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Review article

Combined Orthoplastic Approach in the Treatment of Open Fractures of the Leg Bones: a Review of the Literature

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Abstract

Open fractures of the lower leg bones with a concomitant soft tissue defect is a rather serious problem in traumatology and orthopedics, as well as in reconstructive surgery. Traditionally, in our country and the CIS countries, with this type of fracture, external fixation is used - transosseous distraction osteosynthesis with the Ilizarov apparatus; often practiced late final closure of the skin defect. Currently, the combined orthoplastic method of treating open fractures of the lower leg is gaining popularity all over the world, which involves osteosynthesis of the fracture and skin plasty of the soft tissue defect of the limb in one stage within 72 hours after the injury, which will significantly reduce the time of treatment of the patient, as well as reduce the risks infectious complications.

***The purpose of this review article** is to study research in the international scientific community on the combined use of traumatology and plastic surgery methods in the treatment of open fractures of the lower leg with an accompanying soft tissue and skin defect, to compare the results of treating this type of injury with an orthoplastic approach and traditional orthopedic, as well as the advantages and disadvantages various methods of osteosynthesis. An information search was carried out for scientific articles in the PubMed, Web of Science, Cochrane, Wiley, Cyberleninka databases, using the keywords "open fracture of the lower leg", "orthoplastic method", "Ilizarov apparatus", "skin plasty". We analyzed 58 articles published between 1997 and 2022, including information on the epidemiology of open tibial fractures, issues and methods of treating open tibial fractures, and preventing post-traumatic and postoperative complications. This article includes the results of 2 large systematic reviews, 4 meta-analyses, 1 randomized controlled trial (RCT), 2 prospective cohort studies, 2 retrospective cohort studies, and UK and US guidelines.*

The study concluded that the orthoplastic approach was successful and its advantages over the classical approach in the treatment of open fractures of the lower leg bones, expressed in the reduction of treatment time, optimization of care for patients with open fractures of the lower extremities. In addition, according to reports of various scientific studies, the orthoplastic approach also gives good results in terms of reducing the risk of post-traumatic complications in patients and improving the functional outcome of the injured limb.

***Key words:** combined orthoplastic approach, open fracture of the leg bones, reconstructive surgery.*

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Introduction

According to various literature data, at present, with the development of technology and industrialization, the frequency of work-related injuries and traffic accidents, leading to open fractures of the lower extremities, is increasing. Epidemiological analysis shows that 40% of open fractures occur in the lower extremity and that the tibial and femoral shafts are most commonly affected. Such an injury directly affects the basic function of movement in patients, thereby significantly affecting their quality of life. Temporary disability of victims with fractures of the shin bones varies significantly: from 5-6 weeks to 5-7 months, and with complex fractures it reaches 10-12 months. Thus, this problem has a significant socio-economic and political aspects [1, 2, 3, 4].

Open fractures of the lower extremities are severe, complex, and high-energy injuries, often accompanied by damage of both bones and soft tissues [5]. General principles for the treatment of open fractures include the early use of antibiotics, thorough debridement, determination of the degree of soft tissue damage, temporary or definitive bone stabilization, and soft tissue reconstruction [6].Treatment of such defects takes a long time and has a high risk of infectious and other complications. Serious soft tissue injury and wound contamination are important factors influencing the prognosis of the treatment of open leg fractures. According to the research of Tribble et al. (2018), performed in the USA, patients with severe blast injury that has resulted in significant damage to muscles, soft tissues, and skin are at the greatest risk of developing osteomyelitis [7]. According to the researchers, the overall incidence of infectious complications in open fractures was 18.6%, while 17.0% and 1.6% for superficial and deep infections, respectively, and is more related to the severity, type of fracture according to the Gustilo-Anderson classification [8, 9]. A defect in the soft tissues of the lower leg, in addition to the risk of inflammatory complications, leads to circulatory failure of the fracture zone, which interferes with the formation of callus, and therefore adequate consolidation is often impossible even under conditions of stable fixation [10, 11]. In addition, factors such asage (> 60 years), presence of diabetes, opioid use, male gender, smoking, elevated body mass index (BMI> 40) are also of some importance), regular use of non-steroidal anti-inflammatory drugs (NSAIDs) [12].

The process of fracture consolidation has a huge negative impact on the presence of infectious complications after trauma or after surgical interventions, which leads to a longer period of consolidation and an increasing of the non-union risk. The presence of the above complications leads to lengthening of the hospitalization period, longer periods of rehabilitation and disability, and a patient's lower life quality [13]. Even there are no infectious complications, recovery from injury may be slow, and it may be difficult for patients to return to their previous life even two years after trauma [14]. According to the authors Ian Pallister and others (2021), the Disability Index Index (DRI) rating 12 months after injury is markedly worse in patients with open fractures in comparison with patients who had closed fractures [15].

The purpose of this review article is to study research in the international scientific community on the combined use of traumatology and plastic surgery methods in the treatment of open fractures of the lower leg with an accompanying soft tissue and skin defect, to compare the results of treating this type of injury with an orthoplastic approach and traditional orthopedic, as well as the advantages and disadvantages various methods of osteosynthesis.

Methods of treatment of open tibia fractures, advantages and disadvantages

There is a general tendency in treatment of open trauma – first performing osteosynthesis, while the final closure of the wounds is postponed indefinitely. On the territory of the Republic of Kazakhstan, as well as the CIS countries, the most popular type of osteosynthesis of open leg fractures is external fixation with rod devices, the method of skeletal traction, and the final method of choice for osteosynthesis is transosseous distraction osteosynthesis with the Ilizarov apparatus. At the same time, the treatment of soft tissue damage is delayed for an even longer period, often carried out in several stages, while there is a need for numerous surgeries, necrectomies, and even the usage of VAK-therapy.

In the international literature, there are not many recent studies about the treatment of open leg fractures with external fixation devices, including the Ilizarov apparatus. Existing researches speak to the merits of this treatment method. So, the authors Shahzaib R. Balochet al. (2020) emphasize the advantages of the Ilizarov apparatus, such as minimal intraoperative soft tissue destruction and blood loss, as well as its good stability and precise alignment, and the possibility of adjusting the apparatus during and after surgery. Most importantly, the authors state that the Ilizarov apparatus allows early onset of exercise, which is an important prognostic functional criterion [16]. Serbian explorers Milenkovic, Set al. (2018) use the Mitkovich apparatus in their daily practice. According to their prospective study, the rate of fracture consolidation without complications was 77.96%, while the average fracture healing time was 26 weeks (6.06 months) [17]. Abhishek Choukse (2021) in his publication concludes that for open fractures of the lower leg with crush and lack of soft tissue cover Ilizarov apparatus as a primary and radical treatment option gives reliable and satisfactory results [18, 19].Wang, XH(2020) published the results of treatment of unilateral external fixation for tibial fractures with poor soft tissue condition in 31 patients, 27 cases (87.1%) were "excellent" and 4 cases (12.9%) were "good" [20] . Russian authors Davydkin, Ippolitov and others (2021) noted that the prolonged usage (4–6 months) of external fixation devices and Ilizarov devices often associated with inflammation of the soft tissues around the pins and rods, neurotrophic disorders in the lower leg and foot, lymphostasis, and the development of persistent contractures of nearby joints. In addition, external fixation devices require constant medical monitoring, and their usage significantly reduces the patient's quality of life. At the same time, the authors consider it justified to use external fixation and osteosynthesis in several stages for open tibia fractures, types II and III by Gustilo-Anderson, and the using of blocking intramedullary osteosynthesis is justified only for open injuries of the type I. [21, 22]. Other researchers in their publication about using the Ilizarov apparatus in the treatment of type I and II tibia fractures note low invasiveness, the possibility of perfect reposition in combination with stable fixation, low cost of treatment. At the same time, the authors note "… a really common inflammation of soft tissues at the exit points of

the pins and rods is also easily treatable on an outpatient basis and is rather not a complication, but a feature of the method" [23]. In the Russian scientific literature, a number of clinical cases of open injury of the type III tibia fractures in young patients were analyzed; in all cases, primary external fixation and primary sutures were performed on the wound. Treatment was complicated by the development of osteomyelitis, a significant shortening of the tibia; the treatment turned out to be multi-stage, in a separate case, 13 plastic surgeries were required, including necrectomy, plasty with split skin autografts. At the same time, it was noted that recovery was often achieved after many months, and required a large number of drugs, including different groups of antibiotics [24-27].

Researchers in China Tian et al. (2020) conducted a systematic review and meta-analysis comparing five available methods of fixation of tibial fractures:

1) conservative treatment;

2) open reduction, plate and screw fixation (ORIF);

3) closed reduction, intramedullary osteosynthesis (IMN);

4) synthesis with external fixation devices;

5) open reposition and minimally invasive percutaneous plate osteosynthesis (MIPPO).

The results of the study showed that the rate of nonunion with conservative treatment was the highest in comparison with surgical treatment, and also that intramedullary osteosynthesis and fixation with plates through a minimally invasive approach lead to a lower rate of fracture's nonunion [12]. Another large study was conducted by Giovannini et al. (2016), who reviewed five randomized controlled trials (RCTs) including a total of 239 patients with Gustilo-Anderson type III A/B open tibial fractures and conducted a meta-analysis. All patients underwent soft tissue plasty and fracture fixation with an intramedullary nail or external fixation devices. Based on their study, the authors named intramedullary nailing as the method of choice for Gustillo-Anderson type III A/B fractures, as it is associated with lower rates of infection and fracture nonunion. In turn, according to their study, the external fixation method involves a shorter operating time and is therefore more suitable for patients with multiple injuries [28].

There are several researhes of authors, who studied the time of union of open tibia fractures, depending on the type of fractures and fixation methods. According them, the higher frequency of unsuccessful revisions, as well as repeated hospitalizations, was in patients, who were treated by external fixation method in comparison with patients, who were treated by intramedullary osteosynthesis or plate synthesis. In addition, the authors made a conclusion that intramedullary osteosynthesis and plate osteosynthesis are characterized by a shorter period of fracture consolidation and are more cost-effective than osteosynthesis with external fixation devices [29-31]. Fowler et al. (2019) compared the incidence of infectious complications, flap rejection and nonunion after temporary internal fixation (TF) with temporary external fixation (EF) in the treatment of open fractures of the tibia type IIIB according to Gustilo-Anderson (64 patients). Therefore, 47 patients (WF = 24; NF = 23) met the inclusion criteria and underwent 2-stage surgery. The final fixation was performed with an intramedullary nail. There were 4 cases with complications in the external fixation group (3 infections and 1 nonunion) and 2 cases with complications in the internal fixation group (1 infection and 1 flap rejection). However, the study showed that infection, fracture nonunion, and flap rejection were not significantly associated with the method of temporary fixation or other demographic and treatment variables.

The authors noted that the advantages of intramedullary fixation over external fixation for open tibia fractures are supported by large randomized and quasi-randomized studies with Level I evidence. Al-Hourani et al. (2021) in their study analyzed adult patients with open tibia shaft fractures undergoing any type of definitive fixation. The results of the study suggest that intramedullary osteosynthesis significantly reduces the risk of unplanned reoperation in comparison with osteosynthesis with external fixation devices, with a slightly greater decrease in type III open fractures [33].

Analyzing the advantages and disadvantages of methods of internal and external fixation of open fractures of the lower leg, it is worth noting the importance of the type of injury - whether it is isolated or multiple. The using of the method of intramedullary blocking osteosynthesis brings the best clinical result mainly in patients with isolated trauma, while the using of the external fixation method is more justified in cases of multiple trauma and polytrauma, given the lower surgical burden and time savings when using it, as well as the general condition of the patient [6].

Issues of plastic surgery in the treatment of open tibia fractures

Features of severe open fractures include significant fragmentation of the bone (grinding or segmentation), which is complicated by devitalization of its fragments, their possible extrusion during injury due to the proximity of the tibia to the skin, loss of bone mass and skin leading to difficulties in closing the defect of soft tissues and skin covers [34,35]. Thus, the main problem of the acute period is not the stabilization of the fracture, but the closure of the soft tissue defect. Taking into account that conditionally "healthy tissues" surrounding the wound are located in the bruised area, such techniques as defect plasty with local tissues or tension sutures are inappropriate. Also, if additional incisions are made in this area in order to cut out skin flaps or notches to relieve tissue tension, inevitably leads to a deterioration in the microcirculation of local tissues. And this process with concommitent increasing edema, will lead to necrosis, and subsequently, to an inflammatory process [36]. In this case, the method of choice for wound closure of an open tibia fracture with poor surrounding soft tissue is the usage of complex vascular pedicled flaps (such as the ALT anterolateral femoral flap and others) [37,38] which requires the staff to have the skills of microsurgery, and the hospital to have the necessary optical equipment. Overall, the final closure of soft tissue and skin defects is usually postponed and goes on to the next stage after the final fixation of the fracture, and sometimes requires several steps.

Recently, numerous studies point to the safety of early definitive closure of a soft tissue defect with well-coordinated teamwork of traumatologists and reconstructive surgeons. Thus, Hohmann et al. (2007) indicated that the level of infectious complications does not increase after the closure of the primary wound after careful debridement of open tibial fractures. The authors analyzed 95 patients with open tibia fractures (Gustilo-Anderson type I to IIIA) who underwent primary fracture

stabilization and either delayed wound closure (Group I, 46 patients) or primary wound closure (Group II, 49 patients) with a minimum follow-up period of 12 months. Group I developed one case of infection (2%), group II developed two cases of infection (4%) [39].

Other researchers also speak about the safety and advantage of the early closure of soft tissue defects in open fractures of the extremities. Zuelzer (2021) in his study suggests that primary wound closure in open tibia fractures is associated with a reduced risk of infection and less need for reoperations [40]. Jenkinson and others (2014) analyzed349 Gustillo-Anderson type I, II, and IIIA fractures, of which 87 were treated with delayed primary wound closure and 262 were treated with immediate closure after debridement. Deep infection developed in 3 of 73 fractures treated with immediate wound closure compared with 13 in a comparable group of 73 treated fractures with delayed primary wound closure. Thus, the authors concluded that immediate closure of carefully treated wounds in open grade I, II, and IIIA tibia fractures is safe and associated with lower infection rates compared with delayed primary closure [41]. A study by Scharfenberger (2017) also reports that primary wound closure for an open fracture is warranted in properly selected patients and may reduce the risk of such complications, as osteomyelitis and delayed fracture consolidation compared to delayed wound closure [42]. The authors of Kyu Tae Hwang et al. (2015) report in their study that in cases of severe Gustillo-Anderson type IIIB open fracture, the focus of treatment should be on early and thorough soft tissue closure rather than hastily achieving definitive fixation in the face of poor surrounding tissue. According to the authors, early reconstruction of severe open fractures, performed within 7 days after injury, gives a better clinical result than postponing the final closure of the wound, while the authors note the importance of a clear demarcation of the damaged tissue during plastic surgery [43].

A number of researchers report that, regardless of the degree of damage in an open fracture of the lower leg, cases of infectious complications were significantly less common in patients whose wound was closed within 5 days of injury. While the authors believe that with open fractures of the extremities of the Gustillo 3A / B type, the optimal method of closing soft tissue defects is the usage of skin flaps [44, 45]. David Shi Hao Liuet al. (2012) reduce the period of optimal closure of the skin with flaps to 72 hours, preferably immediately after osteosynthesis, arguing that in this case the risk of infection is minimized [46]. The results of a systematic review by Wood et al. (2012) show that any delay in soft tissue defect closure in open fractures can lead to delayed bone consolidation and infectious complications [47].

Combined application of traumatology and plastic surgery methods for open limb fractures: a combined orthoplastic approach

Historically, orthopedists and plastic surgeons have worked separately when dealing with complex reconstructive cases involving skeletal and soft tissue reconstruction of the lower extremities. Over time, many of them realized that their seemingly separate sets of skills and knowledge can be brought together in a collaborative orthoplastic approach to offer patients the best chance of a successful recovery. This method was first proposed in the early 1990s, and over the past few decades has led to the creation of a unique field of reconstructive surgery [48, 49]. This approach is currently strongly recommended by the British Association of Orthopedists (BOAST) in conjunction with the British Association of Plastic, Reconstructive and Aesthetic Surgeons (BAPRAS), as well as the National Institute for Care and Health Excellence (NICE) in the USA. However, this approach is still not widespread enough around the world. As recommended BOAST & BAPRAS, the establishment of a management plan for fixation and coverage of open fractures and surgical intervention for initial debridement should be carried out concurrently by orthopedic and plastic surgery consultants. Thus, definitive soft tissue closure should be achieved within 72 hours of injury; final internal stabilization should only be performed if it can be immediately followed by final soft tissue coverage [40, 50]. The few studies currently available on this approach in the treatment of this type of tibia fractures, indicating a better clinical outcome of the orthopedic approach compared to the traditional approach for open tibia fractures. Based on the experience of the authors JA Mathews et al. (2015), it is worth striving for a one-stage combined orthoplastic procedure to achieve definitive fixation and soft tissue coverage and optimal results [51]. Authors Arrigoni C. et al. (2019) indicate a longer healing time with the classical orthopedic approach in comparison with the combined orthoplastic approach [53]. Authors' results of Said C Azoury et al. (2021) show differences in the outcomes of treatment of patients with open fractures of the lower extremities by the orthoplastic method from the results of treatment of these fractures based on traditional concepts of orthopedics [48]. Zhao Yang et al. (2021) state that the overall incidence of infection with an orthoplastic approach in the treatment of type IIIB and IIIC open tibia fractures showed a lower trend compared with the results of treatment with a two-stage orthopedic approach [54]. Loh et al. (2022) also point to the need to follow the BOAST guidelines for early closure of soft tissue defects in open lower limb fractures [55]. In addition, the usage of a combined orthopedic approach reduces the number of cases of free flap rejection during soft tissue reconstruction of the lower limb [56].

In their recent study, Klifto et al. (2021) conducted a systematic review and meta-analysis of patients with lower extremity injury who received either orthoplastic or non-orthoplastic treatment. The authors reviewed 9 studies published between 2013 and 2019 comparing patients, of which 1663 were treated with an orthoplastic approach and 692 patients received a non-orthoplastic approach. The authors concluded that orthoplastic treatment, compared with non-orthoplastic, significantly reduces the time of fracture consolidation, reduces the use of negative pressure wound therapy during healing by secondary intention, as well as the risk of infectious complications. The orthoplastic approach also results in more use of free flaps compared to non-orthoplastic treatment [57].

In the United States, a retrospective study was performed in patients, operated by the orthoplastic method for a combat injury. The researchers concluded that limb salvage is possible in a significant proportion of patients, but education, experience, technical ability and an orthoplastic approach should be the priority principles of treatment. The authors note that there is often a lack of equipment in hospitals for microsurgical operations, as well as the availability of experienced surgeons who own microsurgical techniques, which leads to the fact that many orthopedic traumatologists in their country are biased towards saving limbs in patients with type IIIA and IIIB injuries [58].

Conclusions

The orthoplastic method of the reconstruction of the lower extremities is a joint model of the work of orthopedic traumatologists and reconstructive surgeons. This method summarize the optimal method of internal fixation of an open leg fracture and the speedy closure of the wound defect, which, according to the results of numerous studies, is the best solution in the treatment of such injuries. According to available sources, the benefits of a combined orthoplastic approach include reduced time to final fracture stabilization and soft tissue closure, length of hospitalization, reduced risk of postoperative complications, reduced need for revision procedures, and an overall improvement in functional outcomes.

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Аяқ сүйектерінің ашық сынықтарын емдеудегі аралас ортопластикалық тәсіл: Әдебиетке шолу

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Түйіндеме

Жұмсақ тіндердің қатар жүретін ақауы бар төменгі аяқ сүйектерінің ашық сынуы травматология мен ортопедияда, сондай-ақ реконструкциялық хирургияда өте маңызды мәселе болып табылады. Дәстүрлі түрде біздің елде және ТМД елдерінде сынықтың бұл түрімен сыртқы бекіту қолданылады - Илизаров аппаратымен сүйектің дистракционды остеосинтезі; тері ақауының кеш жабылуын жиі тәжірибеден өткізеді. Қазіргі уақытта төменгі аяқтың ашық сынықтарын емдеудің біріктірілген ортопластикалық әдісі бүкіл әлемде танымал болуда, ол жарақаттан кейін 72 сағат ішінде бір кезеңде аяқтың жұмсақ тінінің ақауының сынуы мен тері пластинасының остеосинтезін қамтиды. науқасты емдеу уақытын айтарлықтай қысқартады, сондай-ақ инфекциялық асқынулардың қаупін азайтады.

Бұл шолу мақаласының мақсаты – жұмсақ тіндер мен тері ақаулары бар төменгі аяқтың ашық сынықтарын емдеуде травматологиялық және пластикалық хирургия әдістерін біріктіріп қолдану бойынша халықаралық ғылыми қоғамдастықтағы зерттеулерді зерттеу, емдеу нәтижелерін салыстыру. ортопластикалық және дәстүрлі ортопедиялық тәсілмен жарақаттың бұл түрі, сонымен қатар артықшылықтары мен кемшіліктері.Остеосинтездің әртүрлі әдістері. PubMed, Web of Science, Cochrane, Wiley, Cyberleninka дерекқорларындағы ғылыми мақалаларға «төменгі аяқтың ашық сынуы», «ортопластикалық әдіс»,

«Илизаров аппараты», «тері пластикасы» түйінді сөздері арқылы ақпараттық іздеу жүргізілді. Біз 1997-2022 жылдар аралығында жарияланған 58 мақаланы талдадық, оның ішінде ашық жіліншік сынуларының эпидемиологиясы, ашық жіліншік сынықтарын емдеу мәселелері мен әдістері, жарақаттан кейінгі және операциядан кейінгі асқынулардың алдын алу туралы ақпараттар бар. Бұл мақалада 2 үлкен жүйелі шолу, 4 мета-талдау, 1 рандомизацияланған бақыланатын сынақ (RCT), 2 перспективалық когорттық зерттеу, 2 ретроспективті когорт зерттеуі және Ұлыбритания мен АҚШ нұсқаулары кіреді.

Зерттеу нәтижесінде ортопластикалық әдіс табысты болды және оның төменгі аяқ сүйектерінің ашық сынықтарын емдеудегі классикалық әдіспен салыстырғанда артықшылықтары емдеу уақытын қысқарту, төменгі аяқтың ашық сынықтары бар науқастарға күтім көрсетуді оңтайландыруда көрсетілген. Сонымен қатар, әртүрлі ғылыми зерттеулердің есептеріне сәйкес ортопластикалық тәсіл науқастарда жарақаттан кейінгі асқынулардың қаупін азайту және зақымдалған аяқтың функционалдық нәтижесін жақсарту тұрғысынан жақсы нәтиже береді.

Түйін сөздер: аралас ортопластикалық тәсіл, аяқ сүйектерінің ашық сынуы, реконструктивтік хирургия.

Комбинированный ортопластический подход при лечении открытых переломов костей голени: Обзор литературы

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Резюме

Открытые переломы костей голени с сопутствующим дефектом мягких тканей – достаточно серьезная проблема в травматологии и ортопедии, а также в реконструктивной хирургии. Традиционно в нашей стране и странах СНГ при таком виде перелома применяются внешняя фиксация – чрескостный дистракционный остеосинтез аппаратом Илизарова; зачастую практикуется позднее окончательное закрытие кожного дефекта. В настоящее время во всем мире набирает популярность комбинированный ортопластический метод лечения открытых переломов голени, который предполагает проведение остеосинтеза перелома и кожной пластики мягкотканного дефекта конечности в один этап в течение 72 часов после полученной травмы, что значительно позволит сократить сроки лечения пациента, а также снизить риски инфекционных осложнений.

Целью данной обзорной статьи является изучение исследований в международном научном сообществе о совместном применении методов травматологии и пластической хирургии в лечении открытых переломов голени с сопутствующим дефектом мягких тканей и кожных покровов, сравнении результатов лечения данного вида травмы ортопластическим подходом и традиционным ортопедическим, а также преимуществах и недостатках различных методов остеосинтеза. Был произведен информационный поиск научных статей по базам данных PubMed, Web of Science, Cochrane, Wiley, Cyberleninka, по ключевым словам «открытый перелом голени», «ортопластический метод», «аппарат Илизарова», «кожная пластика». Было проанализировано 58 статей, опубликованные в период с 1997 по 2022 год, включающие в себя сведения об эпидемиологии открытых переломов голени, вопросов и методов лечения открытых переломов голени и профилактики посттравматических и послеоперационных осложнений. В данную статью включены результаты 2 крупных систематических обзоров, 4 мета-анализов, 1 рандомизированного контролируемого исследования (РКИ), 2 проспективных когортных исследований, 2 ретроспективных когортных исследований, а также клинических рекомендаций Великобритании и США.

В ходе исследования был сделан вывод об успешности применения ортопластического подхода и его преимуществах перед классической тактикой лечения открытых переломов костей голени, выражающихся в сокращении сроков лечения, оптимизации ухода за пациентами с открытыми переломами нижних конечностей. Кроме того, согласно сообщениям различных научных исследований, ортопластический подход даёт хорошие результаты также в плане снижения риска посттравматических осложнений у пациентов и улучшении функционального результата поврежденной конечности.

Ключевые слова: комбинированный ортопластический подход, открытый перелом костей голени, реконструктивная хирургия.