

**Technological Aspects of Machining
Dental Biomaterials**

**A Methodology for Experimental Machining
and Surface Quality Evaluation of Dental
Biomaterials**

by

Ján Duplák

Samuel Mikuláško

Jozef Zajac

RAM-Verlag

2026

Technological Aspects of Machining Dental Biomaterials

A Methodology for Experimental Machining and Surface Quality

Evaluation of Dental Biomaterials

Reviewers: Prof. dr Maja Anđelković
Prof. dr Dejan Kojić
Assoc. Prof. Enes Sukić, PhD

© Ján Duplák – Samuel Mikuláško – Jozef Zajac



This scientific monograph was supported by the Slovak Research and Development Agency under the contract No. APVV-21-0293 and supported by the Scientific Grant Agency of the Ministry of Education, Research, Development and Youth of the Slovak Republic and Slovak Academy of Sciences, grant VEGA 1/0258/24.

© Publisher: RAM-erlag
Stüttinghauser Ringstr. 44
D-58515 Lüdenscheid
Germany
RAM-Verlag@t-online.de
<http://ram-verlag.eu>

The publisher cannot be held responsible for any linguistic errors in the book: Such responsibility is only up to the authors.

ISBN 978-3-96595-056-6

Contents

PREFACE.....	1
1 Dental Biomaterials and Machining Characteristic.....	3
1.1 Metallic Biomaterials	5
1.2 Polymeric biomaterials	10
1.3 Ceramic biomaterials	13
1.4 Composite biomaterials	16
1.5 Machinability of dental biomaterials	19
1.6 Factors influencing the machinability of dental biomaterials	21
2 Manufacturing Systems and Technologies for Machining Dental Biomaterials	24
2.1 Digital dentistry and CAD/CAM technologies	25
2.2 Manufacturing technologies in digital dentistry	28
2.2 Machining of dental biomaterials	30
2.4 CNC manufacturing systems for machining dental biomaterials	35
2.5 Tool systems in machining dental biomaterials	38
3 Surface Integrity and Quality of the Machined Surface	40
3.1 Surface integrity of dental biomaterials.....	41
3.2 Influence of machining technological parameters on surface integrity..	43
3.2 Surface roughness of the machined surface	45
3.3 Influence of cutting conditions on machined surface quality	51
3.4 Machinability of dental biomaterials	52
3.5 CAD/CAM technologies in machining dental biomaterials.....	54
4 Methodology of Dental Zirconia Disc Machining	57
4.1 Objective of the experimental part	58
4.2 Characteristics of the investigated material.....	59
4.3 Technological equipment and measurement systems.....	61
4.4 Experimental methodology.....	66
4.5 Surface measurement and quality evaluation	66

5	Practical Approach to Dental Zirconia Disc Machining	68
5.1	Design of experiments for dental zirconia machining.....	68
5.2	Initial experimental machining of zirconia disc for dental applications	70
5.3	Second experimental machining of zirconia disc for dental applications	79
5.4	Third experimental machining of zirconia disc for dental applications	88
5.4	Summary of the experimental investigation	98
	References.....	100

PREFACE

The rapid development of digital technologies in recent decades has significantly influenced contemporary dentistry and dental prosthetics. The introduction of CAD/CAM systems, computer-controlled machining centres, and advanced dental biomaterials has enabled the production of highly accurate, aesthetically acceptable, and biologically compatible prosthetic restorations. As a result, digital dentistry has become one of the most dynamically evolving areas at the intersection of biomedical engineering, materials science, manufacturing technologies, and computer-aided production. The continuous development of dental biomaterials has considerably expanded the technological possibilities available for the fabrication of modern dental restorations. Contemporary CAD/CAM systems are capable of processing a wide range of materials, including metallic, ceramic, polymeric, and composite biomaterials, each possessing specific mechanical, physical, biological, and technological characteristics. These differences significantly affect the manufacturing process, machinability, surface quality, and long-term performance of dental prosthetic constructions. The increasing requirements for manufacturing accuracy, surface quality, and process reliability have highlighted the importance of understanding the technological aspects of machining dental biomaterials. Material properties, cutting conditions, tool geometry, machining strategies, and production system stability all play a crucial role in determining the quality of the final product. Particular attention must also be paid to surface integrity, which represents a complex set of geometrical mechanical, and microstructural

Preface

characteristics of the machined surface and directly influences the functional and biological behaviour of dental restorations. This monograph provides a comprehensive overview of dental biomaterials, their machinability, and the technological aspects of CAD/CAM machining in modern digital dentistry. Attention is devoted to the classification and characteristics of dental biomaterials, factors affecting machinability, machining systems and cutting tools used in dental manufacturing, as well as methods for evaluating surface quality and surface integrity. Emphasis is placed on the relationships between material properties, machining conditions, and the resulting quality of dental prosthetic constructions. The publication is intended for researchers, engineers, students, and professionals working in the fields of manufacturing technologies, biomaterials engineering, dental production, and digital dentistry. It aims to contribute to a better understanding of the technological challenges associated with machining dental biomaterials and to highlight the importance of process optimization in achieving high-quality and reliable dental restorations.