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Technology and Tools for Dental Hard Tissue Machining*

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1. Introduction

The robotics technical solutions find large application in medecine practice in recent 15-20 years. Due to element basis and computer systems development many devices are created and applied in the area of the surgery and microsurgery, orthopedics, cell manipulations etc.

Universal peculiarity of the medicine manipulations is a big variety and complexity of doctor's hand motions, different trajectories and unique manners in every concrete case in combination with requirements for precision and stability of motions. These requirements are valide for stomatologycal practice as well.

The aim of this study is to analyze available in the present dental therapeutics teeth machining instruments and operations and on this basis, to define requirements to orienting module design.

2. An application of the robotics technical solutions into dental practice

The manufacturing dental cutting instruments and devices firms [4, 9] work in major to develop classical solutions, mainly connected with cutting motion drives, burs gripping and fixing, new materials using, handpieces shape improving, cooling etc.

A review of the literature gives information that the main researcher's achievements are concentrated in the field of dental imlantology. Firm Tactile Technologies from Israel reports, that an teleoperated implant locating and placing system (Fig. 1.) is created (2005). System provides radiologycal jaw bone contour measurement and identification, intraoral image-guided precise instrument navigation

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and positioning, carrying out dental implant procedures by disposable micro-robot [10]. Similar systems are developed in Institute of Dental Implants at Good Samaritan Medical Center, West Palm Beach, USA [7], in Surgical Navigation and Robotics Laboratory at the Medical School Charite of the Humboldt University at Berlin (1997-2005) [5,8], (Figs. 2, 3).

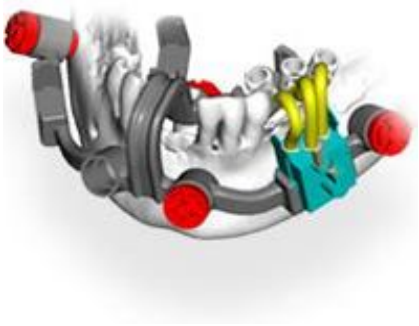


Fig. 1

Fig. 2

In Journal of the American Dentist Association [3] is announced that polish researchers from Medical University of Warsaw have built an artificial oral cavity and a robot on a 40:1 scale. The construction is based on hexapod platform, powered by 6 servomechanisms. Unfortunately more information about this device is not available.

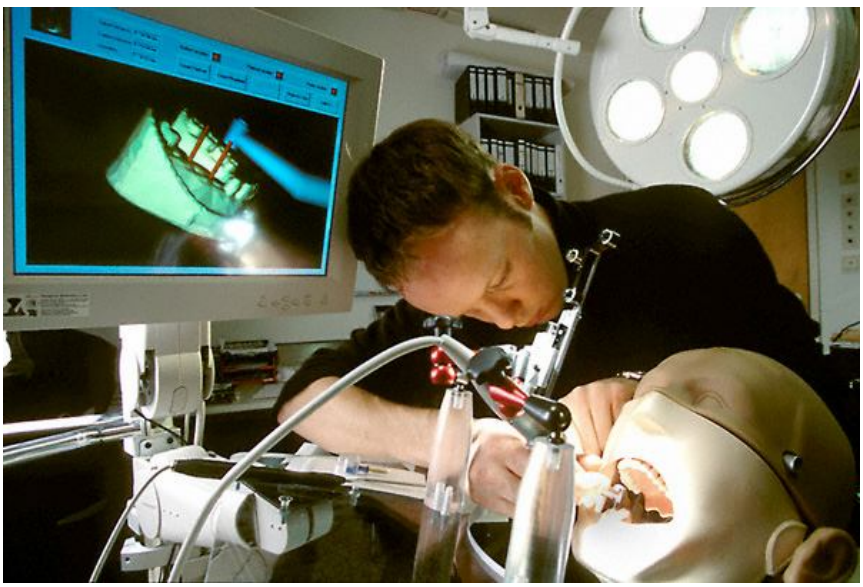


Fig. 3

It is noted that major disadvantages of theese systems as well as these in otrer medecine areas are technical sufistication and high manufacturing rates.

3. Technology and tools for dental hard tissue machining

3.1. Machining tools

The dental hard tissue machining instruments include different rotary cutting tools – borers and tool holder –handpiece

A wide variety of different borers exists – in form of the frustum of a cone, which are used for undermining, for acute angle getting, for making cavity bottom smooth etc. Disk cutting tools are used for undermining the teeth walls of insufficient thickness. (Figs. 3, 4). There are many other instruments with special functions (Figs. 5, 6).

The borers are manufactured with hard alloy cutting element (Fig. 4) and with abrasive cutting element (Fig. 5). The seconds are used to work in teeth enamel with high cutting speed and low feed and consequently with small cutting forces.

Fig. 4. Hard alloy borers

Fig. 5. Abrasive borers

3.2. Technology for dental hard tissue machining

Two basic technological operations for dental hard tissue machining may be differentiated as a result of the literature sources learning [1, 2]:

1. In therapeutic dentistry – it is use machining more often than not for caries treatment. Cutting tools and cutting regimes are different because of work material – enamel or dentin. The root channel preparation may be added to the cavity treatment as well.

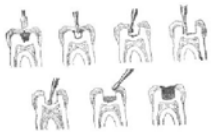
2. In orthopaedic dentistry – a therapeutic preparation precedes the wraparound crowns treatment. There are different rules and methods for tooth crown filing off depending on selected crown ei?iiea and individual peculiarity of every case.

Some of the most typical hard dental tissue cutting operations are shown in Table 1.

Analysis of the technological treatment and of the dentist's activities observation shows that hard tissue machining is rather hard manipulation for both doctor and patient. It is necessary to work in limited variable operating space, at uncomfortable teeth position and bad visibility, especially in the process of surround wall filing off. Creating of the necessary tools work angles, carrying out of the complicated working trajectories and cutting force dosage, require professional reflections and many other skills creation. It has to be marked difficulties in providing of a dentist hand steady support. A muscular tiredness in the hands is of big importance for the treatment quality and for keeping doctor's working capacity for a long time.

The tooth crown filing off is a mechanical process which may be hurtful to the vital teeth. Injurious consequences are connected with the influence of the trauma in well centered handpieces and instruments;

Table 1

No	Scheme of the treatment	Description of the manipulation	Machining tools	Peculiarity
I. Preparation of the cavities for filling [1]				
Masticatory teeth cavity preparation				
1	 A)  B)  C)	Carious cavity uncovering (A)	Fissure borer of small size	Undermined dentin is being cut by abrasive tool in case of advanced caries when the cavity is larger
2		Cleaning of the carious mass from the cavity walls (A)	Spherical borer	Carious mass cleaning has to start from the bottom of the cavity in order to cut off nervous branches and to decrease patient pain (B)
3		"Enlargement with the purpose of protection" (A, C)	Cylindrical, conical or disk tool	For teeth secondary caries appearance protection
4		Creating of a biological cavity shape in relation to the pulp (A)	Spherical borer	The healthy dentin has to be protected as more as possible
5		Chamfer cutting (A)	Cylindrical or conical tools	All extent of the enamel prism has to be included
Treatment of the root channel holes				
		Root channel holes enlargement	Fissure cone burs	It is of big importance to control the borer and handpiece direction continuously, with the purpose of perforation protection

(from the pressure, vibtations) and of the heat on the tooth pulp and parodont. They are followed by tissue damages and patient pain. To decrease the action of hurtful factors it has to be kept the following major requirements:

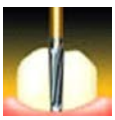
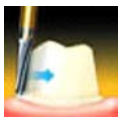
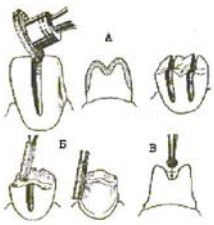
– the filing off has to be realized by the most suitable for every case borers;

– it is necessary to choose the most appropriate work rejime for every part of the tooth;

– the filing off has to be realized by whole tool length, not by small parts (the tip).

– it has to operate by well centered handpieces and instruments.

Table 1 (continued)

II. Teeth filing off for wraparound crowns, [2]				
Masticatory teeth filing off without threshold preparatory border and high speed machines				
1		Separation	Thin needle-shaped diamond borers with realization of a batter of 4°÷5°	Cutting line begins from the vestibular wall surface and goes on to the hard tooth tissue without neighbouring teeth touch
2		Masticatory surface filing off	Small cylindrical and conical burs	Proportional surface decreasing in accordance with the microrelief is being made easier
3		Surround wall filing off	Cylindrical, conical and needle-shaped abrasive borers	Rougher machining is realized by cylindrical and conical tools, the work в in the close of the gums border – by needle-shaped ones
4		Preparatory border shaping	Keen needle-shaped borers	The borer tip get into gum cavity depth and it may be damaged
5		Smoothing of the tooth stub	Suitable fine borers	-
Hard dental tissue file off with threshold preparatory border – a Marxkors method				
1		Filing through tentative furrows in the surround walls (A)	Special disk diamond burs	The furrows are being filed through with 0.6÷1.3mm depth, which limits following cutting depth
2		Surround wall and masticatory surface filing off (B)	Cylindrical diamond burs	A tooth stump has to be guaranted by enough thick denting wall after filing off.
3		Masticatory surface microrelief shaping (B)	Spherical diamond burs	-

4. Conclusions

It is considered [1, 2] rotary dental cutting instruments will be used a long time in the future with all their disadvantages. This means that a dentist's skills will be of prime importance to quality treatment, to prevent tissue damage and to decrease patient discomfort. That's why the autors propose an orienting module to be designed on the basis of the robot kinematic structures.

The most important problems, which have to be solved in the process of the module design, are to achieve needed mobility and stability with the purpose of effective using of the cramped operating space, of good visibility providing, of dentist motion number and complication decreasing. Other aims, which have to be achieved, are to limit force reactions in dentist' hand, to guarantee sterility and patient safety. From constructive point of view new module have to be appropriate to available in practice standard handpieces and to realize needed structure strength and stability considering minimum size of the components.

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Технология и средства для ориентирующих модулей стоматологических инструментов

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(Р е з ю м е)

В предлагаемой публикации показаны существующие в мировой стоматологической практике технические решения в робототехнике. Рассмотрены применяемые в настоящем инструменты для обработки резанием твердых тканей зуба. Анализированы наиболее характерные технологические операции с учетом проблем, возникающих при их осуществлении. На этой основе выявлены требования к проектированию ориентирующего инструментального модуля для нужд терапевтической стоматологии.