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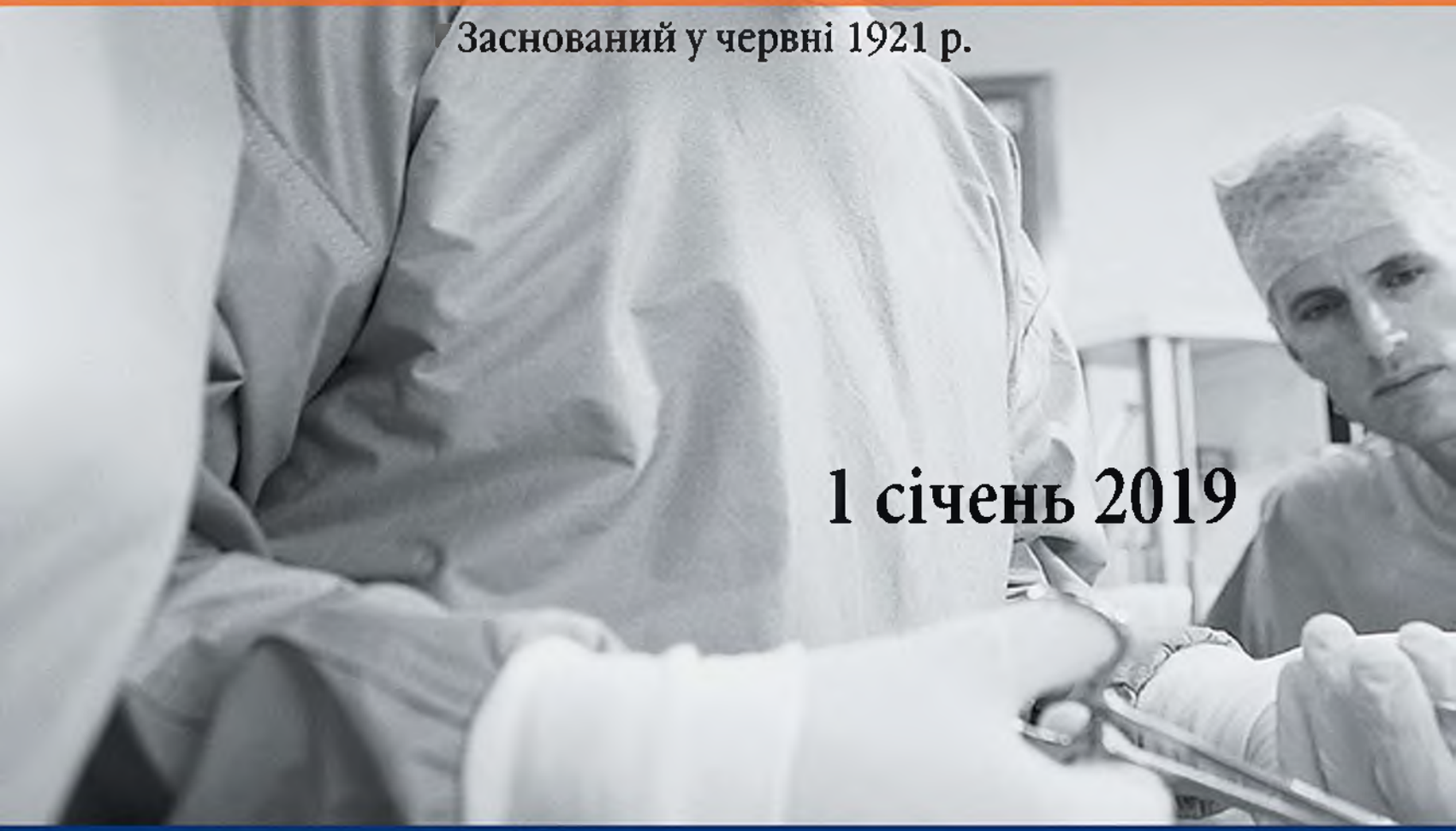

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Тотальне ендопротезування колінного суглоба за наявності кісткових дефектів

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Performing total knee replacement in cases with various degrees of bone loss

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Реферат

Мета. Проаналізувати основні фактори, які впливають на результати ендопротезування колінного суглоба за наявності кісткових дефектів, та їх зв'язок з попередніми оперативними втручаннями, переваги та слабкі сторони існуючих класифікацій.

Результати. Визначено варіанти хірургічного лікування кісткових дефектів, які можуть забезпечити кращу стабільність для ендопротезів.

Висновки. Важливо застосовувати кісткові трансплантати, які в процесі ремоделювання здатні забезпечити стабільність імплантатів у віддалені строки.

Ключові слова: кісткові дефекти; колінний суглоб; артропластика; хірургічне лікування.

Abstract

The paper analyses main factors that effect treatment results of total knee arthroplasties in cases of bone defects, such as a size and types of bone defects, their connection with previous surgeries, existing classification with their benefits and weak points. Authors show various possibilities of surgical treatment of bone defects that can provide better stability for prosthetic devices. The importance of bone grafts is highlighted as their remodeling provides the base for implant stability in late period of outcome.

Keywords: bone defects, knee joint, arthroplasty, surgical treatment

The number of primary total knee arthroplasties (TKA) is continuously increasing in different countries all around the world. The average rate for TKA is 175 procedures per 100 000 population, which grows annually on 5,3–17% in various countries [1]. The surgical procedure effectively resolves problems of the knee joint caused with injuries or degenerative process, but the number of complicated cases and revision TKA is increasing even more rapidly. These surgeries usually require more expenses and have a higher rate of complications [2]. The presence of a bone defect of knee articulating surfaces is considered to be a challenge for implant stability and treatment outcomes. Despite many clinical and experimental studies there is still a place for further research. For both primary or revision TKA we have to deal with defects of various types, sizes and location with sometimes unpredictable long–term results [3, 4].

Aim of research: to determine the types and variety of defects around knee joint and their influence on the replaced knee stability, to choose proper management for TKA according to the size and type of bone defect.

Results and discussion

Causes of defects. One of the common reasons is osteoarthritis in its advanced stage, that usually causes destruction of one of tibial condyles and clinically manifests as genu varus or genu valgus deformity. Another common reason is failure of treatment tibial or femoral condyle fracture with development of articular surface depression and malunion. But the most complicated cases are seen after TKA when the resection of tibial and femoral articular surfaces have been done, and especially in cases of instability and migration of endoprosthetic components.

Diagnosis of defects. In many cases the presence of bone loss is quite obvious from plane X–rays, due to disturbance of joint axis or prosthetic components migration, but to get a full description is not an easy task. So the main points that have to be clarified are:

location (tibial or femoral condyle, lateral or medial side; isolated or not, and their various combinations);

size of defect in three dimensions and expected volume of bone loss;

location of a defect according to the articular surface;

state of surrounding bone tissue.

presence of prosthetic components, bone cement and fixation devices (plates, screws or their parts) also should be noted, as their removal can increase the size of the bone defect.

Commonly used plane X–rays in two views (anterior–posterior and lateral) in many cases cannot reveal true picture

of knee bone defect, so additional oblique views should be performed [5]. But even various views of plane radioghraphy can`t show the true shape and volume of bone defect [6]. In our opinion a computed tomography with 3D modeling is required for preoperative planing in all cases. To reveal osteoporosis of bone tissue surrounding implant digital X–ray images may be analyzed with good sensitivity, but the same X–ray settings should be used for every patient in the study [7]. Another option is dual photon absorptiometry or computed tomography densytometry that provide better accuracy in measurements of periprosthetic areas and may be used both for comparison of injured and symmetrical knee joint, and for revealing changes from normal values of bone mineral density taken from existing databases [8].

Classification of bone defects. Many classifications of bone defects of the knee joint were suggested within last decades, attempting to describe the severity of bone loss. Some of them as Dorr, Rand and Massachusetts General Hospital classifications describe defects only in femur or tibia and do not cover their combine lesions [9]. Most of the classifications allow intraoperative assessment, and only classifications developed by Anderson Orthopaedic Research Institute (AORI), Massachusetts General Hospital, University of Pensilvania and by Huff & Sculco are suitable for preoperative planing [10, 11]. These classifications, as well as Bargar & Gross and Clatworthey & Gross, provide guidelines for bone defects management according to their type. Some classifications, as the one developed by University of Pensilvania, are not widely used because of their complexity [12]. So, among many, most of the authors use AORI classification, as it has more benefits then drawbacks [13]. For better analysis of changes in the knee joint and preoperative planning Morgan–Jones R. and co–authors suggested to divide areas surrounding knee joint into three zones. The first zone includes articular surface, the second – metaphysis, and the third one – distal part of diaphysis for femur and proximal diaphysis of tibia [14]. This classification should be used along with AORI classification in planning revision TKA with replacement of defects respecting the stability of prosthesis after surgery. Before surgery the authors strongly recommend to assess which zone can be used for fixation, suitable fixation method and to choose the best suitable devices for each particular case.

Planing of defects treatment. Bone defects can be replaced with a substance of natural or synthetic origin. Various bone grafts (compacted morsellised bone grafts, structural allografts), modular metal augments are used mostly. The stability of the implant largely depends on the size of a defect and on mechanical properties of material that was used for the defect replacement.

A proper choice of material for bone defects replacement is very important as it effects further implant stability. Metal whole or modular augments have better mechanical properties, but later they can not be replaced with a bone tissue, so the use of bone grafts has more benefits [15]. Use of autologous morsellised bone grafts combined with a cemented knee arthroplasty was studied in vivo on horses before clinical trials. It was shown that all grafts were revascularised within 6–8 months. There were almost no remnants of the grafts as they were incorporated into a new trabecular structure and bone mineral density did not not differ significantly from control areas [16]. Some authors advise to use a special mesh made of metal or polymeric material, that can increase mechanical properties of the graft and may prevent some loss of small bone fragments within the impaction procedure [3]. Another option is to use metal augments with a special coating, which allows ingrowing of surrounding bone tissue and the secondary augment fixation.

Augments design. Augments are made of different shapes to replace defects of femoral and tibial condyles. The point is to preserve as much bone tissue as possible, that will improve augment fixation and its further stability in surrounding bone tissue. Therefore different asymmetrical augments were designed to help to restore surface of the joint and soft tissue balance better, as well as improve knee joint motion [17]. Shape of augments significantly effects their stability, as it was proved by some biomechanical studies [18]:

Wedge–shaped augments (less stable)
Stepped augments (more stable)
Rectangular augments (more stable)

Metal augments are made in the shapes of wedges and blocks of various sizes, and approximate thickness of 1 cm, which are fixed with screws or cement. The segmental defects up to 20 mm can be replaced by such augment with good outcome during 6 years. Use of metal augments is also more favorable in cases of unconstrained defects that are larger than 4 mm [19].

The strength of augment fixation with cement is also decreasing, approximately on ¼ over 6–7 years. Even though the migration is rare in this period, the long–term outcomes of cement augments fixation have not been properly studied yet [20].

The stability of the implant depends on the stem – its size and shape [21]. Contained defects can be filled with cement or with non–structural bone grafts. Management of bone defects should be planed according to the size and location of bone defects in femur and tibia.

Surgical technique. Defect should be classified according to one of the classifications mentioned above for correct management, though many of them describe same type of defect with different names. Treatment of bone defects is usually based on preoperative assessment, but intraoperatively it may be changed, especially in cases when prosthetic components or fixation devices are present in this site and should be removed. The most widely used AORI classification guides well bone defect treatment. Its type 1 bone defects can be described as small defects, that are less than 5 mm in size and involve cancelous bone structure. These are mostly cystic lesions that do not involve cortical bone and metaphyseal areas. The amount of bone tissue present near joint line allows successful fixation of prosthetic components. These defects can be successfully filled with various autografts and allografts, but the most common options are – spongy bone and polymethylmetacrylate cement.

Opinions about surgical tactic for larger Type 2A, 2B, 3 defects remain controversial [22]. Small tibial 2A defects can be filled with cement reinforced with metal screws, but larger defects require some new techniques balancing between mechanical stability and biological fixation. These defects are common for revision TKA. Long–term outcomes for different

surgical techniques were still poorly followed–up. The mechanical factor for surrounding–joint area, especially for tibial condyles, is very important and was estimated in biomechanical studies for various types of defect replacement techniques. Among them the usage of morsellised bone graft made of frozen femoral heads removed within primary total hip replacement. The particles of 3 mm diameter were contained in various types of meshes: metal mesh, bone cement film of polyester mesh bag. These grafts were fixed to bone with unicortical screws and underwent cyclic load. Better mechanical stability was achieved for bone graft contained in metal mesh. So the authors predict the 11 years survival rate up to 92%. But mechanical stability of these bone grafts was still less then for staged modular metal augments, that are commonly used nowadays [23]. The authors consider bone grafting technique beneficial for young patients, as they need more biological fixation than primary mechanical stability [24].

Another new technique is the usage of porous metaphyseal cones, sleeves made of metal, custom made prostheses or tumor–type prostheses which are suitable for large tibial defects of Type 2B and Type 3 and for large femoral defects where fresh–frozen femoral head can be applied [25, 26]. The healing of femoral head allografts were studied for cases of Type 3 AORI defects, when they were combined with long–stemmed prosthesis. It was revealed that average period for graft healing takes 6.6 months, but in some cases it may last up to 16 months. No infection or prostheses migration have been found for 30 TKA series within average period of 76 months [27].

Long–term results. Stability of implanted stems and augments has been poorly studied yet. Better results are expected from the bone grafts usage after their remodeling. Though good stability results were seen in 5–10 years in some studies, any artificial device may ever migrate. In our opinion, respecting such factors as special coating of augment surface (hydroxyapatite, micro–granules, nanoporous coating), use of materials like Tantalus, with high osteointegration potential can reduce failure rate and improve implant stability. Wedged tibial augments made of polyethylene and other polymeric materials can be used in the same way as metal augments, but they have different mechanical properties [28]. Zirconium–titanium alloys with lower Youngs modulus as well as some polymers, like polyethylene or polyamid–12 are less stiff and cause low stress on surrounding bone tissue [29]. This will have effect in better bone material quality of the implantation area [30]. Bioinertness is another important point for long–term implantation that restricts the choice of perspective materials, as some recent studies have found metallosis problems not only for internal fixation devices for fracture treatment but also for endoprosthesis components made of porous metal [31]. Some polymers, like polyamid–12 used as devices for internal fracture fixation were investigated in long–term studies for 30–40 years and showed high bioinertness [32]. So they seem to be promising for augment manufacturing and further investigations in this field.

Conclusion

In cases of bone defects TKA is a complicated surgical procedure, which success depends a lot on combination of such factors, as proper diagnosis, classification of bone defect, preoperative planing, correct choice of surgical technique, as well as augmenting material and implanting device. In cases of large bone defects long–terms results of treatment mainly depend on implant stability and have not been properly studied yet. It is predicted by some authors that stability is progressively decreasing. The usage of various types of bone grafts in combination with new synthetic materials can be a preferred solution and needs further investigations.

Підтвердження

Інформація про фінансування.

Ніякої фінансової вигоди, фінансування третіми особами чи фондами, а також грантовими проектами не було.

Внесок авторів

Всі автори в рівній мірі приймали участь як у написанні статті, так і в процесі її редагування.

Всі автори прочитали та схвалили остаточний варіант рукопису.

Конфлікт інтересів

Автори декларують відсутність конфлікту інтересів.

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Всі автори дали згоду на публікацію цього рукопису.

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