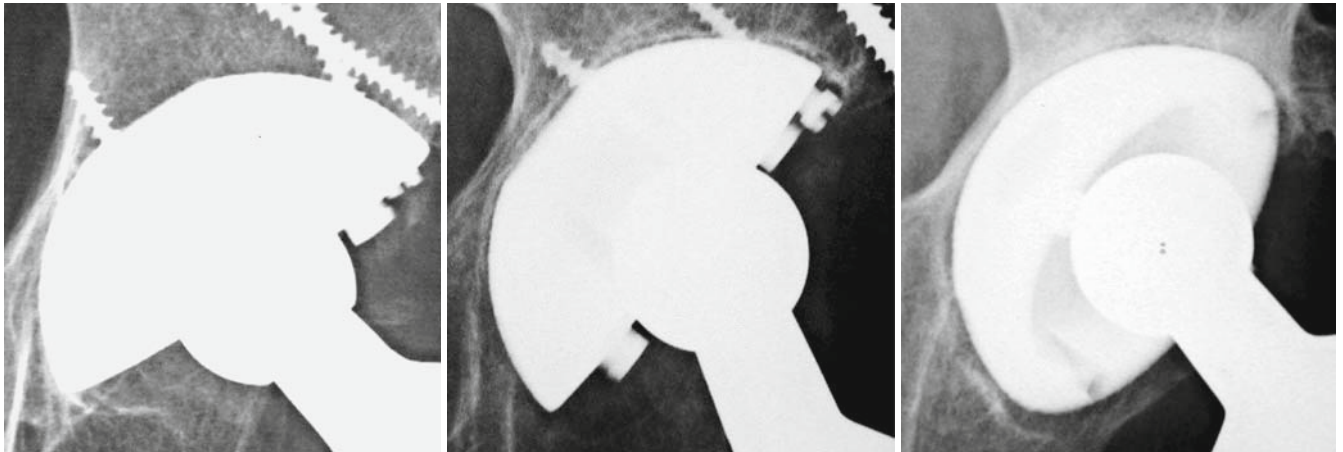
Fig. 6. Results of biological fixation of AML Tri-Lock cups (average 13 years after operation). Biological fixation of the AML Tri-Lock cup implant was evaluated radiologically according to the modified classification of Engh et al.[21] There was a total of 76 joints, and the average postoperative follow-up period was 13 years

Fig. 7. Method for evaluating bone resorption of the proximal femur with cementless stems. The level at which the cortical bone thickness was one-half (*1/2*) was measured in the radiographic antero-posterior (AP) view. The medial cortical thickness in the distal region of the stem on the same side was regarded as the baseline. The mo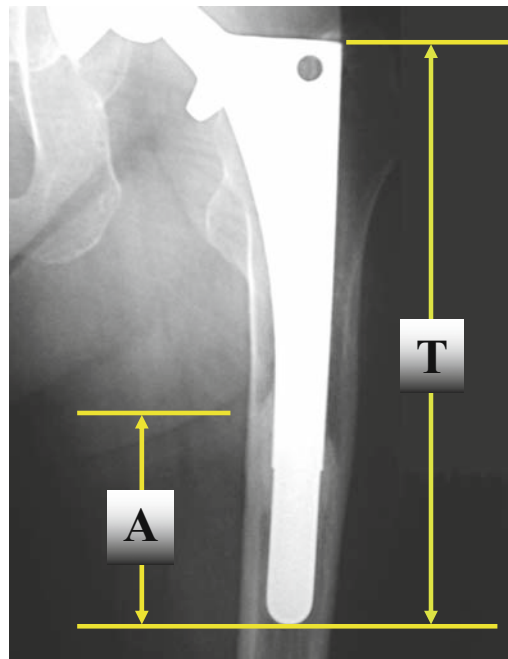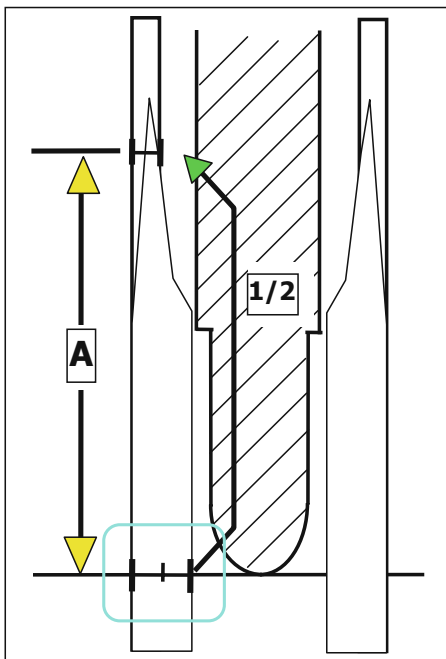st distal point in the region with reduced medial femoral cortical bone thickness to one-half or less of the baseline was determined, and the percent ratio of the length between the distal end of the stem and this point (*A*) to the whole length of the stem (*T*) was calculated[14,16]

femoral cortical bone thickness to ½ or less of the baseline was determined, and the percent ratio of the length between the distal end of the stem and this point to the whole length of the stem was calculated (Fig. 7). The "level with half cortical thickness" immediately after surgery was slightly lower than the lower margin of the lesser trochanter (mean level was 63.7% ± 5.1%), showing a normal distribution-like single peak (Fig. 8A). In contrast, the mean "level with half cortical thickness" was 50.0% ± 11.1% on the final follow-up, showing that the level shifted toward the distal side by 14% of the whole length, compared to the level immediately after surgery (Fig. 8B), and the distribution showed a biphasic pattern with a boundary at 40%–44%. Severe and mild bone resorption groups included 16 (24%) and 51 (76%) joints, respectively. On time-course observation of the "level with half cortical thickness" in the severe bone resorption group, the level was continuously lowered for more than 10 years after surgery (Fig. 9).[15]

(number)

level with half cortical thickness(%)

A: immediately after surgery
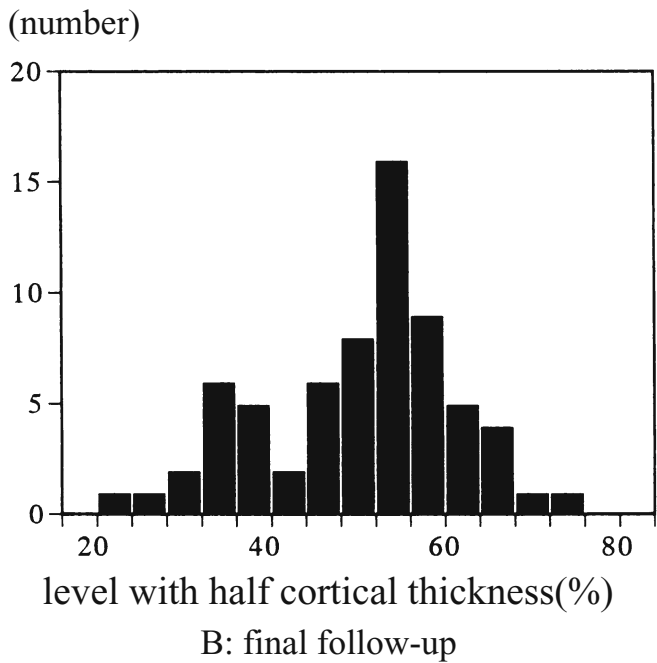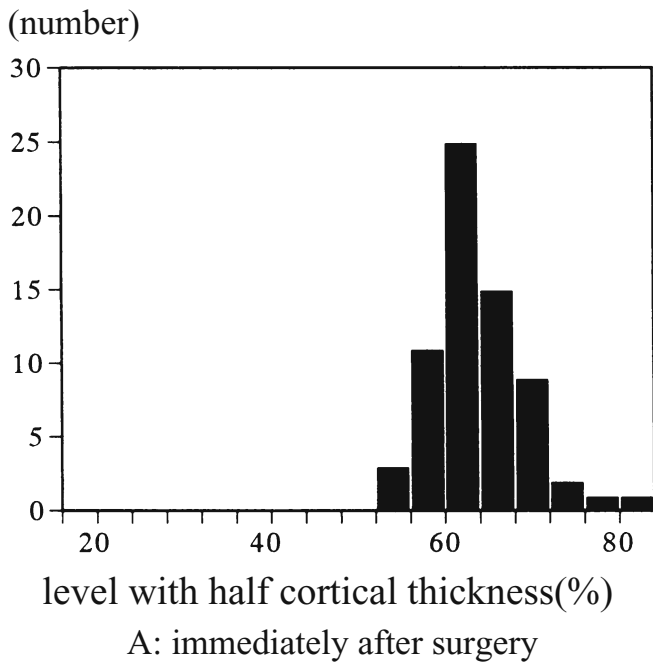
Fig. 8. Bone resorption in AML-A cementless stems. The "level with half cortical thickness" immediately after surgery was slightly lower than the lower margin of the lesser trochanter, showing a normal distribution-like single peak (**A**). In contrast, the mean "level with half cortical thickness" was

(number)

level with half cortical thickness(%)

B: final follow-up

50.0% ± 11.1% at the final follow-up, showing that the level shifted toward the distal side by 14% of the whole length, compared to the level immediately after surgery (**B**); and the distribution showed a biphasic pattern with a boundary at 40%–44%[14]
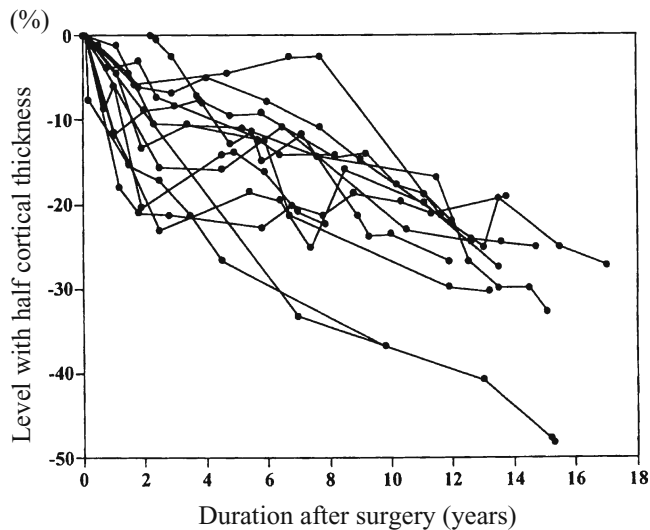
Fig. 9. Bone resorption in AML-A cementless stems. On a time course observation of the "level with half cortical thickness" in the severe bone resorption group, the level was increasingly lower for more than 10 years after surgery[15]

Table 1. Bone resorption of proximal femur after cementless total hip replacement

Parameter	Correlation coefficient	P
Cortical index	0.361	<0.01
Bone quality score	0.431	<0.01
Canal flare index	0.446	<0.001
Distal canal filling rate	−0.048	NS
Age at operation	−0.337	<0.01
Stem size	−0.360	<0.01
Follow-up period	−0.220	NS

Radiological degree of bone resorption and several risk factors were studied. A significant relation was observed with age at operation, bone quality score, cortical index, and stem size[16]

The association between the measured "level with half cortical thickness" and various risk factors was investigated. Significant correlations with the age at the time of surgery, bone quality score, canal flare index, cortical ratio in the isthmus, and stem size were noted,

but no apparent correlation with the time after surgery was detected (Table 1).[15,16]

There have been various discussions on femoral bone resorption in distal fixation-type stems. Bugbee et al. reported that radiographic bone remodeling occurred within 1 year after surgery in many cases with an AML-type cementless stem, and only a few new cases were noted after 2 years.[17] Engh and Massin also reported that bone resorption progressed to the diaphysis during a period of 2–5 years after surgery in only 3 of 163 patients.[18] In contrast, Kilgus et al. investigated cases using dual energy X-ray absorptiometry (DEXA) and found that bone remodeling progressed for several

A   B
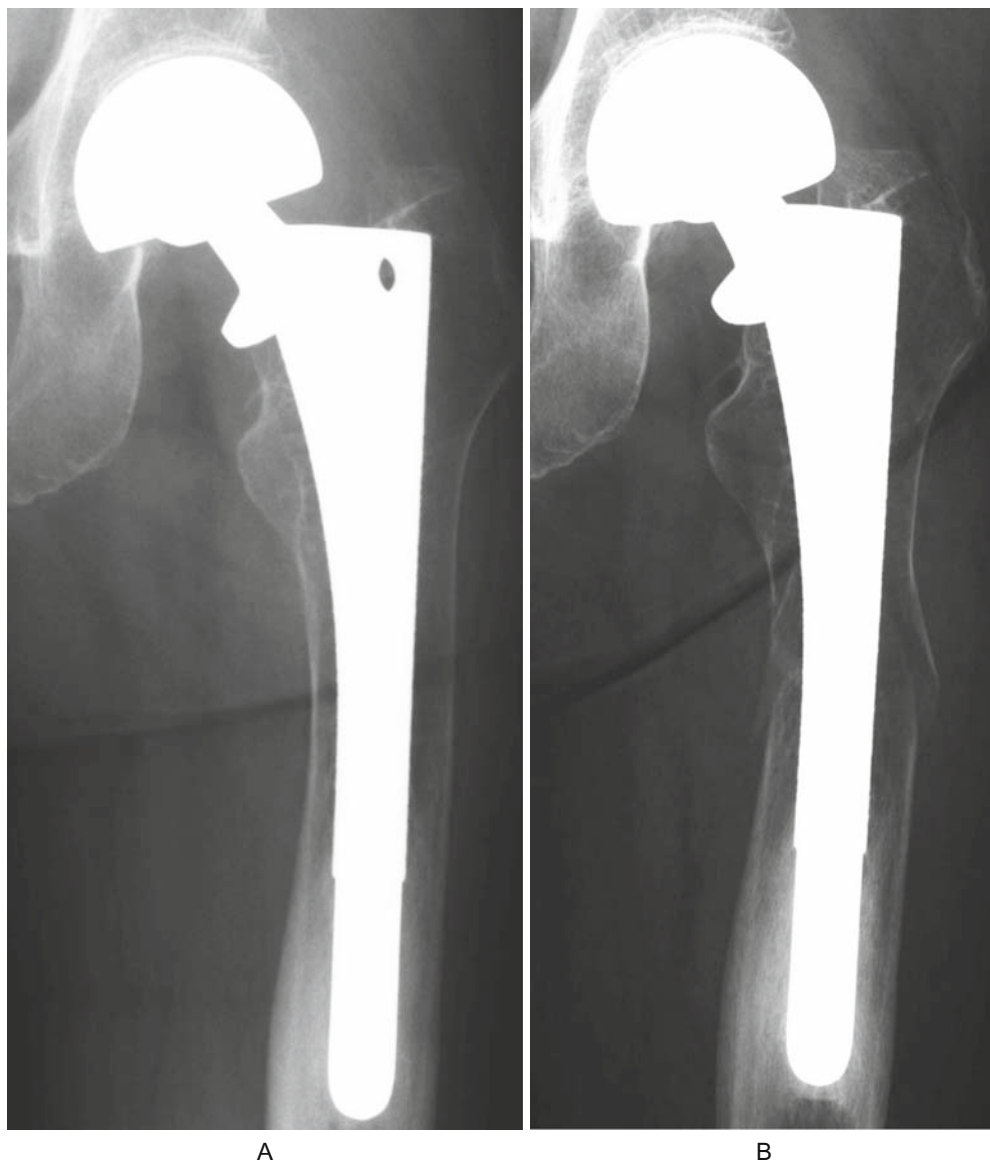
Fig. 10. Metaphysis fracture of the femur with severe stress shielding. This 53-year-old woman with systemic lupus erythematosus was operated on using an AML-A cementless stem as the femoral endoprosthesis for the treatment of idiopathic osteonecrosis of the femoral head. She was treated with low-dose oral steroid administration. She complained of no thigh pain or hip pain at 9 years after operation. Radiological findings at 9 years after operation indicated no osteolysis or loosening; however, there were severe cortical hypertrophy and bone resorption (**A**). She slipped in the bathroom 10 years after her operation and felt severe thigh pain. Radiological findings showed metaphysis transverse fracture of the femur with small displacement (**B**)

years after surgery.[19] In Yoshihara's study, weight transmission from the AML-type stem to the femur was taking place in the distal region in the group with the half cortical thickness at a low level, accounting for only about one-fourth of all cases, and weight was transmitted in the proximal region of the stem in the other three-fourths, suggesting that weight is transmitted in the proximal region, not in the distal region, in many cases even though they were using a distal fixation-type stem. It was also clarified that bone resorption continued for more than 10 years in the severe bone resorption group, showing the necessity of long-term careful follow-up.

Although stress shielding of AML-type cementless stem is severe, impairment directly caused by bone resorption has been considered less likely. However, we recently encountered a patient with this stem in whom diaphyseal fracture assumed to be due to bone resorption occurred. The patient was a 54-year-old woman with steroid-induced osteonecrosis of the femoral head. On a periodic follow-up 9 years after surgery, marked bone resorption extending to the diaphysis was detected by X-ray radiography, but no osteolysis or loosening was present (Fig. 10A). Later, meralgia suddenly appeared when she lost her balance in a bathroom, and fracture in the center of the stem was noted on radiographic examination (Fig. 10B). Although this case was affected by oral steroids, stress shielding-induced bone resorption may have been a cause of the fracture. The mechanism of fracture with disposition around the stem with completed bone ingrowth remains to be further elucidated, but it was suggested that close atten-

A

B
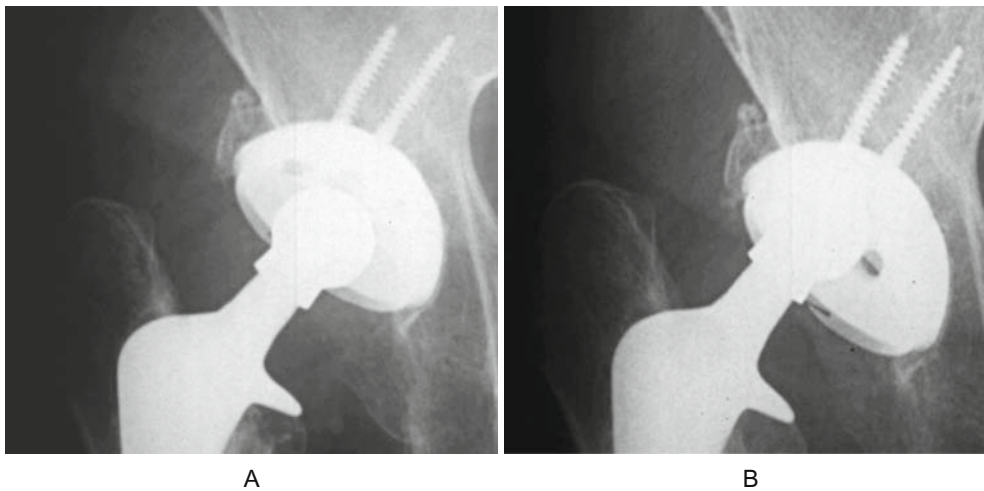
Fig. 11. Displacement of a polyethylene liner due to failure of the locking mechanism. This 64-year-old woman with secondary hip osteoarthritis (OA) due to dysplasia was operated on using a Harris/Galante-type cementless implant 6 years earlier. She had no pain at 5 years after operation (**A**).

However, she felt severe hip pain suddenly and could not walk (**B**). At revision surgery, displacement of the polyethylene liner was apparent due to failure of the locking mechanism. Metallosis was observed

tion should be paid to bone resorption-associated disorders.

Achievements of and problems with the cementless cup

Problems specific to cementless cups have been reported: (1) failure of the locking system of polyethylene liner; (2) use in patients with acetabular dysplasia (cup placement level, influence of bone transplantation; (3) insufficient polyethylene thickness; and (4) use of screws.

Failure of the locking system of the polyethylene liner of the early Harris/Galante-type is well known.[20] The stem neck contacted the rim of the polyethylene liner and produced a turning moment in the liner; the system holding the liner in the cup then ruptured, resulting in a marked dislocation of the liner (Fig. 11), which subsequently causes severe metallosis when untreated.

The incidence of acetabular dysplasia is high in Japan. It is difficult to decide whether a cup should be placed in the physiological acetabular position by concomitant en bloc bone grafting or at a relatively higher level without bone grafting. Placing a cup in the physiological acetabular position is advantageous for most of the following points: leg length, range of motion (ROM), neck impingement, and applicable cup diameter. However, there are also disadvantages with concomitant bone en bloc grafting: risk of future collapse of the grafted bone, necessity of a long-term non-weight-bearing period, and particularly the absence of bone ingrowth from the grafted bone. Russotti and Hendricks reported that cup placement at a relatively higher level was not involved in the clinical outcome when no lateralization accompanied.[21] Hendricks and Harris reported revision cases

with severe acetabular bone loss placed at a high hip center (with an average duration of follow-up of 16.8 years). They noted that only 4.3% were revised because of aseptic loosening and demonstrated that placement of a cementless cup at a high hip center is an excellent technique for selected patients with severe acetabular bone loss.[22]

We divided patients who had undergone surgery with an AML Tri-loc cup more than 13 years ago into groups with and without concomitant en bloc bone grafting and evaluated the biological fixation. The fibrous stable rate was higher in the group with concomitant bone grafting (Fig. 12), and the reactive line was noted at a high frequency in the bone-grafted region (Fig. 13). Although no data indicated that concomitant en bloc bone grafting directly led to poor outcomes (e.g., loosening), we also recently prioritize increasing direct contact with the host bone with blood circulation. We frequently select cup placement at a higher site, which can be handled with chip-type or morsellized bone grafting, avoiding en bloc bone grafting.

In a cementless cup, polyethylene is thinned due to the cup metal thickness. Contact stress increases as polyethylene is thinned, being disadvantageous with regard to abrasion and breakage. On investigation of the relation between the outer diameter of the cup and abrasion of polyethylene, there was no significant relation between the outer diameter of the cup and polyethylene linear wear rate in our series. Similarly, Crowther and Lachiewicz[23] and Shih et al.[24] reported the absence of a relation between the outer diameter of the cup and linear wear rate on investigation of Harris/Galante cementless THR and Osteonics cementless

THR, respectively. These findings suggested the absence of an apparent relation between the cup size and the polyethylene linear wear rate so long as a cementless cup is used.

Whether a screw should be used for cementless cup fixation is controversial. The use of a screw is advantageous in that: (1) strong initial fixation can be obtained, particularly for prevention of rotation; and (2) minute movements can be prevented, and good bone ingrowth can be expected. It is disadvantageous in that: (1) metal wear debris is produced between the screw and cup; and (2) osteolysis on the acetabular side is likely to expand due to dispersion of wear debris through the screw hole. Osteolysis along the screw is not rare in cases of severe

Fig. 12. Biological fixation of cementless cups and en bloc bone grafting. Biological fixation of AML cementless cups (Duraloc and Tri-Loc) was evaluated according to the modified classification of Engh et al.[11] There was a total of 77 joints, and the average follow-up period was 13 years. The rate of stable fibrous fixation was higher in the bone-grafted group than in the non-bone-grafted group

polyethylene wear. We grouped patients into those with and without the use of screw, and investigated the biological fixation of the cup. We found that the fixability was not different between the groups (Fig. 14). Previous studies on the relation between the use of a screw and the incidence of radiolucent line formation were contradictory: The incidence of a radiolucent line was high in cases with a screw in some reports but in cases without a screw in other reports.[25,26] At present, there is no evidence that screw fixation is related to osteolysis. Although there is no apparent evidence for inappropriateness of the use of a screw, it is also unclear whether the use of a screw is advantageous. Thus, its use should be minimized.

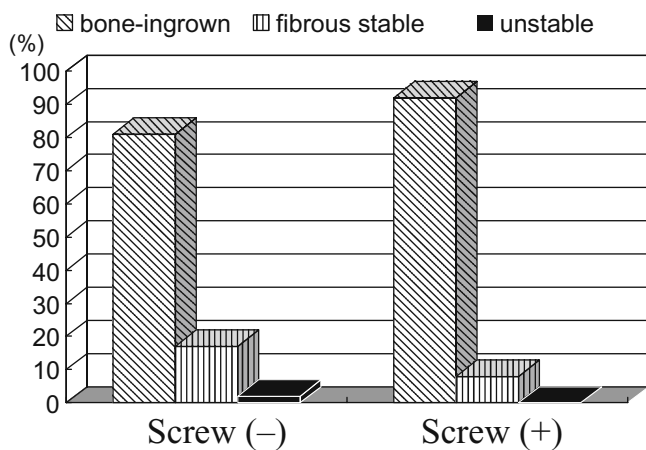*Influence of hydroxyapatite and tricalcium phosphate on bone ingrowth*

Coating the surface with bioactive materials, such as hydroxyapatite (HA) and tricalcium phosphate (TCP), improves biological fixation of porous implants. These coatings were advantageous for a short time in many reports.[27] HA coating enhanced weight transmission and bone ingrowth in the proximal stem region.[28] In clinical cases with HA coating on one side and no HA coating on the other side, there was a less radiolucent line on the HA-coated stem.[29] In a similar clinical study with HA + TCP, earlier disappearance of the initial gap has been confirmed.[30] On the other hand, HA coating has been suggested to have no influence on the revision rate. In an analysis of patients aged 70 years or younger using the Danish Hip Arthroplasty Registry, over 3.4 years on average and setting an endpoint to aseptic loosening, HA coating did not affect the revision rate on the cup or the stem side (Table 2).[31]
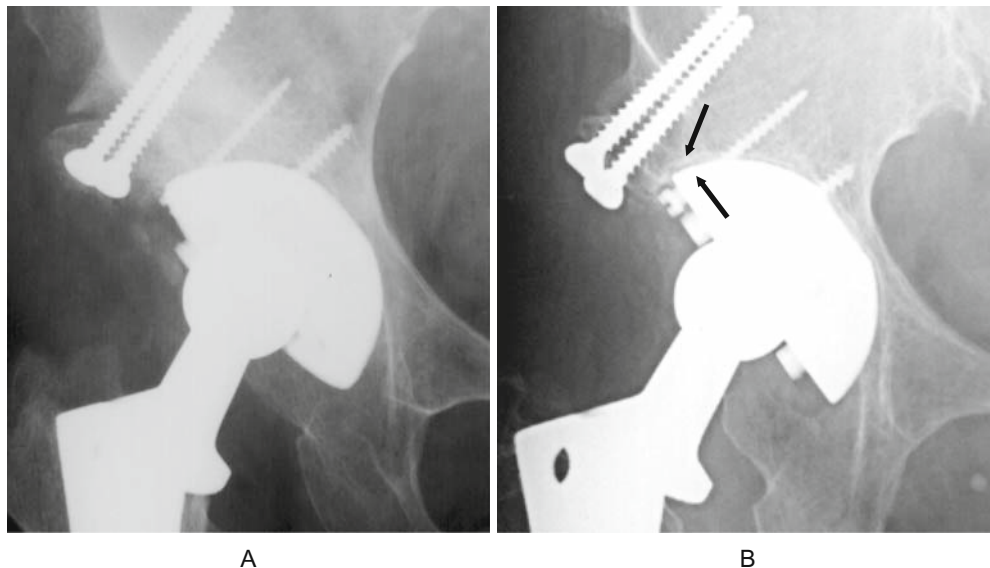
Fig. 13. Biological fixation of a cementless cup at the en bloc grafted bone. Cementless THR was performed for a 52-year-old woman with severe acetabular dysplasia using en bloc bone grafting with a resected femoral head. At 3 years after operation, biological fixation was evaluated as bone ingrown (**A**). At 11 years after operation, radiological findings indicated an apparent radiolucent line at zone 3 (*arrows*), and biological fixation of the cup was evaluated as fibrous fixation (**B**)

Survival rate and failure

In our study, the survival rate of AML cementless THR 10 years after surgery was 95% on both the cup and stem sides; it decreased to 89% on the cup side 13 years after surgery and maintained it at 95% on the stem side. Belmont et al. reported on 119 hips at a mean of 22.0 years after AML cementless THR. Kaplan-Meier analysis, with revision for any reason as the endpoint, revealed that the survival rate at 20 years was 85.8% for the acetabular shell and 97.8% for the stem. The most common reoperation was polyethylene exchange because of wear or osteolysis.[32] Generally, failure of cementless THR on the cup side appears with dislodgement of the polyethylene liner about 5 years after surgery; and osteolysis due to wear of the polyethylene liner, back side wear of the polyethylene, and expansion of osteolysis via the screw hole occur about 10 years after surgery (Fig. 15). The incidence of proximal femoral fracture during and immediately after surgery

is higher that in cases of cemented THR. Stress shielding appeared soon after surgery, and it progressed for a long time in about 25% of the cases with a distal fixation-type stem. Although stress shielding is unlikely to directly cause loosening, fracture may occur during the course in advanced cases. Appearance of osteolysis becomes problematic about 10 years after surgery, similar to that on the cup side (Fig. 16). A previous report indicated that the failure rate is higher on the cup side than the stem side with cementless THR.[33]

Cementless THR versus cemented THR

Is cementless THR superior to cemented THR? Regarding the common problems of THR—wear of polyethylene and osteolysis—the linear wear rate was 0.10 ± 0.11 mm in our study on AML Duraloc cementless cups (11.7 years after surgery on average), showing no marked difference from previously reported values. However, cementless THR was inferior in some reports. McCombe and Williams applied a cement cup on one side and cementless cup on the other using the same implant excluding the fixation method in patients who underwent bilateral THR, in which the cementless cup was inferior with regard to the yearly polyethylene wear rate and incidence of osteolysis on the stem and cup sides (Table 3).[34] Morshed et al. compared the survival

Fig. 14. Biological fixation of cementless cups and use of screws. Biological fixation of AML cementless cups (Duraloc and Tri-Loc) was evaluated according to the modified classification of Engh et al.[11] There were a total of 77 joints, and the average follow-up period was 13 years. No significant differences in the biological fixation was observed between those without screws [*screw (−)*] and those with screws [*screw (+)*]

Table 2. Revision rate and hydroxyapatite coating for cementless total hip replacements

Device	No. of patients	No. of revisions	Adjusted relative risk
Cup			
HA(−)	7737	17	1.0 (reference)
HA(+)	4125	7	0.89 (95% CI 0.37–2.20)
Stem			
HA(−)	7737	14	1.0 (reference)
HA(+)	4125	6	0.71 (95% CI 0.27–1.90)

HA, hydroxyapatite; CI, confidence interval
The endpoint was aseptic loosening
The data shown here are the results of the Danish Hip Arthroplasty Registry[31]

Table 3. Comparison of UHMPE wear and osteolysis between cement and cementless cups
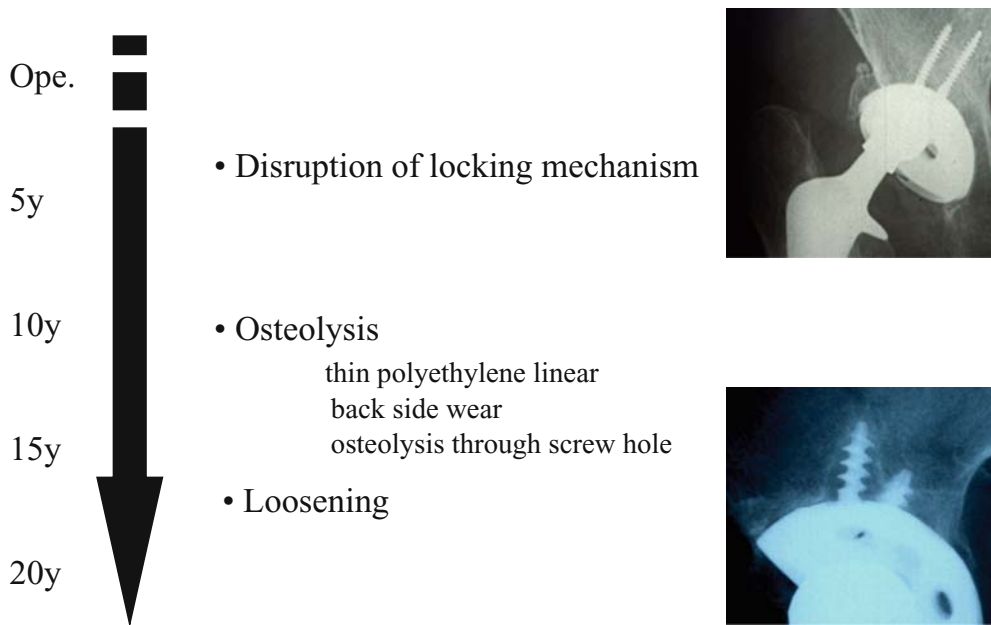
Cup fixation	Linear wear rate (mm/year)	Stem lysis (%)	Cup lysis (%)
Exeter (cemented)	0.07	4.8	0
Duraloc (cementless)	0.15*	25.0*	3.8

UHMPE, ultra high molecular weight polyethylene
A cement cup was applied on one side and a cementless cup on the other using the same implant excluding the cup fixation method in patients who underwent bilateral THR (a prospective, randomized trial). The cementless cup was inferior with regard to the yearly linear wear rate and incidences of osteolysis on the stem and cup sides[34]
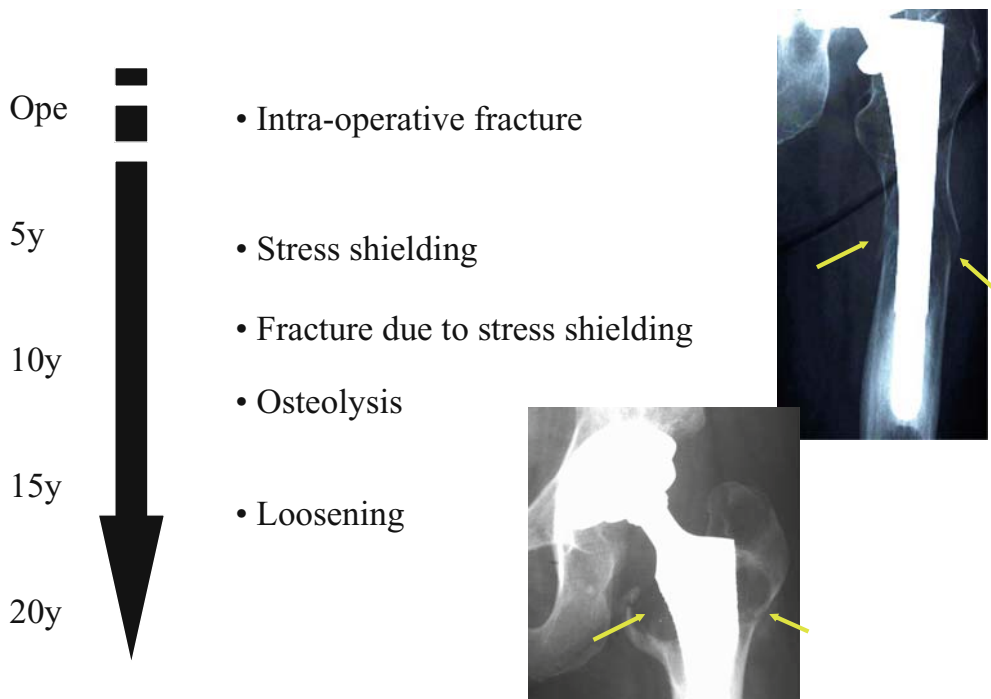* $P < 0.0001$

Failures of cementless cup after operation

Ope.

5y   • Disruption of locking mechanism

10y   • Osteolysis

                   thin polyethylene linear
                   back side wear
15y   osteolysis through screw hole

            • Loosening

20y

Fig. 15. Failures of cement-less cup implants after operation

Failures of cementless stem after operation

Ope   • Intra-operative fracture

5y   • Stress shielding

            • Fracture due to stress shielding

10y   • Osteolysis

15y   • Loosening

20y

**Fig. 16.** Failures of cement-less stem implants (*arrows*) after operation

rate between cement and cementless THR by meta-analysis.[35] Regarding revision surgery on one or both the cup and stem as the failure, cement THR was slightly superior (Fig. 17). However, when revision surgery of the cup or the stem was regarded as failure, there was no significant difference. At present, it cannot be concluded which is superior.
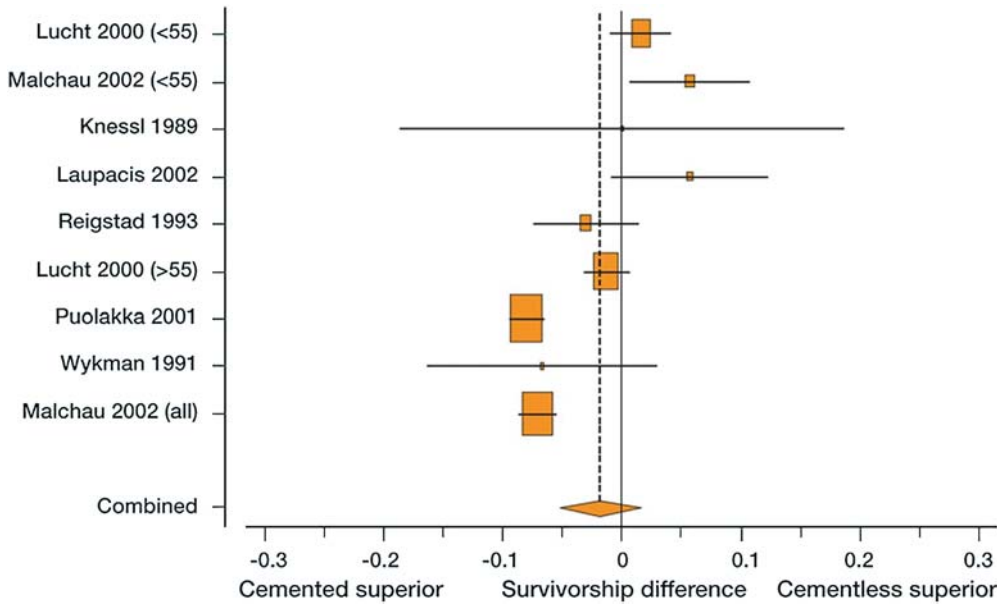
Fig. 17. Meta-analysis of cement and cementless THR. The survival rates between cement and cementless THR were analyzed by meta-analysis. Regarding revision surgery on one of these devices or both the cup and the stem as failure, cemented THR was slightly superior[35]
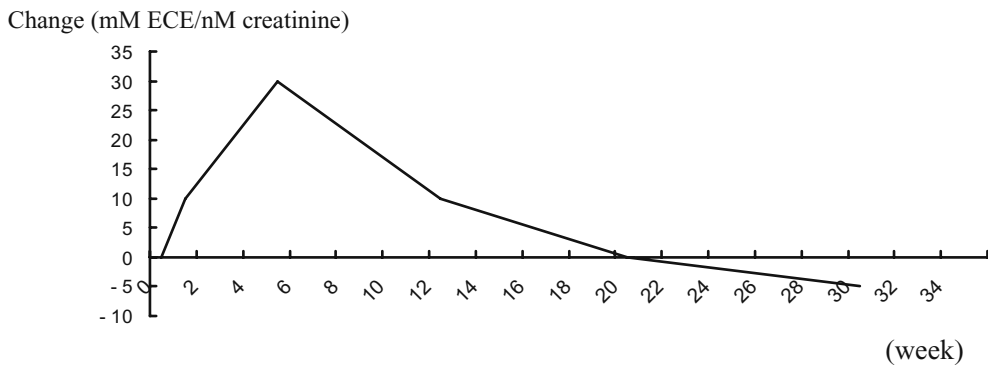
Fig. 18. Bone resorption after cementless THR. A marker of bone resorption (NTX-I) was measured after the THR operation. Peak bone resorption was observed at 4–5 weeks after operation. Surgical stress-induced marked bone resorption occurred immediately after surgery. In contrast, stress shielding-induced bone resorption progressed slowly but continuously
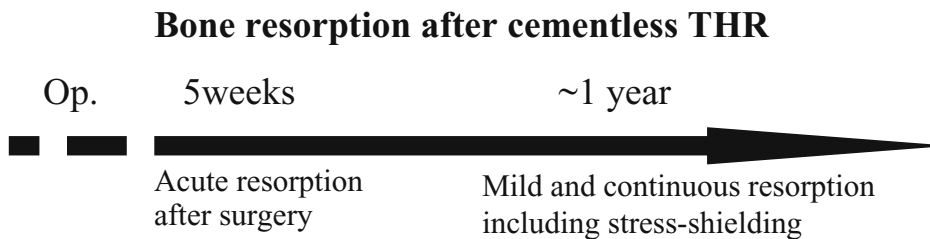
New attempt

An attempt to improve clinical outcomes of cementless THR using bisphosphonate preparation is underway. When bone resorption after cementless THR was evaluated based on a urinary marker of bone metabolism, NTX, the maximum level was detected about 5 weeks after surgery (Fig. 18). Surgical stress-induced marked bone resorption occurred immediately after surgery. In contrast, stress shielding-induced bone resorption continuously progressed slowly. It has been reported that marked bone resorption by 6 months after surgery was inhibited by oral administration of alendronate, and this effect was particularly marked in zone 7.[36] However, the effect of bisphosphonate on the most problematic long-term stress shielding was unclear. A meta-analysis of six randomized controlled trials suggested that bisphosphonates have a beneficial effect with regard to maintaining more periprosthetic bone mineral density than that in controls.[37] Because bisphosphonate disturbs bone mineralization, a negative effect on bone ingrowth following the surgery of cementless THR was of concern,

but zoledronate bound on the surface of porous implant enhanced binding of the implant to bone, increasing the pull-out strength in a canine study.[38]

Conclusion

Cementless THR has specific problems, and it was inferior to cement THR with regard to at least wear of polyethylene in many reports. Cemented THR has been increasingly selected in Sweden because the revision rate following cemented THR was lower than that following cementless THR in the Swedish Total Hip Replacement Register.[39] Why then, do surgeons increasingly use cementless THR today? In my personal opinion, biological fixation, in which the prosthesis is directly fixed to the bone, is an ultimate fixation method; and the absence of cement may be considered to reduce a mechanically unstable interface. Expectation for innovations (e.g., materials, surface property, implant design) aiming at further improvement of outcomes attracts many operators. In any case, whether cementless THR remains a truly useful procedure for hip arthroplasty depends on detailed investigations by unbiased orthopedic surgeons.

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