MRI appearances of Aseptic Lymphocytic Vasculitis-Associated Lesions in metal-on-metal hip replacements.

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Learning objectives

The purpose of this study is to illustrate the MRI appearances of surgically proven Aseptic Lymphocytic Vasculitis-Associated Lesions (ALVAL) in metal-on-metal (MoM) hip replacements.
Background

There has been a recent vogue in managing the younger patient with debilitating hip arthritis with a hip resurfacing arthroplasty (HRA) which has a MoM bearing surface.

There are multiple reasons for using this type of total hip replacement (THA) instead of the traditional polyethylene acetabular cup THA. The larger diameter of the MoM articulating femoral head reinforce the joint stability and eliminates the risk of dislocation. Furthermore, MoM implants provide quite satisfying preservation of bone stock and restoration of hip biomechanics. However, the most important advantage of the MoM THA is the low long term wear percentages, and consequently the reduction in number of operations a young candidate would have [4]. The overall survivorship rates of the newer MoM HRA with cobalt-chromium-molybdenum bearing at 5 and 10 years is 98% and 94% respectively [2].

However, by now it is well established that they are associated with periarticular soft tissue changes which have been described with various names as Adverse Local Tissue Reaction (ALTR), Adverse Reactions to Metal Debris (ARMD), Aseptic Lymphocytic Vasculitis-Associated Lesions (ALVAL), metallosis and pseudotumors. Although the exact cause of these soft tissue changes is not yet well understood, it is thought to be a type IV hypersensitivity reaction to shedding of metallic particulate debris [3]. They can have quite catastrophic effects with associated low success rates following revision.

There is a wide range of clinical manifestation, including absolute absence of any clinical symptoms. Several studies have suggested that the presence of ALVAL demonstrate no significant difference in symptoms when the painful MoM THA compared with the asymptomatic well-functioning MoM THA [2].
Imaging findings OR Procedure Details

Current MR sequences with metal artifact reduction software satisfactory demonstrate hip joints with MoM prosthesis, thus providing diagnostic images and allow identification and characterization of ALVAL. In our department the metal artefact reduction sequence (MARS) MRI protocol includes a coronal and axial T1 weighted sequences, a sagittal and axial T2 weighted sequences and a coronal STIR sequence.

I. NORMAL POSTOPERATIVE FINDINGS

It is very important to be familiar with the expected post-operative appearances; otherwise there is potentially a lot of confusion between these and the actual abnormal findings.

Usually there is no indication for MR imaging of a MoM THA in the immediate postoperative period and therefore these findings have not been systematically studied.

Small simple fluid collections like seromata and postoperative haematomata are included in the normal immediate postoperative findings [1]. Homogeneous fluid signal collections surrounded by a thin capsule can guarantee the non-complicating nature of these lesions.

The type of surgical approach can also lead to different types of findings. The modified lateral approach includes splitting of the gluteus medius muscle fibres, which may lead to various degrees of gluteus medius muscle atrophy and the creation of a potential space communicating with the trochanteric bursa [1].

At the posterior approach the gluteus maximus may be incised, the gluteus medius and minimus muscles are retracted and the short hip external rotators are cut. Whether there is reattachment or not, there is inevitable atrophy of the short external rotators which is more pronounced at the piriformis, obturator internus and quadratus femoris [1].

Years after the MoM THA, patients can present with pain around the hip joint due to benign causes like simple iliopsoas or trochanteric bursitis (Fig. 1 on page 8) or haemorrhagic collections following a fall (Fig. 2 on page 8) with no evidence of ALVAL.

II. SOFT TISSUES CHANGES RELATED TO ALVAL

Great attention should be given on both soft tissues and bones.

ALVAL can look like simple fluid collections, solid or mixed lesions on MRI, which are always in communication with the hip joint (Fig. 3 on page 9, Fig. 7 on page 13C) [4, 5].
A fluid distended thin-walled non-communicating iliopsoas or trochanteric bursa is not believed to represent true ALVAL [5].

ALVAL are always surrounded by a thick ragged capsule which demonstrates isointense T1 signal intensity and very low T2 signal intensity (Fig. 7 on page 13, Fig. 8 on page 14, Fig. 9 on page 15) [2, 5]. The capsule's low signal is thought to be caused by the susceptibility artefacts generated by the deposition of microscopic metallic particles [1].

- The fluid-like periprosthetic collections are isointense to muscles in T1 weighted sequences and hyperintense in T2 weighted sequences and are surrounded by a discrete thick and irregular low signal capsule (Fig. 9 on page 15, Fig. 8 on page 14). It has been suggested that most commonly are found posteriorly, through defects in the posterolateral capsule, following posterolateral approach [1].
- The solid periprosthetic masses are similarly isointense to muscles in T1 weighted sequences and demonstrate heterogeneous intermediate signal intensity in T2 weighted sequences [1] (Fig. 11 on page 17). The capsule of these lesions may be not as discrete as previously mentioned, since it can blend with the core of the mass [5]. It has also been suggested that these solid masses occur mainly anteriorly reflecting a distended iliopsoas bursa.
- The mixed lesions demonstrate mixed characteristics of both the previously mentioned types and can be found around the hip joint with no specific preference (Fig. 12 on page 18). The location of the collection was believed to be related to the surgical approach, but it is now believed that it is related to pathways of least resistance [5, 6], created by the capsulotomy. It is worth mentioning that the MoM THA requires full capsulotomy and that the surgery is likely to create new pathways and potentially new spaces [5, 6].
- Fluid collections can also demonstrate atypical signal features with low or increased T1 and T2 signal intensity (Fig. 10 on page 16, Fig. 13 on page 19). Whether this is related to increased proteinaceous components or increased metal concentration is yet debatable [6].

At the following intraoperative video you can see the appearance of the fluidish and solid components of an ALVAL during a THR revision (Fig. 14 on page 20).

The ALVAL can demonstrate various patterns of extension within the muscle compartments (Fig. 15 on page 21, Fig. 18 on page 24). Muscle infiltration of the gluteal, quadriceps, adductors or hamstrings compartments can be found, probably following the pathway of low resistance. They can also penetrate the deep fascia and extend into the subcutaneous fatty tissues or they can extend along the iliopsoas tendon into the pelvis (Fig. 11 on page 17).

Apart from the muscle infiltration by an ALVAL, post operative muscle atrophy (regardless of the type of prosthesis used) is also a common finding, but by no way specific for ALVAL.
The short external rotators atrophy (Fig. 16 on page 22), the adductor muscles or the gluteal muscles (Fig. 17 on page 23) can be involved.

As the ALVAL progresses involvement of the obturator, sciatic (Fig. 18 on page 24) or femoral nerves may appear.

III. BONE CHANGES / OSTEOLYSIS RELATED TO ALVAL

Bone marrow oedema is the main feature in cases of ALVAL induced osteolysis of the proximal femur or of the periacetabular area. However susceptibility artefact can mimic bone marrow oedema. Therefore T1 marrow signal changes, replacing the high signal fatty marrow is a safer feature to rely on (Fig. 19 on page 25, Fig. 20 on page 26, Fig. 21 on page 27). It is also well recognised that the degree of osseous changes is underestimated with the MRI in comparison with the findings during the surgery [1].

Periprosthetic fractures can also occur in association with ALVAL, but they are also not specific.

ALVAL on MRI do not necessarily mean need for intervention [5]. Therefore Anderson et all developed a grading system [3] which in combination with blood tests and clinical examination helps in desicion making regarding these patients.

<table>
<thead>
<tr>
<th>GRADE</th>
<th>DESCRIPTION</th>
<th>CRITERIA</th>
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<tbody>
<tr>
<td>A</td>
<td>Normal or acceptable</td>
<td>Normal post-op appearances including seromas and small haematomas</td>
</tr>
<tr>
<td>B</td>
<td>Infection</td>
<td>Fluid-filled cavity with high signal wall; inflammatory changes in soft tissues; +/- bone marrow oedema</td>
</tr>
<tr>
<td>C1</td>
<td>Mild MoM disease</td>
<td>Periprosthetic soft tissue mass with no hyperintense T2W fluid signal or fluid-filled periprosthetic cavity; either less than 5cm maximum diameter.</td>
</tr>
<tr>
<td>C2</td>
<td>Moderate MoM disease</td>
<td>Periprosthetic soft tissue mass/ fluid-filled cavity greater than 5cm diameter or C1 lesion with either</td>
</tr>
</tbody>
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of following; (1) muscle atrophy or oedema in any muscle other than short external rotators or (2) bone marrow edema; hyperintense on STIR

C3 Severe MoM disease

Any one of the following: (1) fluid-filled cavity extending through deep fascia, (2) a tendon avulsion, (3) intermediate T1W soft tissue cortical or marrow signal, (4) fracture

According to Anderson et al [3] ALVAL classified as C3 require urgent intervention, though ALVAL which are classified as C2 can be managed with revision surgery electively. C1-classified ALVALs require no immediate intervention, but clinical review and one year follow up MRI, unless patient's symptomatology changes rapidly.
Fig. 1: Patient with bilateral MoM total hip replacement. (A) Axial T2 and (b) axial T1 images. Bilateral thin walled fluid distended trochanteric bursa. No evidence of communication with the hip joint. No evidence of ALVAL.

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**Fig. 2:** Patient with a left MoM total hip replacement 4 years ago presented with pain at the left hip following a fall. (A) Axial T2, (B) axial T1, (C) Axial T1 with GAD and (D) Cor T1. MRI showed a large bi-lobed well defined lesion with thin wall and heterogeneous high T1 (B,D) and T2 signal (A) and no significant enhancement (C). The overall appearance (taking also into account the patient’s recent history of a fall) is typical of a hemorrhagic collection.

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Fig. 3: Patient with a right MoM total hip replacement. (A) Axial T2 at the level of the greater trochanter, (B) Sagittal T2. MRI showed an anterior thick walled homogeneously increased T2 signal collection which clearly extended towards the prosthesis of the joint (arrow in A and B). Posterior extension was also demonstrated. ALVAL was confirmed in the operation.

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Fig. 4: Same patient as in figures 5,6,7. Patient with bilateral MoM total hip replacement. Routine AP hip x-ray shows osteolysis (arrow in A) of the right acetabular roof but the patient was not symptomatic. 1 year later (B) the patient experienced increasing pain over the right hip joint and the follow up x-ray showed again the acetabular changes with no evidence of progression (arrow in B). New finding is collapse of the femoral neck and loosening of the femoral component (thick arrow in B).
Fig. 5: Same patient as in figures 4, 6, 7. CT performed for further characterization of the osseous changes, demonstrating clearly the periacetabular osteolysis (stars in A and B) and an incidental most likely fluid-distended left iliopsoas bursa (arrow in C).

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Fig. 6: Same patient as in figures 4,5,7. AP hip x-ray following revision surgery of the right hip.

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Fig. 7: Same patient as in figures 4, 5, 6. Although the patient was not symptomatic on the left side, an MRI performed 3 months following the revision of the right hip for further characterization of the left sided distended iliopsoas bursa. There is a thick walled low signal irregular capsule and direct communication between the collection and the prosthesis via a narrow neck (arrow in C) strongly suggestive of ALVAL. Incidentally noted thin walled collection posterior to the right revised hip, considered to be postoperative seroma (thick arrow in A).

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Fig. 8: Patient with a left MoM total hip replacement. Axial T2 images and (B) Sag T2 images. MRI showed a fluid collection with typical distribution of trochanteric bursitis (long arrow in A and B). There is however evidence of a narrow neck extending medially towards the neck of the femoral prosthesis (short arrow in A). The capsule is also focally mildly thickened and irregular. The findings were suggestive of ALVAL, which was confirmed in the operation

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Fig. 9: Patient with bilateral MoM total hip replacement. (A) Axial T2 at the level of acetabular roof, (B) Axial T1 at the same level, (C) Sagittal T2, (D) Coronal STIR at the level of posterior acetabulum. MRI shows a thin walled high T2 and low T1 signal fluid distended iliopsoas bursa (thin arrow in A, B and C) and an isointense T1 and high T2 signal fluid collection with a thick irregular very low signal wall at the posterolateral aspect of the RT hip (thick arrow in A, B and D), which was proved to be ALVAL.

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Fig. 10: Patient with a left MoM total hip replacement. (A) Axial T2, (B) axial T1, (C) Coronal STIR and (D) Sag T2. MRI shows a thick walled small posterior collection with high T2 (A and D) and STIR (C) signal and low T1 signal (B), surrounding the neck of the femoral prosthesis. A small anterior component of the fluid collection was also noted on the sagittal sequence (short arrow in D). Operation confirmed ALVAL

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**Fig. 11:** Patient with a left MoM total hip replacement. (A) Axial T2, (B) Axial T1 images at the level of the acetabular roof, (C) Axial T1 images at the level of the femoral prosthesis and (D) Sag T2 images. MRI showed an anterior collection with heterogeneous but very low T2 signal (yellow arrows in A,D) and intermediate T1 signal (yellow arrow in B) which reaches the neck of the femoral prosthesis (arrow in C) and tracks into the pelvis, along the course of iliopsoas tendon. ALVAL was confirmed in the operation.

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Fig. 12: Patient with right MoM total hip replacement. (A) Axial T2, (B) axial T1, (C) Coronal STIR and (D) Sag T2. MRI shows an irregular thick walled fluid collection (yellow star) almost surrounding the femoral prosthesis with homogenously increased T2 signal (A) and low T1 signal (B). The collection extends proximally involving the neck of the femoral prosthesis (arrow in C) and demonstrates multiple nodular mural thickening (arrows in D). It was proved to be ALVAL.

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**Fig. 13:** Patient with left MoM total hip replacement. (A) Axial T1, (B) Axial T2 images at the level of the greater trochanter, (C) Cor T1 images at the level of the posterior acetabulum and (D) Sag T2 images. MRI shows a posterior collection with relatively high T1 (A and C) and T2 signal (B and D) surrounded by a low intensity capsule and extending medially towards the neck of the femoral component (long arrow in A and B). Operation confirmed ALVAL

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Fig. 14: Intraoperative video showing the cystic and solid components of the ALVAL.

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Fig. 15: Patient with a right MoM total hip replacement presented with increasing pain. (A) Axial T2, (B) Axial T1 at the level of the right greater trochanter. (C) and (D) Axial T2 images one year after revision. MRI showed a high T2 and low T1 signal collection at the anterior and posterior aspects of the right hip (yellow arrows in A and B) with a thick ragged capsule, in communication with the joint and extension into the obturator internus muscle (star in A and B). One year following revision surgery simple thin walled fluid distended iliopsoas bursa (arrow in C) and trochanteric bursa (arrow in C) were noted.

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Fig. 16: Patient with left MoM total hip replacement. T2 axial image of the lower pelvis. There is clear evidence of volume loss and fatty infiltration of the obturator internus (red arrow), quadratus femoris (yellow arrow) and adductors (yellow star). No evidence of ALVAL.

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**Fig. 17:** Patient with right MoM total hip replacement and left metal on polyethylene hip replacement. (A)AP X-ray of the pelvis (B)Axial T1 at the level of femoral head prostheses. Muscle atrophy is a common associated but not diagnostic finding of ALVAL changes. MRI shows bilateral gluteal muscles atrophy, mainly however on the left side (yellow star).

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**Fig. 18:** Patient with right MoM total hip replacement. (A) Axial T2, (B) axial T1, (C) Coronal STIR and (D) Sag T2. A large fluid collection (yellow star in A-D), which demonstrates heterogeneous high T2 and isointense T1 signal, is noted at the medial, posterior and lateral aspects of the right hip. The collection posteriorly displaces the sciatic nerve (yellow arrow in A-D) and also extends medially through a defect of the short external rotators (red arrow in B). More distally (C) the changes involve also the lateral aspect of the vastus lateralis (white arrow) and also extend superficially underneath the tensor fasciae lata (yellow star). ALVAL was confirmed in the operation.

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**Fig. 19:** Patient with left MoM total hip replacement. Coronal T2 (A) and T1 (B) at the level of the posterior acetabulum. Intraosseous ALVAL extending into the acetabulum. The changes demonstrate isointense T1 signal and high T2 signal surrounded by a very low signal rim (yellow arrows).

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**Fig. 20:** Same patient as figure 18. (A) axial T2 and (B) axial T1 at the level of the roof of the acetabulum and (C) axial T2 and (D) axial T1 at the level of the inferior pubic ramus. Intraosseous ALVAL extending into the acetabulum and the inferior pubic ramus. The changes demonstrate isointense T1 signal and high T2 signal surrounded by a very low signal rim (yellow arrows). Compare the inferior pubic ramus appearance with the contralateral normal side (red arrow)

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**Fig. 21:** Patient with a right MoM total hip replacement. (A) Axial T2 and (B) Axial T1 images at the level of the greater trochanter, (C) Axial T2 image at the level of the greater trochanter slightly higher than A and B, (D) Sag T2 image and (E) Cor STIR image through the posterior acetabulum. Axial images demonstrate a thick and irregular walled collection with high T2 signal (A, C and D) and low T1 signal (B) that occupies the iliopsoas bursa (long arrows). Multiple ALVAL changes also noted at the posterior aspect of the hip joint (short arrows at D). Apart from the soft tissue changes, a single focal bony erosion seems to involve the posterosuperior aspect of the greater trochanter (thick arrow in C), a finding that was also confirmed on the sagittal T2 image (thick arrow in D). Associated bone marrow oedema is noted on the STIR image (arrow in E).

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Conclusion

ALVAL demonstrates typical features on MRI and radiologists should be familiar with these appearances since prompt and accurate diagnosis can alter significantly the patient's management.
REFERENCES