Case report
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Disengagement of Polyethylene Insert Locking Mechanism in Modular Tibial Components for Knee Arthroplasty: A Case Report

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Abstract

Background. Modular tibial components for knee arthroplasty are used in the majority of modern knee replacement systems. Despite a number of limitations, there are many aspects that make these types of implants indispensable for orthopedic surgeons.

Aim — to demonstrate possible risks associated with a modular polyethylene liner with the use of a modular polyethylene insert with a metal fixator, taking a clinical case as an example.

Case description. We present a case of primary total knee arthroplasty in a 70-year-old female patient. The surgery was performed by an experienced surgical team and resulted in good early radiologic and functional treatment outcome. After discharge, approximately 10 days after surgery, the patient developed knee pain. Control X-rays showed migration of the metal pin locking the polyethylene insert. The patient underwent an emergency revision surgery with replacement of the insert. The authors analyze possible causes of this complication and ways of its prevention.

Conclusion. Migration of the insert locking element and dislocation of the insert in locked systems are quite rare complications of the knee arthroplasty. Their causes are soft tissue imbalance of the knee joint during arthroplasty and a number of technical errors. The very fact of using modular components of the joint is a predisposing factor for the disassociation of these modules.

Keywords: total knee arthroplasty, insert dislocation, arthroplasty complications.

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Клинический случай
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Разобщение фиксирующего механизма полиэтиленового вкладыша в модульном большеберцовом компоненте эндопротеза коленного сустава: клинический случай

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Реферат

Актуальность. Модульные большеберцовые компоненты эндопротезов коленного сустава используются в большинстве современных систем для замещения коленного сустава. Несмотря на ряд ограничений, имеется множество аспектов, делающих такие виды имплантатов незаменимым инструментом для ортопедического хирурга.

Цель — на клиническом примере показать потенциальные риски, связанные с использованием модульного полиэтиленового вкладыша с металлическим фиксирующим механизмом.

Описание клинического случая. Представлен случай первичного тотального эндопротезирования коленного сустава у пациентки 70 лет. Операция была выполнена опытной хирургической бригадой с хорошим ранним рентгенологическим и функциональным результатом лечения. После выписки, примерно через 10 дней после операции, у пациентки появилась боль в коленном суставе. На контрольных рентгенограммах была выявлена миграция металлической «шпильки», фиксирующей полиэтиленовый вкладыш. В экстренном порядке пациентке была выполнена ревизионная операция с заменой вкладыша.

Заключение. Миграция замыкающего элемента вкладыша и вывих вкладыша в фиксированных системах являются достаточно редкими осложнениями эндопротезирования коленного сустава. Причинами, приводящими к данным осложнениям, являются неадекватный мягкотканный баланс коленного сустава в ходе эндопротезирования и ряд технических ошибок. Сам факт использования модульных компонентов сустава является предрасполагающим фактором разобщения этих модулей.

Ключевые слова: тотальное эндопротезирование коленного сустава, вывих вкладыша эндопротеза, осложнения эндопротезирования.

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BACKGROUND

The modularity of the tibial prosthetic component, in addition to the possibility of using metal wedges, blocks, and stems during revision or primary complex knee arthroplasty, also implies the modularity of polyethylene inserts of various configurations [1]. The use of asymmetrical tibial components and inserts for right and left knee prostheses of different thicknesses and geometries (classic posterior cruciate retaining insert, ultra-congruent insert, posterior cruciate substituting insert) within one prosthetic system gives the orthopedic surgeon a greater freedom of action and numerous highly effective intraoperative options [2]. At the same time, it is obvious that the more modules there are, the higher risk of mutual wear, disassembly, and other types of mechanical damage is. In particular, the so-called backside wear, or wear of the backside of the polyethylene insert against the upper surface of the tibial component during flexion-extension cycles in the knee, is an important factor in the development of osteolysis and eventually revision of the artificial joint [3, 4, 5, 6].

The main tools that ensure the modularity of tibial components of modern knee prostheses are various mechanisms of polyethylene insert fixation. It should be noted that their disassembly and dislocation are extremely rare complications and, according to the data of E. Thienpont, account for 0.008% [7], which, nevertheless, does not make them less catastrophic and requires emergency revision arthroplasty with replacement of the modular elements.

Aim of the study is to demonstrate possible risks associated with the use of a modular polyethylene insert with a metal locking element, taking the following clinical case as an example.

CLINICAL CASE DESCRIPTION

A 70-year-old female patient came to the clinic of the Vreden National Medical Research Centre for Traumatology and Orthopedics for terminal left-sided knee osteoarthritis with varus deformity and combined contracture of the joint (Fig. 1).

Total knee arthroplasty was performed on the right knee a year earlier in the same department of the Center without perioperative complications and with a good functional result.

After preoperative preparation performed in accordance with the Center's protocols, total left knee arthroplasty with implantation of the posterior cruciate retaining prosthesis was performed using the standard medial approach (Fig. 2).

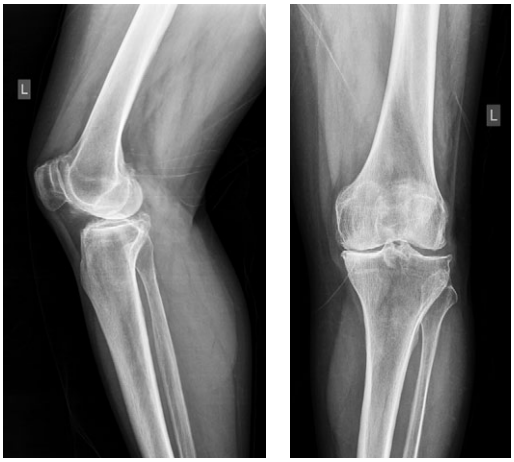

Fig. 1. Knee X-rays performed on admission to the clinic

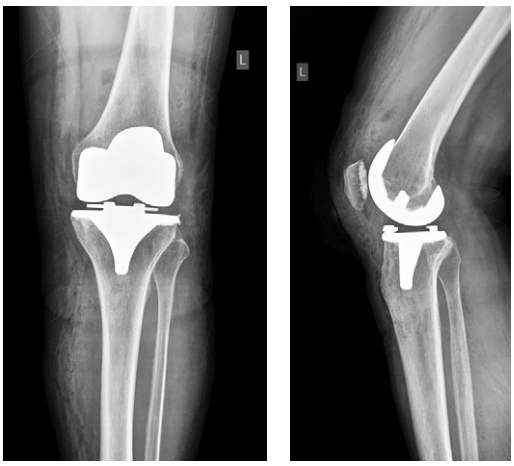

Fig. 2. Postoperative knee X-rays performed the day after arthroplasty

The operation was performed using a pneumatic tourniquet (tourniquet exposure time was 65 min) with minimal intraoperative blood loss. Surgical intervention time was 65 min. Implantation of the locking element (pin) was carried out without any technical difficulties. The pin was inserted into the groove with tight resistance, blocking the polyethylene insert. The operation was performed by an experienced

surgeon who had carried out more than 5,000 arthroplasties and was familiar with the Zimmer Biomet Vanguard system. This surgeon had also performed the arthroplasty in the patient's contralateral knee a year earlier.

The course of the early postoperative period was uncomplicated, and the patient was discharged in satisfactory condition on the 4th day of the postoperative period with a range of motion in the knee joint of 0°/0°/95° (extension/0°/flexion). At the outpatient stage, the patient continued rehabilitation at home, including walking with additional support with the use of crutches and perfoming physical therapy exercises. She reported that, unrelated to the injury, the slight pain that had been bothering her after the surgery became extremely pronounced within a few days, localizing in the anteromedial part of the knee, and the range of motion became limited. The patient addressed to her attending physician. X-ray control of the knee joint in two views was recommended: a migration of the insert fixator was found (Fig. 3).

On the day of referral, the patient underwent preoperative preparation and emergency revision surgery with replacement of the entire module (polyethylene insert and its metal fixator) with a new one (Fig. 4). Knee revision revealed no other injuries, signs of improper insert fixation, soft tissue impingement, frontal or sagittal instability of the prosthetic knee, "open book" symptom, or other problems that could be an obvious cause of the complication.

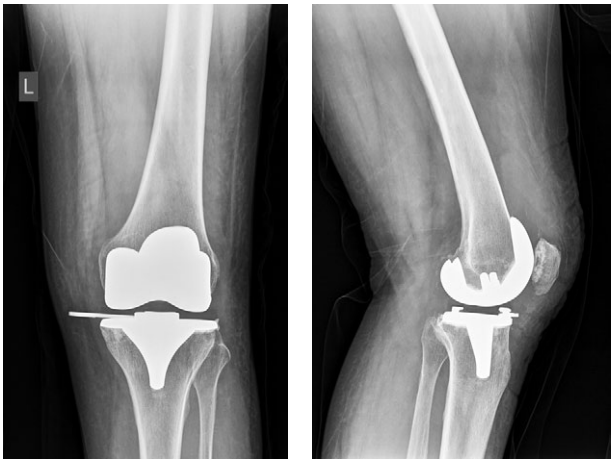

Fig. 3. Knee X-rays with signs of migration of the insert locking element

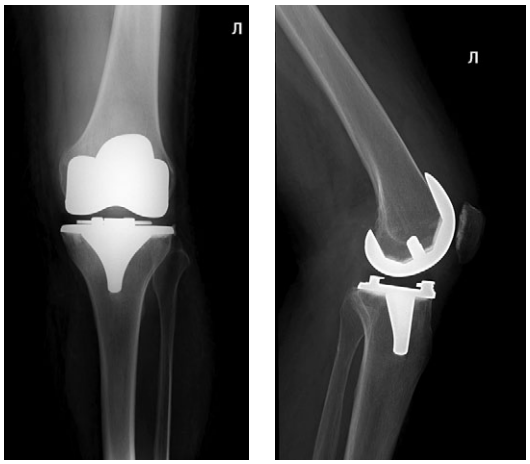

Fig. 4. Knee X-rays after revision surgery

Examination of the explanted insert and its fixator revealed no damage or manufacturing defects. The explanted module was handed over to Zimmer Biomet representatives, and its examination by expert technologists revealed no signs of manufacturing defects or mechanical damage to the fixation system. The postoperative period was uncomplicated, the patient underwent rehabilitation course and completed the treatment with a satisfactory functional result.

DISCUSSION

The complication we have described corresponds to the statement that a serious and often tragic event is caused by the actions that are, at first glance, not obvious and not too related to each other. For example, analyzing the course of the operation, we understand that the implantation of the insert is performed at the final stage of the surgery, when the attention of the operator and their assistants is distracted by the fact that the main, most complicated stages of the operation have been completed. Fixation of the insert is often performed in a hurry, as the cement begins to polymerize, and it is essential to remove excess cement and make sure that the components are placed correctly. At this stage, soft tissue impingement may occur in the locking element of the tibial component-insert module. The polyethylene component in the dovetail system may not fit into the thin metal slides and may not be fixed over the entire surface. The

fixation screw in central fixation systems may not be inserted coaxially with its channel, and these problems can be combined.

Current approaches to insert fixation systems in tibial components. Currently, all variants of fixation of plastic inserts in the metal tibial component can be divided into four main groups with variations: with linear fixation mechanism, peripheral fixation, central fixation or hybrid fixation.

The linear type of fixation is most often represented by the dovetail fixation mechanism, which has metal slides on the tibial component of the prosthesis, over which the polyethylene insert is impacted using the press-fit method (Fig. 5).

Peripheral fixation involves press-fit impaction of the polyethylene insert around the circumference of the tibial insert in the manner of a tight-fitting cap or plug (Fig. 6).

In the central type of press-fit insert fixation, the fixation of the insert in the tibial component is supplemented by the use of a central screw to stabilize the modular components (Fig. 7).

Hybrid fixation can have elements of several of the above-mentioned systems to ensure a high level of stability of the modular system tibial component-plastic insert, as, for example, in the case of the Vanguard implant by Zimmer Biomet (Fig. 8).

The need for different types of plastic insert fixation is heterogeneous in nature. For some types of prostheses, it is an inheritance of the parent prosthetic systems developed in the second half of the 20th century, for others it is an opportunity to design a different device from the competitors in one or another form that can show better fixation characteristics of the insert and less wear of the reverse side of the plastic surface. In practice, we observe that there are no perfect concepts of mechanical fixation and for each there are nuances that can lead to disassembly of the modular system [7, 8, 9].

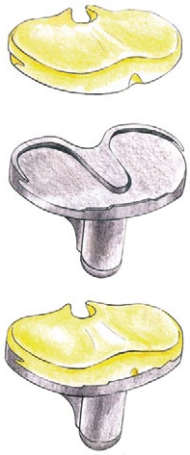

Fig. 5. Linear type of fixation of the polyethylene insert in the tibial component of the knee endoprosthesis (“dovetail”)

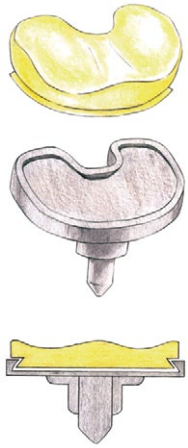

Fig. 6. Peripheral type of fixation of the polyethylene insert in the tibial component of the knee endoprosthesis

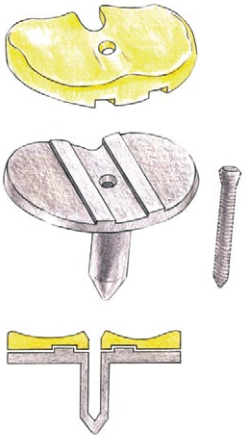

Fig. 7. Central type of fixation of the polyethylene insert in the tibial component of the knee endoprosthesis

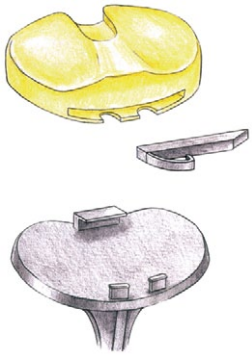

Fig. 8. Hybrid type of fixation of the polyethylene insert in the tibial component of the knee endoprosthesis

Risk factors for disassembly of the modular fixation system of the tibial component and the polyethylene insert. A common factor that can lead to disassembly of the insert and the tibial component or their locking elements is the ligamentous imbalance that persists after arthroplasty [7]. Even modern types of implants cannot fully imitate the native kinematics of the knee joint, and uncorrected pathological motion patterns in the artificial joint can lead to mechanical fatigue of some or other fixation elements [8, 10, 11].

Thus, for central fixation systems, in particular, for a number of revision systems where the polyethylene insert is fixed with a central screw, the realization of the so-called screw home mechanism of the knee is critical, which due to repeated rotational movements leads to unwinding of the polyethylene's fixator element [12, 13, 14].

The so-called lift-off ("open book") and pull-out (pronounced sagittal instability due to excessive height of the flexion gap) phenomena are more critical for central and peripheral fixation systems [15, 16]. In the first case, we are dealing with an unbalanced flexion gap that is tighter in the posterior regions (for example, if the posterior cruciate ligament has not been released), which leads to elevation of the anterior aspect of the insert. In the second case, the lack of sagittal stability due to a too big flexion gap leads to the development of a positive anterior drawer test.

The most critical pathologic motion pattern for hybrid fixation system, which was used in our case, is mediolateral instability due to constant micromotion of the insert, which leads to displacement of the fixation element, the so-called "pin" [7, 17].

Special attention should be paid to the disassembly of the insert from the tibial component in CCK/VVC systems, in which an additional factor that initiates insert disassembly is the increased frontal and rotational load on the plastic stabilizer [8, 13].

Content analysis of the modern literature covering the surgical problem under consideration shows that there are no clear patterns that can be identified in patients with this complication of arthroplasty. Thus, the authors point out that, as a rule, women suffer more frequently, and statistically more often joint replacement is performed in this gender group. According to the researchers' observations, this complication occurs after arthroplasty on the contralateral limb with a favorable outcome. The complication is registered after operations performed by experienced surgeons, which may only indicate that their sample is larger [7, 17].

This complication can occur with all known systems of insert fixation, with the only difference being that with the use of a pin fixing the insert, its migration becomes immediately obvious and forces the patient to consult a doctor, whereas a polyethylene insert fixation failure may remain undiagnosed for some time, even if X-ray is performed.

One of the solutions to this surgical problem, which might occur in all currently used modular systems for arthroplasty, is the wider use of all-polyethylene cemented tibial components (referred to in foreign literature as all-poly) or non-modular (monoblock) implants in which the plastic work surface is fixed to the metal at the manufacturing stage [4]. This is a good surgical option, as this type of orthopedic constructs has a number of clearly underestimated advantages [4, 18, 19]. This type of prosthetic component has no backside wear compared to modular systems for obvious reasons. The lack of modular mobility reduces the amount of wear products of the insert getting into the surrounding tissues. Consequently, osteolysis and aseptic loosening induced by polyethylene microparticles develop more slowly, which is an important factor for better survival of the implant [20, 21, 22].

The lower cost of all-poly and monoblock implants compared to modular tibial components is promising when implementing knee arthroplasty in economically less developed regions. This alternative option when choosing a tibial component allows for rational allocation of funding in case of a limited resource of one or another type of construction. In addition, it saves money in favor of increasing the number of knee arthroplasties performed without compromising the quality and hypothetical survival of the implants placed [4, 23].

An obvious disadvantage of all-poly and monoblock implants is the inability to use modular extension stems/augments in cases where this is necessary (revision arthroplasty, massive bone defects, etc.) [18].

The use of all-poly tibial components, especially with relatively thin plastic, may be associated with uneven loading on the cancellous part of the tibial metaphysis. Modular types of implants do not have this problem due to the distribution of peak impact loads over the entire surface of the metal tibial component, whereas all-polyethylene tibial components do not bypass the forces that are transmitted when the femoral component contacts the plastic work surface. This could theoretically damage the tibial component-cement-bone interface and lead to aseptic loosening in the long term [4, 19]. At the same time, there is a plethora of high-quality studies, including meta-analyses, convincingly showing comparable survival rates of modular and non-modular polyethylene knee prosthetic components [4, 18, 23, 24, 25].

The functional outcome of knee arthroplasty with all-poly and modular designs has no significant differences at all due to the identity of the working module "femoral component -polyethylene", which gives practitioners another reason for the wider use of all-polyethylene components in daily surgical practice [24, 25].

A number of orthopedic surgeons have an opinion about the age limits of all-poly use — this type of tibial components should be used in patients over 70 years of age, as well as in individuals with reduced physical activity and low functional demands [24]. But nowadays, due to excellent survival results and identical functional outcomes, we see a trend towards the use of all-poly components in younger individuals as well [18, 24, 26].

Despite the above-mentioned advantages of all-poly and monoblock tibial prosthetic components, most physicians still prefer to implant modular types of prostheses in their practice. The final argument seems to be that revision of modular systems often only allows for isolated insert replacement, which is a small and time-efficient operation. However, as the analysis of current literature, national registry data, and daily practice show, the percentage of such revisions is extremely low, because aseptic loosening of the prosthetic components is the leading cause of revision interventions [27, 28]. Most often, revision arthroplasties require removal of both the insert and the tibial metal component [19, 29]. Therefore, the main limitation of using all-poly and non-modular tibial components in arthroplasty obviously remains the prejudices of our colleagues.

CONCLUSIONS

Migration of the insert locking element and dislocation of the insert in fixed systems are quite rare complications of knee arthroplasty. Nevertheless, they are catastrophic in terms of the need for emergency hospitalization and the most urgent revision intervention possible. The causes of these complications include mediolateral, frontal, or other ligamentous instability and unbalanced isometric flexion and extension gaps. The cause of insufficient primary fixation of the insert in its metal bed may be the soft tissue impingement with a fragment of the joint capsule or synovial membrane, which was pinched during implantation of prosthetic components. The very fact that modular components are used during knee arthroplasty is a predisposing factor for the disassembly of these modules. Analysis of the modern literature does not provide a simple answer to the question: "How to avoid this complication?", except for the most obvious one – a wider use of non-modular systems (all-polyethylene components and monoblocks) in everyday practice.

DISCLAIMERS

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