IJABR

International Journal of Advanced Biotechnology and Research (IJABR)
ISSN 0976-2612, Online ISSN 2278–599X,
Vol-10, Issue-2, 2019, pp312-320
http://www.bipublication.com

Research Article

Results of Surgical Treatment in Patients with Destructive and Dystrophic Defects of Knee Joint Articular Cartilage

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[Received: 11/02/2019; Accepted: 27/04/2019; Published: 01/05/2019]

ABSTRACT

Purpose. To perform comparative analysis of the results of surgical treatment in patients with layer-by-layer destructive and dystrophic defects of knee joint articular cartilage by different methods of autologous osteochondral mosaicplasty (autochondroplasty).

Materials and Methods. Retrospective comparative analysis of the results of surgical treatment in 109 patients with destructive and dystrophic defects of knee joint articular cartilage was performed. All the patients were divided into three clinical groups. In group I (n=38) conventional mosaic autochondroplasty by L. Hangody was performed. In group II (n=35) the developed method of autochondroplasty (Patent RF № 2239377) was used, autologous spongious bone grafting, taken extraarticular, was performed. In group III (n=35) new approach to

chondroplasty (Patent №2484784) was used, additional myoplasty of the damaged condyle performed. The evaluation of the results was performed by WOMAC scale, M. Lequesne index and Oxford knee score (OKS). Besides, the patients had X-ray study and MRI of knee joint done. The results were evaluated before the surgery and 3, 12 and 24 months after the surgery. X-ray study and MRI was performed before the surgery and 12 months after the surgery.

Results. Evaluation of the treatment results showed significant difference in clinical and functional recovery of the patients from clinical group I in comparison with clinical groups II and III in 12 and 24 months after the surgery, respectively. It should be noted that the results of treatment in the patients from clinical group II and III were similar in long-term observation.

Conclusion. Comparative analysis of the treatment results showed that the best outcome was observed in clinical groups where the surgeons applied the approaches based not only on mechanical replacement of the defected area, but also single-step complex correction of all the main components of pathological process pathogenesis.

Key words: knee joint, cartilage defect, destructive and dystrophic diseases, chondroplasty, organ-preserving technologies

INTRODUCTION

The most significant pathogenetic mechanisms of knee joint chondral defects formation at primary osteoarthrosis and secondary damage of articular cartilage are the processes of dystrophy and destruction of hyaline cartilage that are characterized by progredient development and nearly absolute absence of reparative potential [4, 18]. Microcirculatory disorders in femoral and tibial bones metaphysis with further development of intraosteal venous stasis contribute to the mentioned pathological conditions. They result in local ischemia, hypoxia and cystic transformation of subchondral bone with trophic disturbance of hyaline cartilage basal layer [1, 8].

Hence, enhancement of articular cartilage regeneration and creation of optimal conditions for that is a priority task for surgeons that determines the degree of functional restoration of knee joint and increase of quality of life of the patients [11, 15].

Specific peculiarities of destructive and dystrophic local damage of hyaline cartilage are dimensions and depth: as a rule, these are the defects with the area of 1 cm^2 and more, of III and IV grade by the classifications of Outerbridge (1961) and Yulish B.S. et al. (1987), as well as their location on the most load bearing parts of articular cartilage. These factors significantly reduce the efficiency of such methods of mesenchymal stimulation as abrasive chondroplasty, subchondral forage and microfracturing for surgical treatment [5, 16].

In this situation, implementation of autologous chondrocytes grafting, autologous matrix-induced chondrogenesis (AMIC), cartilage repair devices (CRD) and other cellular technologies is not widespread in Russia because of high cost, lack of stable outcome prognosis and a number of unsolved legal issues [7, 13, 19].

Thus, in clinical practice mosaicplasty remains the most widespread current method of surgical treatment for destructive and dystrophic chondral defects (Autogenous Osteochondral Transplantation) [2, 14]. To replace the defected areas of the articular cartilage, surgeons use autogenous osteochondral grafts, taken from the same joint low load bearing parts of external and internal condyles of femoral bone or from intercondylar fossa anterior to the place of attachment of front cruciate ligament (Hangody, 1997).

Although the method of mosaicplasty is characterized by long-tern positive clinical experience, the authors identified a number of drawbacks in this surgery that negatively influence on the processes of reparative chondrogenesis and short-term and long-term outcome in the case of destructive and dystrophic defects of articular cartilage. They include additional traumatizing of the initially damaged joint and reduction of actively functioning cartilage during autogenous graft retrieval from low load bearing area; natural limitation of donor areas for the required configuration and, consequently, volume of the obtained plastic material; use of pathologically altered cartilage tissue as donor one; risk of development of a vascular (aseptic) necrosis and

cystic alteration in the area of grafting due to remaining microcirculation failure and capillary stasis within deep layers of subchondral bone; development of aseptic inflammation in graft donor area that provokes responsive synovitis; pain syndrome in graft donor area [2, 9].

The above mentioned facts encouraged the authors to develop new methods of mosaic autologous chondroplasty and to evaluate their clinical efficiency in patients with destructive and dystrophic chondral defects of knee joint.

The purpose of the study was to perform comparative analysis of the results of surgical treatment in patients with layer-by-layer destructive and dystrophic defects of knee joint articular cartilage by different methods of autologous osteochondral mosaicplasty (autochondroplasty).

MATERIALS AND METHODS

Retrospective comparative analysis of the results of treatment in 109 patients with destructive and dystrophic defects of knee joint articular cartilage was performed. The patients underwent inpatient treatment at the Department of traumatology and orthopedics at the Clinic №2 of SamSMU within the period from 2012 to 2017 inclusively.

Each patient signed informed consent for the enrolment into the study that was conducted in accordance with the approved protocol and ethical principles of World Medical Association's Declaration of Helsinki (Seul, 2008),

International Conference on Harmonisation - Good Clinical Practice (ICH GCP) and applicable laws of the Russian Federation. The study entry criteria for patients were the following: age – younger than 60 years old; gender – any; diagnosed knee joint osteoarthrosis of II stage by Kellgren and Lawrence classification in Leuquesne's modification (1982); diagnosed articular cartilage unicondylar defect of III and IV stages by Outerbridge classification (1961); signed form of informed consent for the study participation.

The study exclusion criteria for patients were the following: articular cartilage defect area larger than 5 cm^2; signs of cruciate ligaments damage and/or meniscectomy in anamnesis; bilateral joint defects; associated endocrine and metabolic pathology, including diabetes mellitus and gout; diagnosed connective tissue systemic disease; pregnancy; knee joint varus or valgus deformity; alimentary and constitutive obesity of II degree and higher (BMI >33 kg/m^2).

All the patients were divided into the three clinical groups by means of common block randomization by the choice of mosaicplasty approach.

Clinical group I included 38 patients. They underwent conventional mosaic autologous chondroplasty surgery by L. Hangody. The defected area were replaced with osteochondral autologous grafts, probed from low load bearing areas of the same joint.

Clinical group II included 35 patients. They underwent surgeries performed by the authors' developed approach of chondroplasty for knee joint articular cartilage defects (Patent RF № 2239377).

This approach is based on conventional mosaicplasty. However, autologous spongious bone grafts for replacement of the defected areas were taken extraarticular (from wing of ilium).

Clinical group III included 36 patients. They underwent surgeries based on new approach to chondroplasty (Patent RF № 2484784). This surgery involves the technique of mosaicplasty by L. Hangody, performed by the formation of pedicled gracilis muscle flap that is placed under autologous osteochondral grafts via a specially created canal.

To perform the main stage of this surgery, the authors used specialized set of Acufex tools for mosaicplasty (Smith&Nephew) in all the cases.

The patients from all the clinical groups were similar by gender, age and associate pathology. There are 26 female patients (23.8%) and 83 male patients (76.2%). Average patient age was 47.5 year old (from 20 to 59). Overall gender and age related characteristics of the patients is presented in Table 1.

Table 1: Patients distribution by age and gender

Age / Gender	20 – 30	31 – 40	41 – 50	51 – 59	Total
Male	10	22	34	17	83
Female	2	7	9	8	26
Total	12 (11.1%)	29 (26.6%)	43 (39.4%)	25 (22.9%)	109 (100%)

Area and localization of articular cartilage defects in the treated patients are presented in Table 2.

Table 2: Area and localization of the observed chondral defects

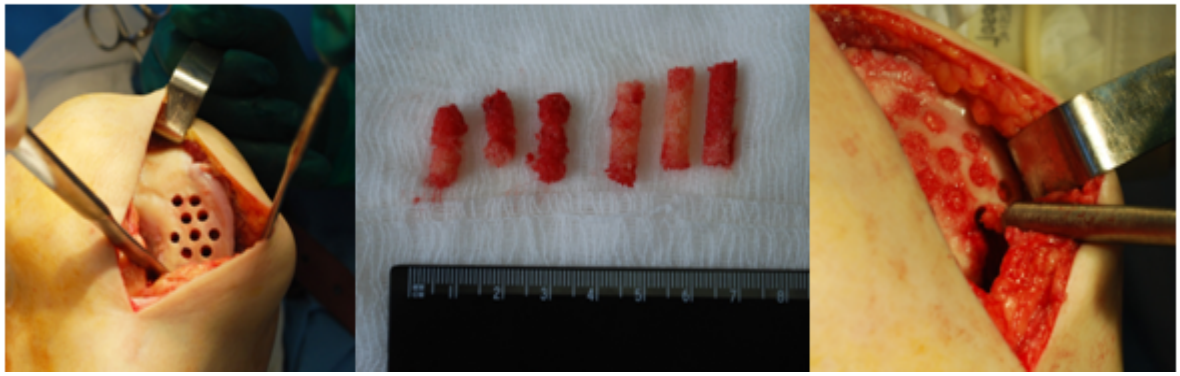
Defect area, cm^2 / Localization	2.0-2.5	3.0-3.5	4.0-4.5	4.5-5.0	Total
Medial condyle	8	39	44	10	101
Lateral condyle	0	3	4	1	8
Total	8 (7.3%)	42 (38.5%)	48 (44.1%)	11 (10.1%)	109 (100%)

The first step of the surgery in all the patients included knee joint arthroscopy for operative exploration of intraarticular structures and evaluation of articular cartilage damage localization, area and degree by Outerbridge classification. If necessary, partial excision of the damaged meniscus, resection of hypertrophic infrapatellar fat pad, shaving of articular cartilage around the defect and smoothing of its edges. Further, the authors performed the main step of the surgery – mosaic chondroplasty. This was open operation in all the cases.

The technique of mosaic osteochondroplasty by L. Hangody, performed in patients from clinical group I, is well-known and described in detail in literature. But the peculiarities of surgical treatment in patients from clinical groups II and III need detailed description.

The patients from clinical group II underwent surgery by the authors' developed approach to knee joint cartilage chondroplasty (Patent RF № 2239377). Defect cartilage edges were excised to visually healthy tissues along the border of scar tissue. In the underlying bone the 5mm i.d. canals 20 mm deep were made with a hollow cutter perpendicular to the contour of subchondral bone. The canals had 2mm walls for increase of grafts contact area with bone tissue below the defect area and for maintenance of their trophic processes under destructive and dystrophic knee joint defect. Further, access to iliac crest was performed by direct discission in its projection, 2-3 cm posterior to spina iliaca anterior superior. Donor autologous grafts of the required size and in required amount were taken from wing of ilium. After that the prepared autologous osteografts were inserted into the formed canals so that the grafts distal part was leveled with the articular cartilage surrounding the defected area.

The main steps of this surgery are presented in Figure 1.

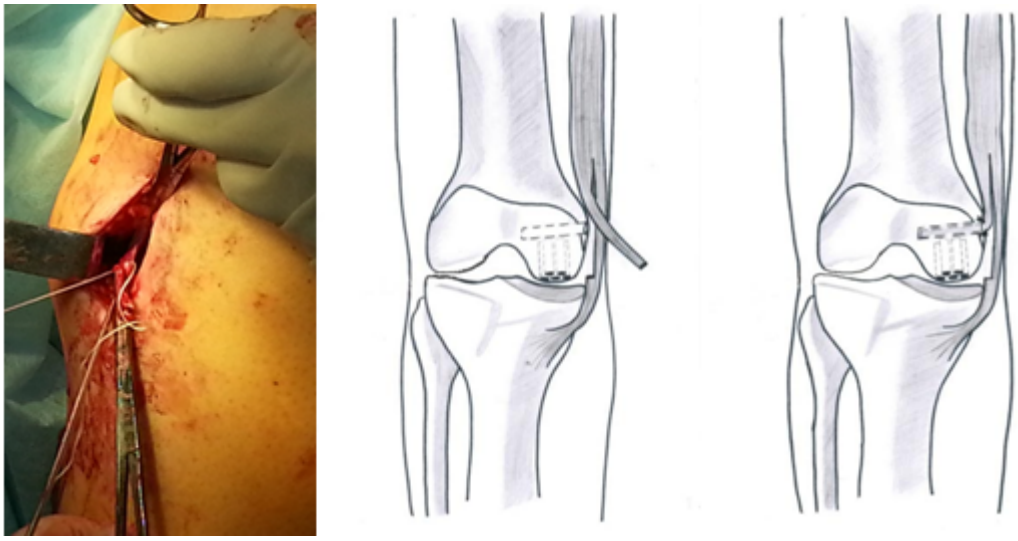


a) b) c)

Fig. 1. The main steps of mosaic autologous chondroplasty with autologous spongious bone grafts: a) canals are formed in the area of articular cartilage defect; b) autologous spongious bone grafts are taken from wing of ileum; c) autologous bone grafts are inserted into the defected area.

The patients from clinical group III underwent new surgery for knee joint articular cartilage defects approach to chondroplasty (Patent RF № 2484784). This approach is based on a series of experiments on modelling and operative treatment for hyaline cartilage defects that were conducted at the Institute of Experimental Medicine and Biotechnologies of Samara State Medial University (SamSMU). The results of the conducted experiments provided substantiation for the necessity to target subchondral area of epiphysial cartilage, as the main component of cartilage tissue homeostasis, during reparation of articular cartilage defects.

Technically, the surgery was performed as follows. After the mosaic chondroplasty with autologous osteochondral grafting, additional 2-3 cm skin discission was made along the interior knee joint cartilage in the projection of m. gracilis. Further, the surgeon separated the muscle and formed pedicled gracilis muscle flap that was strengthened by stay suture. Via the same assess under electron-optical image converter control (EOC), 4-5 cm transverse canal was made in femoral condyle for osteochondral autologous grafts base line in the defected area. After that, pedicled gracilis muscle flap was inserted into the formed canal in femoral condyle with further transosteal fixation. Intraoperational picture and surgical steps layout are shown in Figure 2.



a) b)

Fig. 2. Formation and insertion of pedicled gracilis muscle autologous graft: a) formation of muscle autologous graft (m. gracilis); b) insertion of muscle autologous graft (m. gracilis) under the base line of osteochondral grafts.

Postoperational patient management protocol was identical in all the clinical groups. It was based on early start of flexion-extension movements under complete restriction of leg bearing load. On the 3rd or 4th day after the surgery all the patients started exercising on continuous passive motion device (CPM). Besides, during perioperative period all the patients received systemic preventive antibiotic therapy, parenteral administration of second generation cephalosporins intraoperationally and within 24 hours after the surgery, as well as symptomatic drug therapy.

RESULTS

Clinical evaluation of the treatment results, characterized by the degree of pain syndrome intensity and functional capabilities in patients with knee joint pathology, was performed by the systems recommended by OARSI (Osteoarthritis Research Society International): The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Algofunctional Index M. Lequesne and Oxford knee score (OKS) [4, 13].

Clinical and functional treatment outcome was evaluated before the surgery and 3, 12 and 24 months after the surgery. Besides, for analysis objectification of structural alterations in the defected area, the patients had knee joint X-ray study and MRI done. The specified studies were performed before the surgery and 12 months after the surgery.

Intergroup comparison was performed by Kruskal-Wallis test (nonparametric analysis of variance) with further comparison of the groups by Wilcoxon-Mann-Whitney test. Critical level of statistical significance was taken as $p \leq 0.05$. Statistical processing of the obtained results was performed by the software package STATISTICA (Statistica for Windows, Release 6.1, StatSoft Inc., USA).
The dynamics of WOMAC total index values in patients from clinical groups is shown in Table 3.

Table 3: Dynamics of WOMAC total index

Period of observation / Clinical group	Before surgery	3 months	12 months	24 months
I (n=38)	876±52.4	776±29.2	653±98.8	511±44
II (n=35)	914±63.5	724±77.7	597±59.3	436±71
III (n=36)	895±76.4	789±62.7	526±43.6	457±32
t-test*	0.132	0.206	0.087	0.897

Note: * – $p \leq 0.05$

Dynamics of Algofunctional Index M. Lequesne values in patients from clinical groups is shown in Table 4.

Table 4: Dynamics of Algofunctional Index M. Lequesne values

Period of observation / Clinical group	Before surgery	3 months	12 months	24 months
I (n=38)	8.32±0.41	6.18±0.36	5.12±0.21	3.88±0.27
II (n=35)	7.68±0.18	5.77±0.19	3.52±0.76	2.34±0.43
III (n=36)	8.04±0.65	5.88±0.28	4.06±0.37	2.07±0.19
t-test*	0.054	0.235	0.068	0.187

Note: * – $p \leq 0.05$

Dynamics of Oxford knee score (OKS) values is shown in Table 5.

Table 5: Dynamics of Oxford knee score (OKS) values

Period of observation / Clinical group	Before surgery	3 months	12 months	24 months
I (n=38)	37.28±2.2	32.12±0.36	27.32±0.21	22.89±0.27
II (n=35)	41.61±0.18	34.56±0.19	24.12±0.76	16.03±0.43
III (n=36)	39.23±0.65	35.76±0.28	22.77±0.37	17.69±0.19
t-test*	0.308	0.024	0.789	0.076

Note: * – $p \leq 0.05$

Evaluation of the obtained results showed significant improvement of the studied parameters in patients from all the clinical groups. However, the performed analysis revealed significant difference in clinical and functional recovery in patients from clinical group I in comparison with patients from clinical groups II and III in late postoperative period and in 12 and 24 months after the surgery. It should be noted that the results were close in patients from clinical groups II and III after long-term observation (WOMAC total index – 436±71 and 457±32; Algofunctional Index M. Lequesne – 2.34±0.43 and 2.07±0.19; Oxford knee score – 16.03±0.43 and 17.69±0.19, respectively). The authors believe that this is associated with optimal conditions for regeneration processes, created by the proposed approaches to chondroplasty. Thus, in clinical group II utilization of autologous spongious bone grafts, taken extraarticularly, led to reduction of intraoperational joint trauma, provided the required amount of grafts, that were more capable of integration with surrounding tissues and morphologic transformation in comparison with potentially defective cartilage tissue, when grafts were taken from the same joint.

In clinical group III, despite the fact that autologous osteochondral grafts were taken from low load bearing area of the joint, myoplasty of metaphyseal area of transplantation resulted in improvement of local blood circulation, activation of trophic processes, complete

osteointegration of bone grafts in recipient area and creation of optimal conditions for reparative processes in donor area.

During X-ray images analysis, the authors evaluated the structure of metaphyseal area of the damaged condyle and progression of destructive and dystrophic process. MRI images were used to evaluate articular cartilage state, pathologic alterations in intraarticular tissues, as well as to confirm bone marrow edema, its intensity and localization.

In clinical group I in 12 months after the surgery, X-Ray images of the knee joint in two projections revealed sclerosing of metaphyseal area of the damaged condyle with progression of asymmetric narrowing of joint space in 13 (34.2%) cases. Similar X-Ray picture was observed in 7 (20%) patients from clinical group II and in 8 patients (22.3%) from clinical group III.

In 18 (47.3%) patients from clinical group I in 12 months after the surgery, MRI images revealed reduced signal from articular cartilage; articular hyaline cartilage in the transplantation area was thin; single or numerous subchondral defects with fluid characteristics of signals (cystic transformation) with sclerotic rim and areas of moderate perifocal edema within the damaged femoral condyle were visualized. In clinical group II the specified alterations were less expressed and were observed in 12 (34.3%) patients. In clinical group III MRI images showed restoration of articular cartilage in the area of chondroplasty with absence of perifocal edema in the area of femoral condyle in 25 (69.4%) cases.

DISCUSSION

Current trend in surgical treatment for destructive and dystrophic unicondylar defects of knee joint articular cartilage is unicondylar replacement. However, this approach has a number of potential risks and drawbacks, the main of which is total replacement at the development of early aseptic instability of endoprosthesis components [3, 5]. Besides, significant negative aspect of unicondylar replacement is the risk of development of infectious complications and persistent pain syndrome [1].

On the other hand, despite the existing skeptical attitude to mosaic chondroplasty at osteoarthrosis, scientific literature review and the data, obtained in the present study, prove the feasibility of this method at stage II of osteoarthrosis, provided the thorough and weighted analysis of the associated factors, like patient age, localization, depth and dimensions of the defect, position of the mechanical axis of the limb and BMI, is performed [6, 10, 12, 17].

This is also confirmed by some clinical macroscopic observations in the area of transplantation in patients with progressing osteoarthrosis, who had total replacement of knee joint and previous chondroplasty in anamnesis. These observations showed that chondroplasty area did not look fatally destructed and, more than that, it had evident formation of fibrous cartilage tissue that was visually altered not more than the surrounding cartilage (Figure 3)

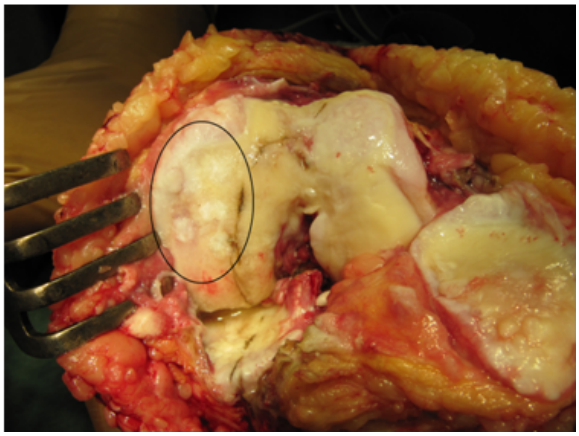


Fig. 3. The area of replacement of layer-by-layer destructive and dystrophic defect of the articular cartilage of medial femoral condyle 6 years after mosaic chondroplasty (outlined in the Figure)

CONCLUSION

Mosaic autogenous osteochondroplasty at destructive and dystrophic defects of knee joint articular cartilage is a pathogenetically proved and clinically feasible method of articular cartilage surgical restoration, which results in significant clinical remission and provides functional restoration of the joint. At osteoarthrosis associated with formation of unicondylar layer-by-layer chondral defects, this

method can be considered as the main organ-preserving option of surgical treatment.

Comparative analysis of the surgical treatment results in patients with layer-by-layer destructive and dystrophic defects of knee joint articular cartilage showed that the best outcome was observed in clinical groups where the surgeons applied the approaches based not only on mechanical replacement of the defect area, but also on single-step complex correction of all the main components of pathological process pathogenesis.

Based on these facts, the authors recommend the specified approaches to chondroplasty for clinical practice and open new prospects for their further development.

ACKNOWLEDGE:

The study was conducted in accordance with the research plan of the Department and Clinic of traumatology, orthopedics and extreme surgery at SamSMU. The authors did not receive any financial support from pharmaceutical companies.

Conflict of interest: The authors declare no conflict of interest.

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