Total hip arthroplasty revision in case of intra-pelvic cup migration: Designing a surgical strategy

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Summary

Intrapelvic acetabular cup migration is a rare but serious complication, which can occur after cup loosening following total hip arthroplasty. To make safe intrapelvic implant removal, several principles must be respected: identification of potential risks with a thorough preoperative workup, preoperative planning of a surgical strategy for removing protruding hardware without injuring noble anatomical structures, preserving muscle and bone stock, pelvic anatomy reconstruction (including, as needed, osteosynthesis of the pelvis), and prosthetic components selection correcting any length discrepancy. Preoperative assessment is based on a complete radiological workup, angio-CT, as well as studies searching for signs of inflammation (blood workup and joint aspiration). All cases of intrapelvic migration of an acetabular component do not systematically command a subperitoneal approach. The presence of some residual bone shell, an intrapelvic foreign body, or a path deviation from normal in a vascular bundle or an ureter must be analyzed before deciding on the approach. The potential problems managing this mode of loosening event are a reminder for the need of periodical total hip arthroplasty follow-up. This regular monitoring helps preventing complications sometimes life threatening.

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Introduction

Intrapelvic cup migration is a rare but severe complication that can occur with loosening of a total hip arthroplasty (THA) implant [1]. Revision of this type of loosening event with intrapelvic material exposes the patient to a number of risks: neurovascular injury [1–3], involvement of the pelvic organs [4,5], and potentially lethal complications [1,6].
Figure 1  a–c: cases of small intrapelvic material (cup fixation screw) appearing to be nonthreatening on the standard x-rays. CT (with no injection because of an allergy to iodine) shows the narrow contact between the screw and the iliac vessels.

Compared to the 350,000 implant revisions done annually in the world [6], the prevalence of this type of complication seems rare, but its frequency is tending to increase because of the increase in life expectancy, the growing number of prosthetic implantations, and the greater frequency of mechanical loosening events after these procedures [6].

Intrapelvic cup migrations can result from several situations: mechanical loosening, malposition of the cup with chronic instability, infections, injury, etc. [5–9]. The term “intrapelvic migration” is retained when the material passes the pelvic inlet [10]. However, certain acetabular revisions present the same dangers for the noble structures, even though the x-rays do not show this limit has been surpassed and are therefore not suggestive of this danger. A screw or a stud that is too long, difficult to identify without CT or three-quarter images, can also expose the patient to the same risks (Fig. 1). These cases resemble the usual intrapelvic migrations but present an additional problem in that they often go unidentified without an in-depth preoperative workup.

Safe intrapelvic material removal is based on several inseparable principles: identification of the potential risks through a precise preoperative workup, surgical tactics designed to remove protruding material without injuring noble tissues, saving muscle and bone capital, reconstruction of the pelvic anatomy (including osteosynthesis of the pelvis), and prosthesis revision correcting any length discrepancy. The objective of this focus article was to evaluate the diagnostic and therapeutic strategy that should be adopted to manage intrapelvic cup migration of a THA.

Diagnosis

Severe intrapelvic protrusions of THA components occur in cases of chronic infection [5,7,8,10,11]. However, certain protrusions exist in cases of strictly aseptic mechanical loosening [7,12], notably in cases of major flaws in surgical technique [9] in rheumatismal disease [6,7,10]. The frequency of infections accompanying acetabular loosening with intrapelvic migration is very high, reaching 43% for Stiehl [10]. This high risk is probably secondary to communication between the subperitoneal space and the hip joint [13,14]. In a review of the literature, Stiehl [10] observed 11 established infections (with Staphylococcus aureus the most frequently found bacterium [6/11]) among the 16 cases of intrapelvic migration of hip prostheses.

In a review of the literature covering 50 cases, Bach et al. [7] observed a higher frequency of intrapelvic migrations after primary THA (31 cases) than following revisions (19 cases). The components threatening the noble organs were most often cement and screws (33 cases) than the cup itself (17 cases), whereas infection was observed in 27 cases out of 50. Bach et al. [7] collected complications occurring during revision of intrapelvic acetabular components. Of 50 complications, 22 involved vessels, 17 the urogenital structures (13 of which involved the bladder), six the digestive tract, three the sciatic nerve, and in two cases the iliopsoas muscle. All these complications therefore required an exhaustive and detailed preoperative workup.

Regional anatomy and preoperative workup

Vascular anatomy around the acetabulum

Before planning complex surgery to revise intrapelvic migration, the morphological and anatomical anatomy of the acetabulum must be well known [15,16]. The vascular system around the coxofemoral joint is complex, with numerous arterial and venous structures [15–17] (Figs. 2 and 3):

Common iliac arteries

These arteries originate in the division of the abdominal aorta at the fourth lumbar vertebra. The common iliac artery descends downward and outward, along the spinal column to its division into the external and internal iliac arteries at the caudal pole of the sacroiliac joint. The two common iliac arteries flow into the arterioles supplying the iliopsoas muscles and the ureters

External iliac arteries

These arteries are superficial in relation to the iliaca fascia, which is highly resistant. It isolates the iliopsoas muscle in contact with the bone from the iliac vessels. The external iliac artery, located 1 cm from the anterior cortex of the acetabulum, is relatively well protected by the thickness of the iliopsoas muscle [17].

Internal iliac artery (hypogastric)

Its origin projects inward and backward from the origin of the external iliac artery. It terminates most often opposite the greater sciatic notch either by two main anterior and posterior trunks or in an arterial bundle. The dividing branches supply three territories: intra- and extrapelvic parietal and visceral.
Iliolumbar artery
The iliolumbar artery follows a diagonal trajectory upward and outward and crosses behind the external iliac artery. It branches into the vertical lumbar and the iliac horizontal branches. In the sacroiliac obliterations, anastomoses with the last lumbar arteries (originating in the median sacral artery) and with the deep circumflex iliac artery provide functional collateral circulation.

Superior gluteal artery
This artery arises from the posterior trunk of the internal iliac artery. It has an extrapelvic portion (via the suprapiriform canal and the greater sciatic notch) and in its intrapelvic part, it evolves in the fatty tissue, which provides it with a certain mobility.

Inferior gluteal artery
The inferior gluteal artery arises from the anterior trunk of the internal iliac artery, which branches off the obturator, pudendal, umbilical, and other visceral arteries.

Obturator artery
This artery runs along the quadrilateral surface of the acetabulum protected by the internal obturator muscle. It is separated from the acetabulum by 0.2 cm in its inferior portion.

Internal pudendal artery
This artery supplies the perineum and the external genital organs.

External iliac vein
The anatomy and the trajectory of the external iliac vein are important factors that must be taken into account given the vein’s proximity to the medial acetabular wall (Figs. 2 and 3). The external iliac vein is located 0.3 cm from the medial pelvic wall in the acetabular dome portion. Along its ascending trajectory, the external iliac vein is located 0.5 cm from the anterior acetabular cortex protected by the close proximity of the pectineus muscle.

Anatomopathology of vascular lesions
Vascular injury is rare during primary arthroplasty implantation (frequency, 0.008—0.67%) but is very serious (mortality rate, 7%) with significant morbidity [1,18–22]. During revision to remove intrapelvic material, these vascular injuries are more frequent because of the displacement and/or fibrosis of vascular structures as well as the possible presence of metallosis [1,18,19,23] or infection and the surrounding inflammatory reaction, which attracts the vascular structures [6,13]. This makes prosthetic revisions the source of 39% of vascular injuries involving hip arthroplasties [6]. This risk is higher in cases of a history of vascular disease or irradiation [1].

During THA revision, vascular injury involves, in descending order [1,20]: the external iliac artery, the common femoral artery, the external iliac vein, the internal iliac artery, and the gluteal vessels [24,25] (Figs. 2 and 3). The type of vascular lesion is classified into four groups: laceration, thrombosis, pseudoaneurysm, and arteriovenous fistula.
Figure 4  a, b: analysis of psoas muscle and iliac vessels on angio-CT is decisive to decide the adequate approach. a: a major intrapelvic migration of a Kerboull cross that has traversed the psoas and vessels. Revision through the transperitoneal approach, with the psoas judged to be partially traversed; b: lord cup with intrapelvic migration and displacement of the psoas and vessels. The approach was subperitoneal and the iliopsoas judged not to have been traversed.

[17]. Other than the intrapelvic implantation of prosthesis material, the surgical act can itself be the cause of injury, if retractors are improperly placed on the anterior wall or because drilling or insertion of screws is too deep [1,20], even from a cement fragment in contact with the noble structures and the exothermal reaction related to polymerization [6,17,24]. During revision surgery, it seems preferable to use foam retractors than the more aggressive pointed retractors. Use of reconstruction cages can spare cementing directly in the cavity impaired by bone substance loss and thus limit the risk of cement escaping [6,7,24]. Particular attention should be paid to measuring the size of the screws during pelvic bone plating or reconstruction cage fixation [20].

Preoperative vascular workup

Other than the proximity of vascular structures, the workup should look for abnormalities on the vessels such as false aneurysms or arteriovenous fistulae that may have developed in contact with the cement studs, a screw, or the cup [1,17,23–26]. The best exam to clarify the locations of the various structures and search for any abnormalities in contact with the implants is currently the angio-CT with venous return. It is probable that angio-MRI has better performance but today it remains disturbed by artifacts related to the prosthetic material [1,27]. In any event, angio-CT is vital to guide the therapeutic strategy: either the noble tissues appear to be intact and continuous and this investigation indicates that it is possible to undertake revision through the hip approach with no vessel workup beforehand or there is vessel displacement or an abnormality of the vascular trajectory, or simply in case of doubt, this exam leads to direct release of the vessels so that the implants can be removed safely. For Stiehl [10], migration of an implant beyond the ilioinguinal line systematically means there is displacement of the external iliac vessels as well as the femoral nerve, requiring a double approach. Finally, with migration near the vessels, this exam clarifies the status of the iliopsoas muscle, which conditions the approach for checking the vascular structures and extracting the material: the subperitoneal approach can be recommended if the iliopsoas muscle is intact [8,11,12]; if this muscle is injured or destroyed, a subperitoneal approach can be envisaged to simplify later procedures, but if the noble structures are threatened, the transabdominal approach may be preferred [13,28] (Fig. 4). The angio-CT workup is not systematic, however, in particular if there is a continuous bony capsule that allows the lesions to be separated or if neurovascular structures are nearby. On the other hand, at the least doubt, in particular if there is doubt on the position of all or part of the material, this workup is necessary to prevent unexpected discoveries during surgery, a potential source of serious complications (Fig. 1) [1,2,7]. The angio-CT is preferable to simple angiography, which does not provide sufficient mapping because certain anatomical structures are superimposed (Fig. 5). Angiography does not provide the distances between implants in the intrapelvic position and the noble structures. Angio-CT should systematically be done during the late phase for the venous return study and the urinary tract study.

Figure 5  a, b: because of superimpositions, subtraction angiography (a) contributes less information than angio-CT (b) to visualizing the vascular structures.
Acetabular revision for intrapelvic cup migration

Since protrusion is most often a progressive phenomenon, it can lead to scarring and the formation of a thick capsule around various components [28] and sometimes a continuous bony capsule that provides relative protection of the surrounding noble structures [7,11,12,29], but vascular ulcerations [25,26] and even injury to the pelvic organs [5,24] have been observed as have symptoms related to the incorporation of the noble organs in this neocapsule [11,30]. The same reasoning can be applied to the presence of intrapelvic foreign bodies. Angio-CT is required in all cases [22]. Apart from the rare cases of a continuous bony capsule, angio-CT indications should be wide. Moreover, it allows searching for pelvic discontinuity, which can modify the surgical strategy using a specific complementary approach (ilioinguinal) for pelvic fixation.

Preoperative urologic workup

In case of preoperative signs involving urinary function or when the angio-CT illustrates close proximity between the cup implant and the ureteral tract (Fig. 6) or during persistent infection of the operative site, a lesion of the urinary system should be suspected [13,31].

Different pathways between the hip joint and the lower urinary tract or the genital apparatus have been described after THA: vesicoacetabular fistulization [31–33], ureteroarticular fistulae [34–36], and hip-vaginal fistulae [4]. The most frequent lesions of the urogenital system after THA are ureterocacetabular and ureterovaginal fistulae whose clinical diagnosis is difficult [13,37–39]. Other than a complete clinical exam including pelvic examination and opacification, their diagnosis is not easy [8,13,39] and one must be particularly attentive to the urinary function signs and the proximity of the implants with the ureter trajectory [40].

In practice, with intrapelvic material, it is prudent to perform preoperative opacification of the urinary tract. As a matter of principle, this can involve the late phase on the angio-CT, or in cases of narrow passages with the urinary structures of preoperative manifestations a urinary tract CT may be required [7–9]. The urinary tract CT localizes the lesions and can evaluate its repercussions on the kidneys [13,33]. It can help in planning preoperative ureteral catheterization immediately before the orthopaedic stage to secure the dissection and facilitate location of the ureter, which is occasionally extremely deviated during this type of revision surgery [13,33] (Fig. 6).

Digestive tract workup

Fistulae have been described between the hip and the rectum or the sigmoid colon [5,41,42]. Similarly, a fistula can form in the digestive tube causing pelvic bone substance loss [43]. These call for completing the preoperative workup with opacifications (digestive and/or articular with CT verification) when the digestive structures are exposed, which can result in a derivation procedure beforehand or at the time the intrapelvic material is removed [8,41–44]. A rectocolic endoscopy can be discussed, but the endoluminal pathway does not provide precise locations with the prosthetic structures and appears poorly adapted when perforation is suspected. The existence of digestive problems or the discovery of bacteria from the digestive flora (Escherichia coli, Salmonella, etc.) during articular aspiration is cause for searching for communication between the digestive tract and the joint [5,45]. For Bach et al. [5], intrapelvic migration of a loosened cup facilitates formation of a fistula with the digestive tube and secondary infection. Although very rare, this complication is particularly serious and can lead to patient death by multiorgan failure [5].

The infectious disease workup

The preoperative workup, in addition to the habitual tests, should include a blood workup for infectious diseases (blood cell count, sedimentation rate, C-reactive protein rate). Although puncture cannot be systematic, its indications should be broad, in particular if there is a history of infection, if the biological workup is abnormal, or if material migration cannot be explained by
mechanical failure phenomena [10,13]. Finally, if any doubt persists, it is indispensable to eliminate a low-key evolving infection by joint puncture, which would modify the conditions of material ablation and any prosthesis reimplantation [7,10,13,14,45]. The difficulties performing the puncture when the intrapelvic protrusion is severe must be underscored, thus requiring CT guidance both to identify the joint space and not to injure the neighboring noble organs.

Conclusions on the preoperative workup before intrapelvic material ablation

Other than searching for digestive, urinary, and/or gynecological function signs, the clinical workup should seek signs of neurological deficit and/or irritation that may signal nerve trunk and most particularly plexus compression when the material is in contact with the bottom portion of the sacroiliac joint, thus threatening the lumbosacral plexus. In practice, the preoperative paraclinical workup of intrapelvic migration of a THA should therefore systematically include:

- AP pelvic x-ray and AP and lateral hip images, if possible completed by three-quarter views to search for pelvic discontinuity that is not always identified on CT because of artifacts;
- angio-CT is the key exam for complementary exams showing other vascular components as they are related to nerve, urogenital, and digestive structures. This angio-CT should also include late phases for the exploration of veins and the lower urinary system;
- a complete blood workup.

Other exams are requested as needed depending on the preceding tests and the existence of suggestive clinical signs: in case of doubt concerning a urinary lesion or the close proximity between the intrapelvic material and the urinary tract, a urinary tract CT can confirm the lesion and its repercussions; digestive tract opacification if the angio-CT shows the intrapelvic material to be threatening the digestive structures.

Surgical strategy

Patient preparation

Digestive preparation is desirable in cases of close proximity between the intrapelvic material and the digestive structures, suggesting a possible digestive tract opening or if a digestive system lesion is immediately suspected from the preoperative workup. Cystoscopically guided retrograde placement of a double-J ureteral stent (Fig. 6) is recommended before the orthopaedic intervention to secure the dissection when the ureter and the intrapelvic material are in close proximity or there is ureteral deviation (infection, irradiation, iterative surgery) [13,32,39]. Dissection of the ureter that is in contact with fibrous tissues and retracted is difficult; manual intraoperative palpation with a double-J probe can easily locate and protect the ureter [13,32,39]. Similarly, complementary identification of the stent in place using an image amplifier can be helpful, as can the classical injections of methylene blue.

Approaches

Conventional approaches

Different approaches are possible (conventional and specific) to prevent injuring the noble structures during ablation of prosthesis components in protrusion situations. Evans et Nelson [8], Eftekhar and Nercissian [11], and Tazawa et al. [31] recommend a conventional approach if protrusion is moderate and if the protruded components are not in proximity of the noble structures. Therefore, infection with protrusion should lead to greater caution because of more pronounced inflammatory reactions and the possible retraction of noble structures in contact with infected tissues [13]. A transfemoral approach simplifies ablation of the components if there is also significant stiffness, but it does not provide specific protection of the noble structures [46].

For Shafi et al. [47], the conventional approach is systematically used however severe the migration may be. This reasoning is based on the fact that a conventional hip approach is more familiar and the risk of infection, ileus, and bleeding is greater with an abdominal or peritoneal approach. We believe that this tactic is debatable, particularly if the preoperative workup shows the possibility of surgical vascular lesion, a source of substantial morbidity and mortality, notably in cases of unexpected intraoperative bleeding [1].

In cases of pelvic migration of cement, it is possible to combine a conventional approach with the use of ultrasound instruments [30]. According to Smith and Eyres [30], this makes it possible to limit recourse to a specific approach for ablation of protruded material while avoiding significant traction of the acetabular component, a source of iatrogenic lesions. However, this method is costly and thermal lesions of the noble structures, in particular the nerve trunks, must be kept in mind.

Specific approaches

In cases of loosening with intrapelvic protrusion threatening the noble organs, a specific approach is recommended to ensure that the vessels and pelvic structures are under control [7,8,10,13]. Four types of surgical approach are possible.

The subperitoneal approach [11,12,48]

The patient is installed in the dorsal decubitus position on a standard table (possibly with a cushion under the ischium to disengage the buttocks). This approach can also be used in the lateral decubitus position with care taken to place the pubis inward. This installation allows a combined approach and mobilization by gravity of the peritoneal sac toward the table, thus facilitating exposure. The cutaneous incision follows a diagonal trajectory downward and inward a finger width inside the anterosuperior iliac tuberosity to the external edge of the right external oblique muscle. The aponeurosis of the external oblique muscle is incised
following the muscle fibers; then the aponoeures of the internal oblique and transverse muscles are penetrated. The peritoneum located immediately behind this plane must absolutely be kept intact and cautiously pulled back using abdominal compresses.

The edges of the iliopsoas muscle are then located to spare the femoral nerve. The primary iliac vessels must then be dissected and placed on external and internal ties. Abnormalities of the vascular structure trajectories should be anticipated with very meticulous dissection and by identifying the acetabular component. It should be extracted once its borders have been delimited so as not to create lesions on the noble structures during its extraction. The cup can then be removed under visual endopelvic guidance [1,44]. Alternatively, a second conventional hip approach (anterior, lateral, posterolateral, etc.) can be used and the cup extracted through the subperitoneal approach with extrapelvic guidance.

**The Mears triradiate approach [49,50]**

It has been described for fractures of the acetabulum but does not provide satisfactory control of the intrapelvic organs and should not be recommended in our opinion. On the other hand, the triradiate approach with an ilioinguinal extension provides adequate neurovascular control while allowing reconstruction of bone damage [49]. Moreover, for Stiehl et al. [50], extrapelvic extraction of the protruded cup through an extended triradiate approach controlling the noble structures through the ilioinguinal approach has been shown to be more logical and less damaging than the same procedure through the peritoneal approach. However, cup ablation through the lateral approach frequently requires a trochanteric or femoral osteotomy.

**The laparoscopic transabdominal approach [13,31]**

This is a classical median inferior laparotomy, executed on a subject in the dorsal decubitus position. Collaboration with the general and/or vascular surgeon is recommended. This approach safely controls the common and external iliac vessels as well as the ureter and the pelvic organs. Release of the subperitoneal space allows ablation of the cup and if required all of the implants [13]. However, the patient is exposed to laparotomy-related digestive tract complications (late resumption of bowel movements, adhesion occlusion, eventration).

**Combined simultaneous approaches [11,48,50,52]**

In cases with a double approach strategy, Petreria et al. [48] and Augereau et al. [51] perform a simultaneous double approach, whereas Eftekhar and Nercissian [11] prefer to perform this procedure in two distinct operations. This double-approach strategy must be defined on a case-by-case basis and depends most particularly on the duration of surgery, the bleeding observed during the abdominal procedure, and the presence of infection.

**Laparoscopy and celiac surgery [53—56]**

It may be useful to plan for laparoscopy to extract free foreign objects from the pelvic cavity [53], which has the advantage of simplifying the postoperative phase, but dissection can turn out to be difficult in patients with hip prostheses that have loosened and migrated [55], notably if infection is present [56].

**Choice of the approach**

If the noble structures are not endangered, notably in cases of continuous bony capsule, ablation and reconstruction can be performed through a conventional arthroplasty approach [32]. When the noble structures are already injured or threatened, most often the subperitoneal approach allows ablation of the acetabular component; then the femoral stem is withdrawn via a conventional hip approach (lateral, posterolateral, etc.). It is sometimes possible to remove the cup and the stem through the subperitoneal approach if the latter is loosened [8,13,47]. Once the cup and the migrated material have been extracted, if the stem is not loosened, it must be removed through a conventional revision approach, if need be, by performing a trochanteric or femoral osteotomy [46]. The objective of femoral osteotomy if it is not possible to dislocate the hip is to mobilize the implant downward so as not to produce a fracture if a strong force is to be used, then the second objective is to improve pelvic bone exposure [46].

Tazawa et al. [31] defined the respective indications for subperitoneal and transabdominal approaches depending on the condition of the iliopsoas muscle: if the muscle is intact, it ensures sufficient protection and the subperitoneal approach can be recommended; if the iliopsoas muscle is damaged and the components are in contact with the peritoneum, the transabdominal approach is preferred. Systematic use of the transabdominal approach can be discussed because of the severity of the postoperative condition [13], because sufficient vascular verification can be carried out through the subperitoneal approach [19], but if there is a direct threat to the noble and/or intrapelvic structures, laparotomy seems better adapted [13,31].

**Treatment of bone lesions**

In cases of associated bicolumn or T-fracture or transverse pelvic fracture [57], the ilioinguinal approach can allow first ablation of the acetabular component and cement and then reduction and osteosynthesis of the fracture (Fig. 7). The second phase, most frequently during the same anesthesia, allows acetabular reconstruction using cages (Fig. 7). It is possible to use a combined Levine-type approach [98], which associates an ilioinguinal and anterior acetabulum approach for reconstruction. Osteosynthesis of the posterior column is often necessary, which can be provided by the cage [59—63], but it cannot be the only element providing fixation; therefore, a complementary plate is necessary (either intrapelvic through the ilioinguinal approach or endocavitary) (Fig. 7) [60]. Bone substance loss can be reconstructed with morselized allograft material [60—63] or a solid graft [64]. In cases of pelvic discontinuity, an autologous graft is recommended to ensure healing with stable osteosynthesis (combined bone plating and reconstruction cage) [59—63].

The results of this type of reconstruction are rarely analyzed in large series because most of the results are reported as clinical cases: Kosashvili et al. [61] reports...
results at 5 years of follow-up with 88% survival using Burch-Schneider™ cages in Trabecular™ metal and morselized allograft with no complementary osteosynthesis despite pelvic discontinuity in the 26 cases analyzed.

Conclusions

Managing THA loosening with pelvic migration requires complete preoperative clinical assessment. The paraclinical workup includes a complete radiographic workup, an angiogram, CT, as well as a workup for inflammatory diseases (blood workup and joint puncture). This workup should be completed by other exams as dictated by the clinical signs (urinary or digestive system opacification, ultrasound, etc.). Depending on the results of this preoperative workup, it is possible to determine a therapeutic strategy (choice of the approach, revision in one or two stages, etc.). All intrapelvic migrations of arthroplasty material do not systematically require a subperitoneal approach. One must analyze whether a bone barrier, an intrapelvic foreign object, or an abnormality of the vascular or ureteral trajectory is present before choosing the approach.

If a subperitoneal approach is chosen, ureteral dissection needs to be secured, by placing a double-J ureteral stent. Laparotomy can be recommended when the psoas muscle is damaged and when the lesion threatens the noble structures. It provides broad exposure and direct visualization of all the pelvic structures. The difficulty managing this type of loosening indicates the need for constant THA monitoring before life-threatening complications arise.

Conflict of interest statement

None.

References


