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The effectivity analysis of the software used in implant biomechanics

Implant biomechanics is one of the several applied subfields of the biomechanics used to create and improve implants design and to test its behavior before and after the surgery. Biomechanists working in this field should know how to use a wide range of software to carry out successful research. In this article, a review and analysis of the commonly used software is introduced as well as its effective combinations. This study focuses on investigation based on already completed researches.

A simple classification is introduced in this study to combine all the software used by the scientists. It consists of the general and special purpose software. A general-purpose software is represented by text editors, databases, spreadsheets, multimedia and graphic editors which can be combined in office suites. A special purpose software contains computer algebra systems (CAS), digital product development (DPD) software, highly specialized and authoring software.

General-purpose software is used by researchers to store text, numeral and graphical information obtained from experiments and theoretical research. A huge amount of data obtained is usually organized and stored in databases and researchers can easily select, sort and manipulate any results needed like was done in work [1]. Collected data can also be stored in spreadsheets in tables [2] that allows researcher to easily build charts [3] and make simple calculations. All manipulations used in mentioned studies are rather effective especially when applied in complex like was done in [4].

While preparing papers to be published all the formulas are typeset with the help of formula editors. In formula editors, formulas can be created manually using a markup language, e.g. TeX or MathML, by graphical user interface like in Microsoft Equation Editor, build-in equation editor in Microsoft Word or any of the computer algebra systems. The choice of the preferable ones depends on the researcher's needs, tastes and knowledge. Mostly researchers use TeX because it provides the same formula's look on computers with various operating systems and is free of charge.

Multimedia and graphics editors usually come in handy while creating presentations for lessons, conferences or articles like was done in [2]. In this case, office suites can help researchers simplify their work with data by providing profitable functional features.

According to the survey carried out in Belarusian State University, about 84% questioned biomechanists utilize office suites like Microsoft Office, Apache OpenOffice, LibreOffice, etc. as a general-purpose software while the rest 13% prefer to use standalone software. Fifty differently aged researchers from 25 to 62 years old were chosen to take part in this survey. Figure 1 shows the main reasons for choosing office suites taking into account the age of researchers.

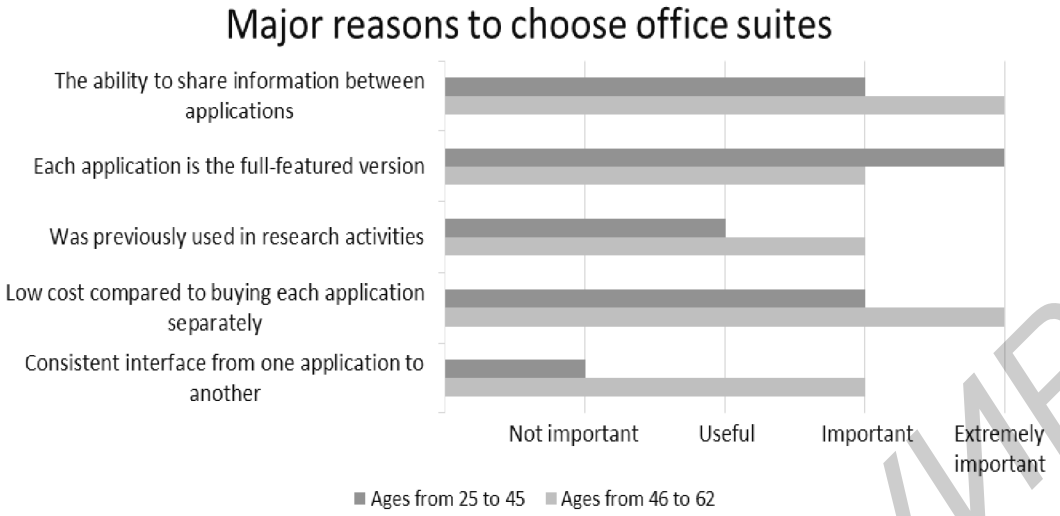

Figure 1. – Major reasons to choose office suites

The survey showed younger researchers usually choose office suites because of its full-featured version while biomechanists aged 46 to 62 feel comfortable working with office suites because of the consistent interface from one application to another. Both survey samples value the price and the ability to share information between applications and the fact it was previously used in research activities. The results of the survey proved that biomechanists prefer to use office suites because of abovementioned reasons and continue using it because it shows the effectivity of approach.

Researchers usually cannot fulfill their investigations without the special purpose software. All the calculations in the studies are usually done and checked in computer algebra systems like Mathcad, Mathematica, numerical analysis software MATLAB, etc. For instance, scaling factors were calculated from obtained results by using a non-negative linear least square optimization technique with the help of MATLAB in [2].

Digital product development (DPD) software in this study refers to the complex consisting of computer-aided engineering (CAE), finite element analysis (FEA), computer-aided design (CAD) software. In implant biomechanics, the usage of finite elements analysis (FEA) has become an alternative to the surgical assessment. For researchers it is essential not only to understand how mechanical parameters influence on the bone, material or structure behavior but also to have the ability to model the process. In this case, FEA software can help by providing a wide range of simulation options and detailed stiffness, strength and displacement visualization. In [5] study computational FE model of the Kansas knee simulator was developed

in Abaqus/Explicit, the same software was chosen to create specimen-specific FE models of tibial and femoral bone with total knee replacement implants in [6]. Commonly, FEA is included in CAE and combined CAE/CAD software like ANSYS, Femap, CATIA, etc. Researchers more often choose combined CAD/CAE software to have the ability to create and transform 2D or 3D models before the computation rather than just CAE itself.

CAD software includes such commonly used programs as SolidWorks, Pro/Engineer, ABAQUS, etc. SolidWorks has a wide range of available design features, for example, it was used to design the wear in the knee implants inserts [3], dental implants, attachment systems of the overdentures and the superstructure of the fixed full-arch implant-supported prosthesis [7], intramedullary nails [8]. Other CAD programs can provide almost the same design functions as SolidWorks do.

CAD/CAE programs give an opportunity to build plots according to the obtained results during the simulation and FEA. For example, predicted A-P motions of the femoral medial and lateral condyle was shown on the plot in [5], the variation of the maximum stress and equivalent plastic strain in the liner against loading directions and micro separation distances was displayed in [9] and compressive bone strain before and after kneeling for total knee replacement implants in [6]. In addition, CAD software allows researchers to validate the obtained results by comparing it to the experiments that had been held previously [8, 10, 11, 12]. Researchers can easily change the geometry and material properties of the 3D model in case the results differ from the experimental ones.

To increase the software effectivity some researchers prefer to use one software to design and assemble 3D models and another to generate a finite element model, e.g. in [8] SolidWorks was chosen for design and ANSYS Workbench for analysis.

In this paper highly specialized (HS) software refers to the software that focuses on the particular speciality, for instance, orthopedics biomechanists use the same software orthopedic surgeons do. Researchers interested in upper or lower extremities implant biomechanics often use the results of magnetic resonance (MR) or computed tomography (CT) scans to reconstruct 3D models of bones and soft tissues e.g. geometry of femoral, tibial and patellar bone and cartilage were segmented from the MR scans using ScanIP software in [6]. As was shown in the [13] the combination of image processing software MIMICS, CAD software Pro/Engineering and FEA software

ANSYS was found rather effective in accomplish research goals. The effectivity of using the following HS complex in prosthodontics biomechanics is stated in [14] and introduced in Table 1.

Table 1.

Software used in prosthodontics

Field of use	Software
Training, scientific research	
Simulation (software for reproducing clinical trials)	CLINSIM (Morita, Japan); PREPassistant (KaVo Dental GmbH, Germany); DentSim Compact (Yoshida, Japan)
Sharing of experience, manuals, distance learning	Medline, EMedicine, Europe PubMed Central
Clinical application	
Obtaining digital photos and video of the oral cavity	AcuCam Concept N (Gendex), ImageCAM USB 2.0 digital (Dentrix), SI-ROCAM (Sirona Dental Systems GmbH
Intraoral dental X-ray	GX-S HDI USB sensor (Gendex), Im-ageRAY (Dentrix), Dixi2 sensor (Planmeca)
Detection of teeth optical characteristics	Transcend (Chestnut Hill), Shade Scan System, VITA Easyshade
Virtual articulators	MAYA, CEREC 3D, CAD (AX Compact)

Authoring software is the last type of software included in the group of specialized ones. Authoring software is usually created to solve particular problems occurred in the specific research and is not publically released. Authoring software can be created by both researchers and programmers. For example, in [15] a special software was created to automatize the process of inserting glenoid adapter into the glenoid cavity.

This study focused on investigation of software use in implant biomechanics based on already completed researches. The simple classification that combines general and special software used by the scientists was introduced in this study. According to the carried out survey mostly biomechanists prefer to use office suites as a part of general purpose software. The survey also took into consideration the age of respondents and revealed the preferences according to the age

group. While analyzing the use of special purpose software it was showed that computer algebra systems, digital product development software, highly specialized and authoring software are often used in researches and give effective results. Moreover, a combination of different kinds of special purpose software was stated as the most effective.

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