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Survival of unconstrained ceramic wrist joint implants

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Abstract

Introduction Survival of implants is an important indicator of improvement in the patient's quality of life. In foreign literature, the issue of implant survival finds special attention. **The aim** of the work was to evaluate the efficacy and survival of an unconstrained ceramic wrist joint endoprosthesis. **Materials and methods** We analysed 83 cases of total wrist arthroplasty with an unconstrained ceramic implant at long-term follow-up. At the Novosibirsk RSITO, total wrist arthroplasty was performed in 81 patients with severe changes in the wrist joint from 2011 to 2021. Two patients underwent arthroplasty on two joints. A retrospective uncontrolled cohort study was conducted which divided the hospitalized patients into three groups according to the etiological cause of the disease. Radiological methods were used to control the state of the implant (radiography in two projections and CT-scans of the wrist joint). For binary indicators, the number, rates and 95 % confidence interval of frequencies were calculated according to the Wilson formula in the groups. Comparison was carried out by Fisher's exact two-sided test. The p-error was corrected using the Benjamini – Hochberg method. Kaplan – Meier curves were constructed for survival analysis. The groups were compared using a generalized chi-square test. **Results** Each case of repeated surgical intervention was evaluated from the standpoint of selected groups. Depending on the time elapsed from surgery to revision, we calculated the time frame for overall and group survival of the components of the wrist joint endoprosthesis. The causes and scope of surgical revision are presented. **Discussion** There are no data on the survival of unconstrained ceramic wrist joint implants in the foreign literature. Graphic images according to a proposal for the division of the orthopaedic postoperative period are presented. Conclusions 1. Intermediate conclusions in regard to total arthroplasty with an unconstrained ceramic endoprosthesis of the wrist joint inspire optimism in obtaining a stable positive effect of motion range lost due to the degenerative process in the wrist joint. 2. An 11-year follow-up period demonstrates that the survival rate of an unconstrained ceramic wrist endoprosthesis is 88 %.

Keywords: endoprosthesis, replacement, wrist joint, implant survival, postoperative period

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INTRODUCTION

The statistics of the early and late postoperative periods of a totally replaced wrist joint with an unconstrained ceramic implant was presented in our previous study [1]. Survival of implants is an important temporal indicator of improvement in the patient's quality of life [2]. In the Russian-language literature, there are a limited number of articles on the results of wrist joint arthroplasty [3, 4]. Therefore, there are gaps in the coverage of the problem: there are no data on the survival of implants. Foreign journals and scientific books pay special attention to the issue of implant survival, but there are no data on the use of ceramic implants [6-15].

Purpose To evaluate the efficacy and survival of an unconstrained ceramic wrist joint implant.

MATERIALS AND METHODS

The surgeons of the Tsivyan Novosibirsk Medical Research Institute for Traumatology and Orthopedics performed more than 120 surgical interventions to replace the wrist joint by the time of this study completion. Eighty-three cases of surgical treatment were analyzed at long-term follow-up. The protocol of the local ethics committee for the study approval is dated January 17, 2023, extract number 002/23, meeting minutes number 001/23. We recorded all cases of repeated surgical interventions, their causes and their results. We evaluated the time of re-hospitalization and the result of revision surgery. The Kaplan – Meier curve allowed us to assess the survival of the components of the wrist endoprosthesis (EP). From 2011 to 2021, total wrist arthroplasty was performed in 81 patients with severe degenerative changes in the wrist joint who voluntarily agreed to surgical treatment and agreed to the proposed treatment plan. Two patients underwent surgery on two joints.

A retrospective uncontrolled cohort study was conducted. The hospitalized patients were divided into three groups, according to the etiological cause of the disease.

The RA group included patients with rheumatic diseases of the wrist joint. The Trauma group included patients with consequences of injuries and surgical interventions. The small AVN group included cases of dysplasia and osteochondropathy of the wrist joint.

All patients underwent radiographic examination before surgery, at the end of the surgery and at follow-up appointments. If patients complained of pain, MSCT of the replaced joint was prescribed to assess the stability of the endoprosthesis components. Once the cause of the re-appearance was revealed, we determined the scope of revision operations.

The evaluation of implant survival had two time-points: the first point corresponded to the primary wrist arthroplasty, the second point was the date of repeated surgical intervention. All re-operations were recorded in a table indicating the time elapsed since the first operation. The results were subjected to statistical analysis. Patients who did not seek reoperation continued follow-up examinations.

Statistical methods For binary indicators of sex, involvement of an endoprosthesis, arthrodesis, operations without a prosthesis, positive dynamics, the number, rates and 95 % confidence interval (95 % CI) of frequencies were calculated using the Wilson formula in groups. To quantify differences between the groups, odds ratios (ORs) were calculated with 95 % CI. Comparison was carried out by Fisher's exact two-sided test. The correction of the error in multiple comparisons in the achieved significance levels *p* was carried out by the Benjamini – Hochberg method (Table 1). To analyze the freedom from reoperations, Kaplan – Meier curves were constructed. Endoprosthesis survival tables were compiled with estimates of freedom and 95 % CI. Groups were compared using a generalized chi-square test.

RESULTS

The reasons for repeated referral were periprosthetic fractures, dislocation of the component, dislocation of the endoprosthesis, arthrofibrosis of the totally replaced wrist joint, hand mal-position (maintenance and fixation of the hand in a mal-position versus the initial state), and aseptic instability of components. According to the types of orthopedic care, we divided the revisions into three subgroups: EP exchange, arthrodesis, and soft tissue interventions.

Radiographic study methods allowed us to evaluate clinical manifestations described by patients at follow-up examinations. The position of the endoprosthesis components, peri-implant osteolysis, and design defects were assessed. In cases of instability of the EP components or disintegrity of the peri-implant bone tissue (periprosthetic fracture), the surgical intervention was implant exchange (EP exchange arthroplasty). If it was impossible to reinstall the endoprosthesis component, we performed total arthrodesis of the wrist joint (arthrodesis). We never found any mechanical destruction of the implant components. If instability of the endoprosthesis components was not detected, surgical assistance was release of the articular surface of the implant from scar tissues and tendon transfer to achieve a balanced position of the hand. Comparative indicators of the results of the re-interventions, causes of revision and the scope of surgical care in regard to gender and age are presented in Table 1. Table 1 also shows the quantitative indicators of each study group that were included in the diagrams of the presented material.

To estimate the time of the active EP functioning, each operation was marked on the time curve, where the starting point is the time of the operation (Fig. 1). Depending on the time elapsed from the moment of the first to the second operation, the time frames were calculated. Based on the fact that the initial state of the patients and the cause of the degenerative change of the wrist joint were different, the results were combined into a specific group of patients. Combining the results enabled to determine the group survival of the endoprosthesis (Fig. 2, 3, 4).

Table 1

Comparison between the groups RA, Trauma, AVN

Parameters	RA (n = 26)	Travma (n = 48)	AVN (n = 9)	Comparison	
	n, % [95 % ДИ]	n, % [95 % ДИ]	n, % [95 % ДИ]	OR [95 % CI]	Two-tailed Fisher test, p-level, correction
Sex, males	1, 4 % [1 %; 19 %]	28, 58 % [44 %; 71 %]	5, 56 % [27 %; 81 %]	RA vs. Tavma: 33.5 [4.7; 1475] RA vs. AVN: 0 [0; 0.4] Travma vs. AVN: 1.1 [0.2; 5.9]	RA vs. Tavma: < 0.001*, < 0.001* RA vs. AVN: 0.002*, 0.004* Travma vs. AVN: > 0.999, > 0.999
Implant exchange	1, 4 % [1 %; 19 %]	6, 12 % [6 %; 25 %]	1, 11 % [2 %; 43 %]	RA vs. Tavma: 3.5 [0.4; 170.6] RA vs. AVN: 0.3 [0; 28.2] Travma vs. AVN: 1.1 [0.1; 59]	RA vs. Tr.: 0.410, > 0.999 RA vs. AVN: 0.454, > 0.999 Travma vs. AVN: >0.999, > 0.999
Arthrodesis	0, 0 % [0 %; 13 %]	3, 6 % [2 %; 17 %]	0, 0 % [0 %; 30 %]	–	RA vs. Tr: 0.548, > 0.999 RA vs. AVN: > 0.999, > 0.999 Travma vs. AVN: > 0.999, > 0.999
Interventions on soft tissues	2, 8 % [2 %; 24 %]	9, 19 % [10 %; 32 %]	2, 22 % [6 %; 55 %]	RA vs. Tavma: 2.7 [0.5; 28.1] RA vs. AVN: 0.3 [0; 4.9] Travma vs. AVN: 0.8 [0.1; 9.3]	RA vs. Tr.: 0.309, 0.803 RA vs. AVN: 0.268, 0.803 RA vs. Tr.: > 0.999, > 0.999
Positive dynamics	26, 100 % [87 %; 100 %]	45, 94 % [83 %; 98 %]	9, 100 % [70 %; 100 %]	–	RA vs. Tavma: 0.548, > 0.999 RA vs. AVN: > 0.999, > 0.999 Travma vs. AVN: > 0.999, > 0.999

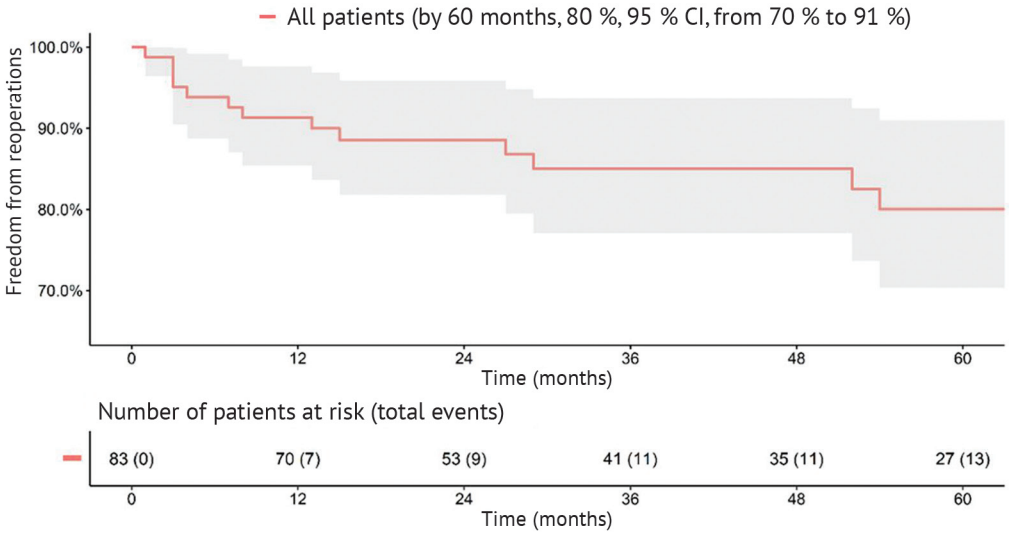

Fig. 1 Kaplan – Meier curve of freedom from reoperation in all patients

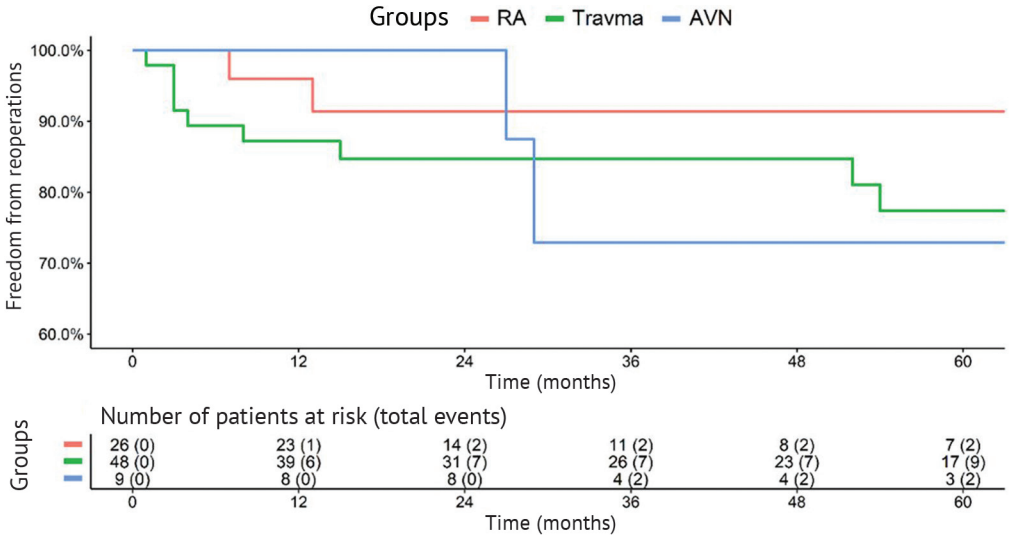

Fig. 2 Kaplan – Meier curve of freedom from reoperation risk in patients groups

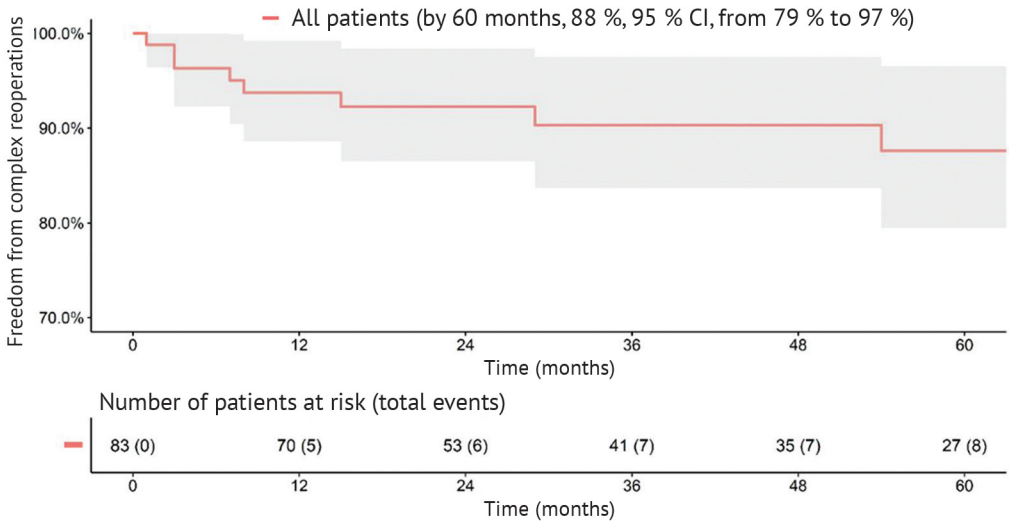

Fig. 3 Kaplan – Meier curve of freedom from reoperation risk with implant exchange in all patients

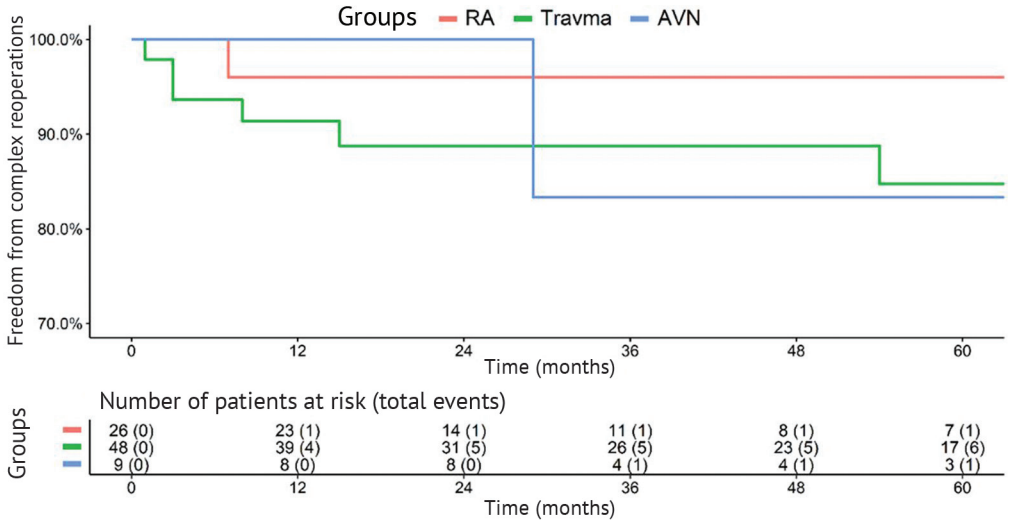

Fig. 4 Kaplan – Meier curve of freedom from reoperation risk with implant exchange in the groups

An important element of a satisfactory result of the restoration and preservation of the wrist joint motion is the interaction at all stages of orthopedic treatment with specialists from related fields. Rehabilitologists, rheumatologists and neurologists should be named among the main narrow specialists.

The assistance of rehabilitation specialists is an urgent need at the first stage of the postoperative period. A significant number of researchers point to the indispensability of the participation of rehabilitation specialists in the postoperative period. Controlled exercises for the joint assist in correcting wrong stereotypes of joint motion that persisted in patients over many years of illness [16-20]. The participation of rheumatologists is necessary for the selection of basic therapy, taking into account the common pathological mechanism of morphological changes in the joint [6, 17, 21]. The involvement of neurologists assists to correct the afferent-efferent connections of the upper limb what has a positive effect on the final result.

The reason for repeated surgical intervention in the RA group was the failure to compensate for the underlying disease. Clinical manifestations were reactive tendovaginitis of the flexor tendons of the fingers. Long-term reactive tendovaginitis aggressively affects the general well-being of the patient and the stability of the EP components. Such a pathological condition requires close interaction "rheumatologist-patient-traumatologist". In the initial stage of clinical manifestations, conservative correction of the pathological condition is possible. Primary total wrist arthroplasty is performed from the dorsal side, and upon the approach, synovectomy of the extensor tendons of the wrist and fingers is performed. It is for this reason that, in ineffective conservative treatment within a month, approach to the flexor tendons is necessary. A subtotal synovectomy of the flexor tendons of the wrist and fingers is required. It should be noted that the opening of the carpal tunnel with the release of the median nerve only is not enough. X-ray signs of instability of the endoprosthesis components are the basis for exchange of the components using bone cement.

After a total wrist replacement, it is very important for a person to return to social activities with an improved quality of life. There were cases when patients completely stopped feeling that the joint was subjected to the operation. Along with the positive characteristics after arthroplasty of the wrist joint, there were cases when the joint was subjected to an excessive physical activity. In a number of such cases, the performance of heavy physical labor limits the functionality of the operated joint in the absence of radiological signs of instability of the endoprosthesis components. Therefore, the attention of patients should be drawn to the fact that the joint replaced is an artificial one, and the force load on the joint should be limited.

In the group of patients with post-traumatic joint alterations, there were periprosthetic fractures, dislocations, and dislocations of EP components. Their reason was falling down on the involved arm. Despite the small size of the capitatum, it was necessary to exchange the distal component in several cases using the Pressfit method, followed by good osseointegration of the EP. Unfortunately, it was in this group that three cases were identified that ended in total arthrodesis of the wrist joint (Fig. 5).

Despite the small size of the AVN group, it should be noted that the greatest difficulties arose with the patients who were diagnosed with wrist joint dysplasia. The long-standing stereotype of movements minimized the efforts of rehabilitators and traumatologists. This group had instability

of the proximal EP component. During the revision surgery, individual components were exchanged using bone cement. Along with the implant component exchange, tendon transfer was performed to correct the position of the hand. The flexor and extensor tendons of the wrist underwent transposition that depended on the initial state of the hand. These measures were sufficient for stabilization and a long-term positive effect of the surgery.

The data obtained allow us to state that the survival rate of total arthroplasty with an unconstrained ceramic wrist joint implant was 88 %.

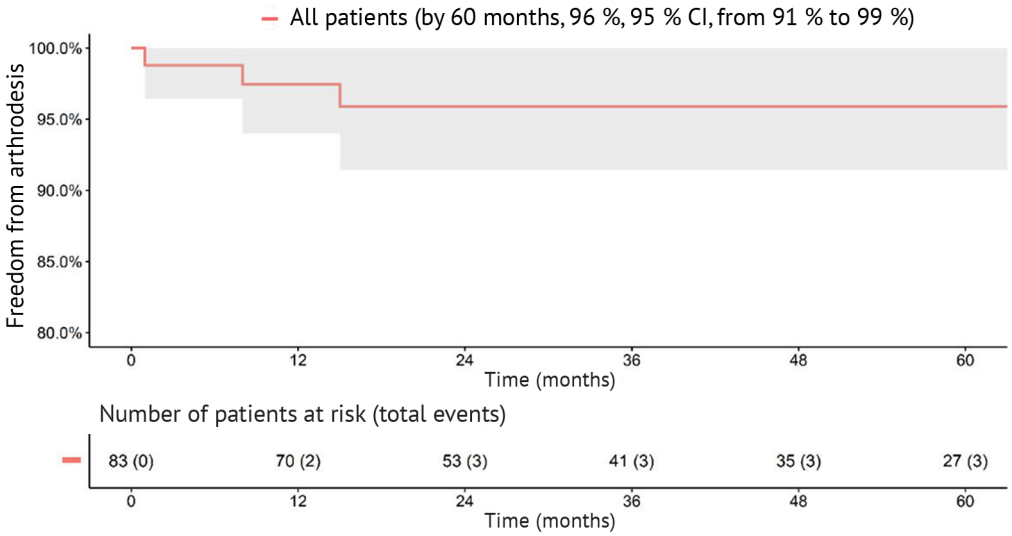

Fig. 5 Kaplan – Meier curve of freedom from arthrodesis in all patients

DISCUSSION

In the classical literature, the notion of the postoperative observation period has diverse characteristics. Many sources give the same names, but different time frames are implied. Scientific publications indicate time frames without explaining their meaning. A five- and ten-year assessment of the implant survival has been demonstrated [33-45]. We found the only definition of the postoperative period in the Big Medical Encyclopedia.

The postoperative period has two successive stages [5]. The immediate postoperative period begins from the completion of the operation and continues until the patient is discharged from the hospital. The late postoperative period runs outpatiently and is used for the final elimination of general and local disorders caused by surgical trauma.

In the Russian literature, there are no data on the survival of any types of wrist joint implants. In foreign publications, there is information about the complications of total wrist arthroplasty, reaching 35 %. Menon J reported a 33 % failure rate in wrist arthroplasty with Volz implants 40 months after implantation [6]. The failure rate in the study by Cooney et al. for the use of Meuli prostheses was 23 % after 5 years of follow-up [6]. Rademer et al. in 2003 revealed 80 % of poor results 52 months after implantation of APH endoprosthesis [46].

The rate of negative results described above is primarily associated with the search for the optimal shape and material for the implant. The rejection of the compromised implant attracted the designers to search for a new model. The negative effects of the tribological friction pair forced the search for modern materials for a new generation of endoprostheses. The demand for improving the quality of life and maintaining the mobility of the lost joint on the part of patients obliges researchers to look for the optimal shape and material.

The rate of positive results of ceramic endoprostheses in our study was 88 %. We did not find similar articles in terms of the chosen method of surgical treatment, devoted to the study of the survival of ceramic endoprostheses of the wrist joint, in the literature. We have made an attempt to interpret our results obtained in different time periods.

In joint arthroplasty, the foreign body in the human body is planned to be implanted for a long period of time. Dislocations, suppuration, persistence of pain and limitation of function, loosening of the endoprosthesis components are complication risks of joint arthroplasty [22-32]. These manifestations can occur at different times and for different reasons. Joint arthroplasty does not entail recovery, but only a long-term improvement in the quality of life.

Based on this thesis, the postoperative period is an important stage of observation and analysis. The results obtained by us are actually and statistically presented in Table 1. Their values were used in the graphs what allow us to determine the patterns that we propose for discussion.

Analyzing the literature data and the results of the study, we divided the orthopedic postoperative period into immediate (inpatient), early (up to 2 years), medium-term (from 2 to 8 years) and long-term (more than 8 years).

The immediate postoperative observation period is 6-8 days. It allows to regularly evaluate the postoperative suture, the position of the hand, radiological signs of the position of the components of the EP.

The early postoperative period must be distinguished due to possibility to detect disorders that can be corrected. In this time period, scar tissue is formed, the stereotype of movement in the replaced joint changes.

In the postoperative period from 2 to 8 years (mid-term), secondary changes in the components of the endoprosthesis may be observed. The most common symptom is periprosthetic osteolysis (aseptic instability). During this period, the social adaptation of patients has already been completed and patients use the hand without focusing on the artificial joint.

The long-term postoperative period serves one purpose: to determine the survival of EP.

This division of the postoperative period seems to us to be optimal and reasonable, unifying the notion of the implant function. This division allowed us to evaluate the results of the surgical method.

CONCLUSION

The results of the study demonstrate the positive dynamics in complex rehabilitation of patients after total wrist arthroplasty.

The analysis of the data obtained in the long-term period allows us to conclude that total arthroplasty with an unconstrained ceramic endoprosthesis of the wrist joint has a stable positive effect.

An eleven-year follow-up period demonstrates that the survival rate of an unconstrained ceramic wrist endoprosthesis is 88 %.

Due to insufficient literature data on this issue, there is a need to conduct further studies of the results of total wrist arthroplasty.

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