

OPINION

By Prof. Hristo Georgiev, MD, DSc.

Professor of the Department of Orthopaedics and Traumatology, Faculty of Medicine
Medical University - Sofia, Vice Dean of Faculty of Medicine

Subject: **Public defence of PhD thesis (dissertation paper) by Stoyan Zhelyazkov Hristov, MD** on "Surgical treatment of proximal humeral fractures with locking plate, through and without augmentation - comparative analysis" for the award of Doctoral educational and scientific degree (PhD).

By order of the Executive Director of University Multi-disciplinary Hospital for Active Treatment and Emergency Medicine "N. Pirogov" EAD No. RC 523 of 14 February 2022, I was appointed a member of the Scientific Jury and by decision of the latter (Minutes No. 1), I was appointed to present the opinion on the dissertation paper of Stoyan Zhelyazkov Hristov, MD, free doctoral student at the Scientific Council of University Multi-disciplinary Hospital for Active Treatment and Emergency Medicine "N. Pirogov" EAD, in the field of higher education 7. "Health and Sports" in professional field 7.1 "Medicine" and doctoral program "Orthopedics and Traumatology".

Relevance of the topic: On the basis of own clinical material, the surgical treatment of proximal humeral fractures was analysed. Scientific research is focused on proving the benefits of augmentation with synthetic bone substitute polymethylmethacrylate. This is another dissertation paper in Bulgaria examining the pathology, but it is first for our country comparing the types of augmentation and their ability to reduce the expected high rate of incorrect bone healing, avascular necrosis, osteosynthesis debricolage and subacromial impingement. The medico-social significance of the dissertation paper is determined by the severity of the pathology, mainly in adult patients with poor bone quality and severe morphology of the fracture.

Compliance with Art. 29, paragraphs (1) and (2) of the Regulations for the development of the academic staff at University Multi-disciplinary Hospital for Active Treatment and Emergency Medicine "N. Pirogov" EAD - Sofia from 2018 - "Requirements

for dissertation paper for obtaining Doctoral educational and scientific degree. The dissertation paper is presented in a similar structure for this type of work containing 133 pages, 53 figures and 41 tables (which also includes graphs). It includes an introduction (1 page), a literature review (46 pages), a bibliography (7 pages containing 250 titles in Latin and 1 in Cyrillic). In the remaining part of the dissertation paper Hristov, MD formulates the goal and the four tasks arising thereby, the scope of the study, the clinical methodology of the study, the used surgical equipment and postoperative treatment protocol, own results, author's analysis and conclusions. The dissertation incorrectly includes an initial summary, similar to the ones used in a scientific publication, contributions and a list of own publications on the topic. I accept this as a deviation from the requirements for a dissertation paper. Their place belongs to the Abstract. As a mistake in the structure I consider placing the conclusions and the derived algorithm after the conclusion and placing the goal and tasks before the literature review. The lack of Bulgarian authors in the bibliography is an omission. The dissertation papers related to the topic could be cited the least, both the older ones of Kalapov (1980) and Bonev (1989) and those of Totev (2017), Kaykchiyan (2017), Patrikov (2019) and Mitkovski (2020).

The literature review is extensive enough. It addresses all aspects of the problem. In logical sequence the dissertation paper presents surgical anatomy, biomechanics and the mechanism of trauma, clinical and imaging diagnosis with high informativeness of tomographic examination with 3-D reconstruction, classification systems and epidemiology of fracture and known treatment methods and complications and the need for augmentation. The scope of the review exceeds the permissible 30% of the total volume. For me personally, some propaedeutic data are not directly related to the dissertation topic, such as anatomy, and they may be omitted, and the detailed examination of surgical accesses should be placed in the Methods section. As criticism to the literature review, I can point out the lack of a brief analytical summary at the end of the proven, unresolved and theoretically probable facts on the problem. With these exceptions, the literary review is concretized to the dissertation and represents a synthesis of the extensive knowledge of the problem of Hristov MD. This chapter can be considered as a short modern course, refreshing our knowledge in the treatment of proximal humeral fractures, methods of various osteosynthesis and synthetic bone substitutes.

The goal is clearly stated - "To analyze the possibilities of augmentation with polymethylmethacrylate in the surgical treatment of the proximal humeral fractures with a locking plate." The four tasks are specific, clear, correctly defined and fully consistent with the goal.

The chapter "Patients and Method" contains the methodology and clinical material.

The dissertation paper uses a series of surgically treated patients with proximal humeral fractures during the period 2016 - 2019 in the Department of Orthopaedics and Traumatology at University Multi-disciplinary Hospital for Active Treatment Burgas AD. 114 closed proximal humeral fractures were observed in 112 patients based on well-defined inclusion and 5 exclusion criteria. All patients had fresh, 3- and 4-fragments fractures. The average age of the participants in the study was 67 years, with the youngest patient being 22 years old and the oldest being 87 years old, and 90% of the patients were females. The main injuries were from low-energy trauma, most often falling from one's own height. 11.4% of patients had polytrauma. According to Neer classification, 101 of the fractures were 3-fragments fractures (2 fractures- dislocations) and the remaining were 4-fragments (1 fracture-dislocation). The statistical processing of the reported parameters is correctly presented in clear graphs.

In all patients the diagnosis was made on the basis of clinical orthopaedic examination and imaging studies - AP and Lat radiography of the affected joint, and in 37 (32.46%) patients a CT scan with 3D reconstruction was performed.

Surgical treatment in 74.5% was performed up to the 24th hour. It includes open reduction with deltoid-pectoral approach (77 cases) and anterolateral approach in the other cases, osteosynthesis with locking plate and augmentation in 50 cases, where in 25 fractures with crista iliaca bone autograft and in the remaining 25 cases with polymethylmethacrylate.

This chapter systematically presents the preoperative preparation and surgical technique, the technique of both types of augmentation, the technique of plate placement and the protocol for four-projection radiosopic tracking of the osteosynthesis position. This is of great practical value for any orthopaedist-traumatologist. A protocol of postoperative treatment and control with radiographs at the sixth week, and then every three months, was presented.

In this chapter, in my opinion, there are unnecessary analyzes and comments on literature data, e.g. Yian et al., Katolik et al., Boehm et al. and others. The place of these authorial interpretations is in the discussion section.

In processing the results, the dissertation paper applies reliable modern statistical methods used in biomedical sciences. They are presented in this section.

The results of the clinical series of the study are correctly presented in Chapter III. Bone healing reported in the presence of radiographic signs of bony callus formation of at least three cortices in bi-planar projections is present in all fractures, in the interval between 6 and 10 weeks after surgery. Anatomical repositioning of the fracture was achieved in 99 cases (86.84%), acceptable in 15 cases (13.16%). In 12-month follow-up, the dissertation data show the following "Impressive is the higher percentage of preserved reposition at the 12th month in bone cement augmentation, as well as the significant dynamics in patients without augmentation. A clear change was observed in proximal humeral fractures treated without augmentation of the osteosynthesis - a marked decrease in cases of anatomical reposition at the expense of the categories "acceptable" and "poor" by 28% and 14%, respectively".

The author's observations regarding the neck-shaft angle are similar. "In the analysis of the results, we found that between the group augmented with bone autograft (M = 124.6, SD = 11.80) and the group augmented with polymethylmethacrylate (M = 130.8, SD = 6.06), there is a statistically significant difference between the values of neck-shaft angle measured in the 12th month postoperatively (p = 0.011). The conclusion we made is that bone cement augmentation contributes to greater structural stability".

Functional assessment is performed by monitoring pain, using the Constant-Murley score test system and DASH score test system. I can summarize the achieved results:

- In the observed group of patients it was found that 76 cases (66.67%) were without pain;
- 96% of patients with augmentation do not experience or report mild pain that does not interfere with their daily life, compared to 86% of those in the group without augmentation;
- There is a certain advantage of the augmented group of patients in terms of absolute and relative Constant-Murley score as the difference is statistically significant only at the beginning - in the 3rd postoperative month and in relation to the relative Constant-Murley score (p<0.05);
- Analyzes showed superiority of synthetic bone augmentation over bone autograft during all follow-up periods, but there was a statistically significant difference in the

measured flexion in the 3rd and 6th month ($p < 0.05$) and abduction in the 3rd month ($p = 0.006$).

- On the 12th postsurgical month, the data from the functional tests are equalized.

63 complications were correctly presented in 41 (36%) patients and in 21 patients the complications were more than one. In the group of patients without augmentation, 19 patients were registered, in those with polymethylmethacrylate and bone autograft 8 and 14 respectively patients were reported with one or more complications. The most significant of them are 7, for whom a second surgery was required. I think it was necessary to classify the complications, e.g. according to Clavien-Dindo Classification for surgical complications. I accept this as a shortcoming of the paper, which, however, does not change the scientific value of the dissertation work.

In the chapter, the doctoral student also presents four clinical cases. They are documented with highly informative photographs, adequate to the presented results.

Chapter VII "Discussion" consisting of 18 pages presents an extensive comparative analysis of the views and results of the doctoral student on the subject with those of other authors who worked on the same problem. In general, the discussion is aimed at demonstrating the benefits of augmentation with synthetic bone substitutes. This chapter is the most creative part of the dissertation paper. It convincingly proves the high erudition of Hristov, MD on the presented issues. For me personally, it was the most interesting, especially the part referring to the analysis of complications.

The dissertation paper ends with five conclusions and its own algorithm for the treatment of proximal humeral fractures. They prove the view of Hristov, MD that "in the proximal humeral fractures of adult patients with advanced osteoporosis, treatment with locking plate with augmentation has its place in careful selection of patients and strict assessment of fracture morphology and risk factors for expected complications". I completely agree with the author's conclusions and I accept that the set goal of the dissertation paper is fulfilled.

The presented bibliography is arranged in alphabetical order.

In general, the dissertation paper is written in the correct literary language. The graphics and photos used are of high quality and informative, fully consistent with the text. The remarks made by me are of a methodological nature, they do not reject the scientific value of the work and rather show insufficient assistance from the supervisor in the final design of the dissertation work.

I can point out the following **more important contributions** of the scientific work of Stoyan Hristov, MD presented to me for giving my opinion. They are of scientific-applied and confirmatory nature:

1. For the first time in our country the role of augmentation in osteosynthesis with locking plate in the surgical treatment of the 3- and 4- fragments proximal humeral fractures in patients with osteoporosis was monitored.

2. The selected scientific thesis is proven by a statistically reliable and group of patients, operated by the author, showing the ability of the dissertation for reliable analysis, imposing the benefits of intraoperatively augmentation.

3. Practical approaches applicable at each level of trauma care in the country in patients with proximal humeral fractures are given.

On the dissertation topic the doctoral student presented three publications and two presentations meeting **the Minimum National Requirements under Annex 1 of the Regulations for the development of the academic staff in the Republic of Bulgaria**. They contain separate parts of the developed material. The presented Abstract of the dissertation paper in the volume of 73 pages is formed according to the generally accepted requirements.

In conclusion, the dissertation paper submitted to me for review and opinion meets the qualitative and quantitative criteria set out in the Requirements for dissertation work for obtaining Doctoral educational and scientific degree the Regulations for the development of academic staff at University Multi-disciplinary Hospital for Active Treatment and Emergency Medicine "N. Pirogov" EAD and the Law on development of the academic staff in the Republic of Bulgaria. Therefore, I give **a positive assessment** of the work and address the members of the Scientific Jury to award Stoyan Zhelyazkov Hristov, MD the educational and scientific degree "DOCTOR" (PhD) in the scientific specialty "Orthopaedics and Traumatology".

28 February 2022

Prof. Georgiev, DSc

