

POSITION

Reviewer: **Assoc. Prof. Dr Stoyan Hristov, PhD**

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On dissertation "**Shoulder arthroplasty – analysis of results and complication**"

For acquiring the educational and scientific degree PhD / "Doctorate"

By Order RD -26 - 1933/ 04.10.2024 of the Director of the University Hospital "N.I. Pirogov" EAD I have been selected as a member of the Scientific Jury and appointed to prepare an opinion on the procedure for the acquisition of the educational and scientific degree "Doctor" with candidate Dr. Maria Andreeva Hadzhinikolova, PhD student in free form , discharged with the right to defend by Order RD - 26 -1162/14.06.2023 in the scientific specialty "Orthopedics and Traumatology".

The rates of shoulder arthroplasty are increasing globally each year since it is a highly successful treatment method for both degenerative diseases of the glenohumeral joint and complex proximal humerus fractures. With the introduction of this treatment method, significant surgical experience has been accumulated over the years, contributing to the refinement of operative techniques and advancing and modifying the design and requirements of the implants used, with the aim of achieving optimal clinical outcomes.

The achieved results have led to a shift in concepts and a logical decline in hemiarthroplasty in favour of the increasing share of total arthroplasty, particularly with the RSA. All of this improves the final functional outcomes; however, complications persist that await solution. The requirements are further heightened by the fact that advancements in medicine have led to increased life expectancy, and elderly patients are the most common recipients of this type of surgery.

This raises questions regarding the investigation of implant survival rates, the necessity of a standardized approach to patient follow-up, and an in-depth analysis of expected complications to facilitate their prevention or resolution.

The dissertation of Dr. Mariya Hadzhinikolova is dedicated to this topical issue in contemporary science. It spans 170 pages, with a 33-page bibliography, and is richly illustrated with 18 tables and 65 figures, graphs, and photographs. Remarkably, the study is based on the review of 520 literary sources, which contributed significantly to the development of this work. The literature review is sufficiently comprehensive yet does not exceed the permissible 30% of the total volume. It thoroughly examines all aspects of the problem, paying special attention to the anatomy and biomechanics of the shoulder joint, as well as the clinical and imaging diagnostics in patients with implanted shoulder prostheses. Emphasis is placed on ultrasound elastography as an imaging method that evaluates the stiffness or elasticity of the studied tissue, either qualitatively or quantitatively, depending on the technique. The dissertation also delves into the topic of shoulder arthroplasty in detail—its indications, types, and the most common complications associated with each.

Dr. Hadzhinikolova highlights that, despite significant advancements in the design of components used in unipolar arthroplasty, uncertain clinical outcomes and a high rate of complications are still observed. She discusses loosening as a significant issue with the bipolar anatomical prosthesis and underscores the “revolutionary technological advancement” represented by reverse shoulder arthroplasty.

The dissertation has a clearly formulated objective, five feasible tasks, and a defined study design.

The “Materials and Methods” chapter includes the methodology and clinical material. Criteria for patient selection are outlined. The final number of patients monitored and treated with hemiprostheses is 33, with an average follow-up period of 26.41 months (ranging from 7 to 68 months). For patients with reverse shoulder prostheses, the final number monitored is 26, with an average follow-up period of 19.92 months (ranging from 6 to 48 months). Ultrasound evaluation of the rotator cuff at the final follow-up was performed on all 33 patients. Patients who underwent elastographic studies were divided into two groups. Group 1 included the operated shoulders of patients with reverse shoulder prostheses, while Group 2 consisted of healthy controls. The number of patients studied is entirely sufficient for statistical analysis of the results. At the final evaluation, all patients were assessed by the author for range of motion, pain, shoulder abduction strength, changes in daily activities and occupation, as well as social interactions. The retrospective nature of the study allowed the identification and targeted investigation of specific complications following unipolar and reverse shoulder arthroplasty. Radiographic criteria for complications are clearly defined, including those related to the tubercles, proximal migration of the implant, glenoid erosion, and the congruence of the reverse prosthesis. The protocol for ultrasound evaluation of the rotator cuff in cases of hemiarthroplasty is described in detail, including the characteristics of complete lesions. Additionally, the protocols for assessing the deltoid muscle using the two elastography techniques are thoroughly outlined.

The results and complications are accurately reported and analyzed in Chapter IV. The analysis of the healing of the greater tuberosity (GT) and lesser tuberosity (LT) in patients with hemiprotheses shows that within the first six months of follow-up, GT and LT healing occurred in 90.6% (n=28) of cases. Among patients with hemiprotheses, an increase in the resorption of LT and GT was observed at the final follow-up. The average acromiohumeral distance (AHD) measurements on the first postoperative X-ray, at six months, and at the final follow-up were 10.4 mm, 8.5 mm, and 7.2 mm, respectively, which fall within the normal range (above 7 mm) for this parameter. However, in practice, by the six-month follow-up, 24.2% of patients had an AHD below 7 mm, and at the final follow-up, 60.6% of patients had an AHD below normal. Patients without glenoid erosion within the first six months accounted for 37.5% (n=9), while the most commonly observed types of glenoid erosion were E0 (25%, n=6) and E1 (20.8%, n=5). At the final follow-up, a redistribution of patients without glenoid erosion was noted. The ultrasound indicators assessed exclusively in patients with unipolar shoulder prostheses included the integrity of the *m. supraspinatus*, *m. infraspinatus*, and *m. subscapularis*. Among these, 21.88% (7 patients) had a fully intact rotator cuff.

In patients with reverse shoulder prostheses, nonunion of the greater tuberosity (GT) and lesser tuberosity (LT) within the first six months was observed in two patients and remained constant until the final follow-up. For patients who achieved union of GT and LT, the rate was 92% (n=24). However, three patients (11.4%) developed shoulder instability, which in all cases was early-onset. The discussion spans 58 pages and analyzes the characteristics of the most commonly used techniques for shoulder arthroplasty. It critically reviews the study's results, including ultrasound findings, and the recorded complications.

Dr. Hadzhinikolova proposes a well-founded patient follow-up algorithm. Based on the analysis of accessible studies and her findings, she recommends that patients be monitored at one month, three months, six months, and one year after surgery. If no complaints arise, subsequent follow-ups should occur in the second year, with the next visit scheduled for the fifth year.

The conclusions are clearly formulated and logically derived from the author's in-depth analysis of the subject matter.

1. Considered the gold standard for the treatment of irreparable proximal humeral fractures (PHF), hemiarthroplasty is a method with uncertain clinical outcomes.
2. Unipolar shoulder arthroplasty predominantly leads to poor functional outcomes in patients undergoing secondary arthroplasty.
3. Reverse shoulder arthroplasty results in faster and better functional outcomes, both for patients with PHF and those undergoing secondary arthroplasty.
4. Conventional ultrasound has a role in monitoring the condition of the rotator cuff in patients with unipolar prostheses.
5. Ultrasound elastography has the potential to become an established method for evaluating the function of the *m. deltoideus* in reverse shoulder arthroplasty

patients, particularly in assessing its elasticity and the associated functional outcomes.

The following contributions can be distinguished in the work of Dr. Mariya Hadzhinikolova:

1. A detailed retrospective analysis of the results and complications associated with unipolar and reverse shoulder arthroplasty has been conducted.
2. An in-depth and comprehensive comparative statistical analysis of the final outcomes of the two applied methodologies has been carried out, considering each examined complication: nonunion and resorption of the tuberosities, GT malposition, implant migration, rotator cuff lesions, glenoid erosion, and shoulder instability.
3. The relationship between shoulder instability in reverse shoulder arthroplasty and factors that may contribute to instability has been analyzed. These factors include BMI, glenosphere size, surgical approach, number of previous interventions, *m. subscapularis* restoration, and the development of infection.
4. A conventional ultrasound method is proposed for monitoring rotator cuff tendon lesions in unipolar prosthesis patients.
5. An ultrasound methodology—ultrasound elastography—is introduced to evaluate the biomechanical characteristics of the *m. deltoideus* in shoulder prosthesis patients and its relationship with clinical outcomes.
6. An algorithm for patient follow-up is proposed to enable early monitoring of complications.

In conclusion, I can state that the dissertation meets all the criteria outlined in the requirements for a dissertation to acquire the educational and scientific degree of "Doctor." I give a positive evaluation of the work and urge the members of the scientific jury to award Dr. Mariya Andreeva Hadzhinikolova the educational and scientific degree of "Doctor."