

Electronic System for Data Record and Automatic Diagnosis Assessment in the Temporomandibular Joint Disorders

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Abstract

Background: The research goal of the Dental segment of the Centre of Biomedical Informatics is focused on the electronic health record (EHR) development for dentistry.

Objectives: At the beginning there has been constructed an electronic dental cross "DentCross", which was representing patients dental data in the graphical form. It has been completed with the system of the automatic speech recognition (ASR) and voice synthesis module (TTS).

Methods: The main goal of this work was to reach the high entirety of the system and its automatization. For this reason it has been completed with the special record medium for the temporomandibular disorders (TMD).

Results: Concerning the experience with the old version the knowledge database (KB) for TMD has been structured differently. A classification diagnostic schema by the American Academy of Orofacial Pain (AAOP) has been used. The KB has been created in the MUDR KB Editor application. On this basis a relational database has been constructed and a user interface for data collection based on MUDR and MUDRLite EHR systems was developed.

Conclusions: The main advantage of this system is determination of probable diagnosis of the disease (AAOP) by the system ("custom" component). It is based on the



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characteristic data, which have been recorded in the electronic form after the investigation. For the creation of the component of its alone MS Visual Studio.NET 2003 development tool has been used. The whole component is programmed in C# language.

Keywords

Temporomandibular joint, temporomandibular joint disorders, DentCross, electronic health record, AAOP classification

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1 Introduction

Nowadays, the level and general development of medical care for patients brings not only much higher demands on knowledge and skills of providers (medical personnel, especially doctors), but also on appropriate systems for storing and handling the increasing amount of data. The

main task of these systems for electronic health record (EHR) is another quality of care. Earlier data recording in the classical paper form is no longer for its complexity and quantity of data so convenient and development of IT technologies enable us to leave this type of data storage. Today's EHR systems thus serve not only for easier data manipulation, faster communication and even

greater data protection against abuse, but also allow more comprehensive, more effective and safer medical care.

All these parameters and needs apply in different areas of medicine. Dentistry is no exception and there is an effort to develop an EHR for this area, with all the specifics that it brings. It is about a graphic design application for dentistry, and shot the whole issue of orofacial system, including contingent multifactorial diseases such as temporomandibular joint disorders in particular (TMD). Electronic health records just for temporomandibular joint disease are not yet available and its development is due to the complexity of the problem very complicated.

The temporomandibular joint (TMJ) itself is among the most complex joints throughout the body. It is the compound joint and is closely linked to the chewing muscles and periodontal complex. The American Academy of Orofacial Pain, defined in 2008 the stomatognathic system as a "functional and anatomical relationship between the teeth, jaws, muscles of mastication and TMJ" [1]. Due to the complexity of the system of conditional multifactorial pathology, and many system functions (speech, mastication) [2] is the correct diagnosis, screening and choosing right therapeutic regimen a very demanding process that requires especially good access and organization of all information.

There are several internationally recognized classifications, but few of them are used extensively and are also usable internationally. Probably the most used is the AAOP (American Academy of Orofacial Pain) classification [1], which is used more for clinical use and classification of the RDC / TMD (Research Diagnostic Criteria for Temporomandibular Disorders) [3], which is more suitable for scientific purposes.

The actual study and treatment of TMD are very important and desirable because it is a relatively neglected area. TMD being deemed to be the most frequent cause of pain in the orofacial area of non-dental origin [4]. Among the most common clinical signs of TMD belong muscle or joint pain, joint sound phenomena, limited mouth opening or deviation of jaw when opening mouth [5]. Furthermore, it can be associated with symptoms as headache or earache, neuralgia, vertigo, and toothache.

EHR development in the field of dentistry and TMD are engaged in a long time and the experience with its use and modern trends, so we decided to update and rearrange the electronic form of TMD. The aim is to achieve better control and transparency for the end user, the complexity of the knowledge base for the TMD in the final stage of preparation and applications for automatic diagnosis from the specified anamnestic data.

2 Methods

2.1 MUDR EHR, MUDRLite, DentCross

For purposes of our research the MUDR KB Editor modeling tool, which has been developed in the EuroMISE

Centre, has been used to create a model for MUDR EHR. In this application the knowledge base for the field of dentistry [6, 7] has been already constructed and now the new version of TMJ knowledge base was added. MUDR EHR is a predecessor of the MUDRLite application, which is serving rather for the smaller environment needs (e.g. dental outpatient department).

Based on this two applications the DentCross system has been developed (for easier applicability by the final user and better graphical image), which represents user interface and TMD form. This form has been transformed after clinical experiences and completed with the system for automatic diagnosis selection. Voice control by the Automatic speech recognition (ASR) system and module for the voice synthesis Text-to-speech (TTS) are also included (same as the older version of DentCross) [7].

2.2 Classification TMD (AAOP, RDC/TMD)

As mentioned above, the best scheme for the TMD classification seems to be from our point of view the classification performed by the American Academy of Orofacial Pain [1], which is suitable for the clinical use and is concerned with the whole problematic of temporomandibular joint (TMJ) and surrounding diseases.

It is more extensive than RDC/TMD [3, 7], which is dealing more with the temporomandibular joint and is omitting many facts. Both of them have been involved in the knowledge database for TMJ, but for the user interface just the AAOP classification has been used.

AAOP

1. TMJ

(a) *Congenital diseases:*

- I. *Aplasia* – connected with hemifacial mikrosomia, face asymmetry, congenital, insufficient growth of the one side condylus, movement to the affected side, restricted mouth opening.
- II. *Hypoplasia* – growth limitation, other bones could be affected, less serious than I., restricted mouth opening, asymmetry during mouth opening.
- III. *Hyperplasia* – excessive skull growth, face asymmetry, asymmetry during mouth opening.
- IV. *Dysplasia* – childhood and adolescence, slowly excessive growth and fibrotic tissue changes, face asymmetry and mouth opening.
- V. *Tumors* – complex affection, medical imaging with pathological findings, pain, restricted mouth opening e.g.

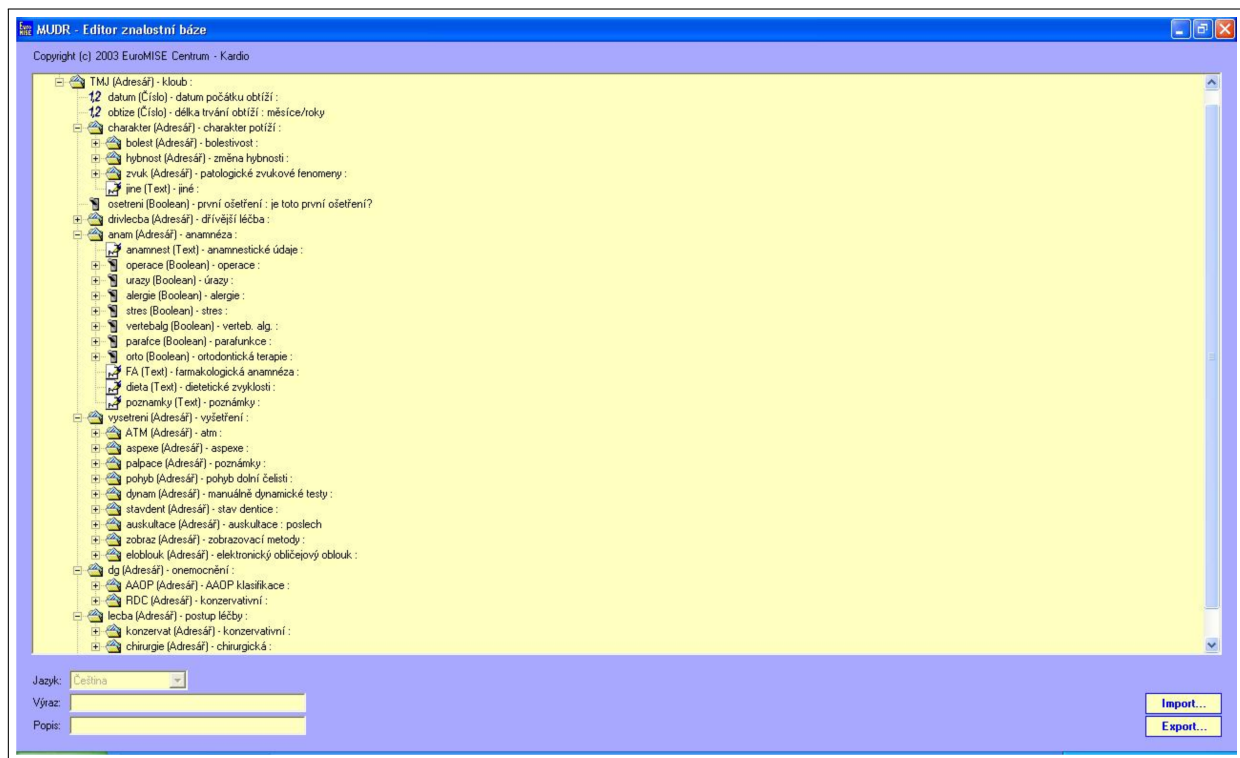


Figure 1: Knowledge base for TMD.

(b) *Joint disc diseases:*

- I. *Dislocation with reduction* – joint sounds during jaw opening and closing, asymmetric opening (S-shape deviation towards affected side), restricted mouth opening.
 - II. *Dislocation without reduction* – restricted and asymmetric mouth opening (movement towards affected side), without joint sounds.
- (c) *Dislocation TMJ (luxation)* – acute state, pain, patient is not able to close his mouth.
 - (d) *Inflammatory diseases* – arthritis (capsulitis, synovitis, polyarthritis included) – restricted mouth opening, pain, joint sounds, painful palpation in the TMJ region.
 - (e) *Non-inflammatory diseases* – arthrosis – primary (etiology not known) and secondary (consequence of the trauma or systemic disease). Chronic affection. Restricted mouth opening, without pain, rigidity feeling, sound phenomena (crepitation, creaking), asymmetric opening (movement towards affected side).
 - (f) *Ankylosis* – restricted to impossible mouth opening, protrusion and lateropulsion limitation, face asymmetry, chronic disease.
 - (g) *TMJ fracture* – trauma in anamnesis, pain (spontaneous as well as during palpation), positive X-ray findings, possible restricted mouth opening, disrupted articulation, asymmetric opening, acute origin.

2. Masticatory muscles affections:

- (a) *Local myalgia (muscle pains)* – painful TMJ movement and muscle palpation, could be connected with stress, disrupted articulation and muscle injury.
- (b) *Myofascial dysfunctional syndrome* – rest pains, trigger points present, could be connected with vertigo, steaming, parafunctions, stress etc.
- (c) *Central provoked myalgia* – chronic, long lasting muscle pain similar to myositis, but without inflammatory sings. Could be combined with neurological inflammation symptoms. Important is presence of the persistent pain.
- (d) *Myospasmus (muscle contraction)* – acute involuntary tonic muscle contraction, restricted mouth opening, without severe pain.
- (e) *Myositis (muscle inflammation)* – rest and movement muscle pain, red skin in region, swelling possible.
- (f) *Myofibrotic contraction* – chronic, pain not present. Caused by fibrotic degeneration of tendons, ligaments and rarely of muscle fibers. Manifested as muscle shortening.
- (g) *Muscle tumors* – benign and malignant character, wide scale of symptoms, positive histological findings and medical imagining.

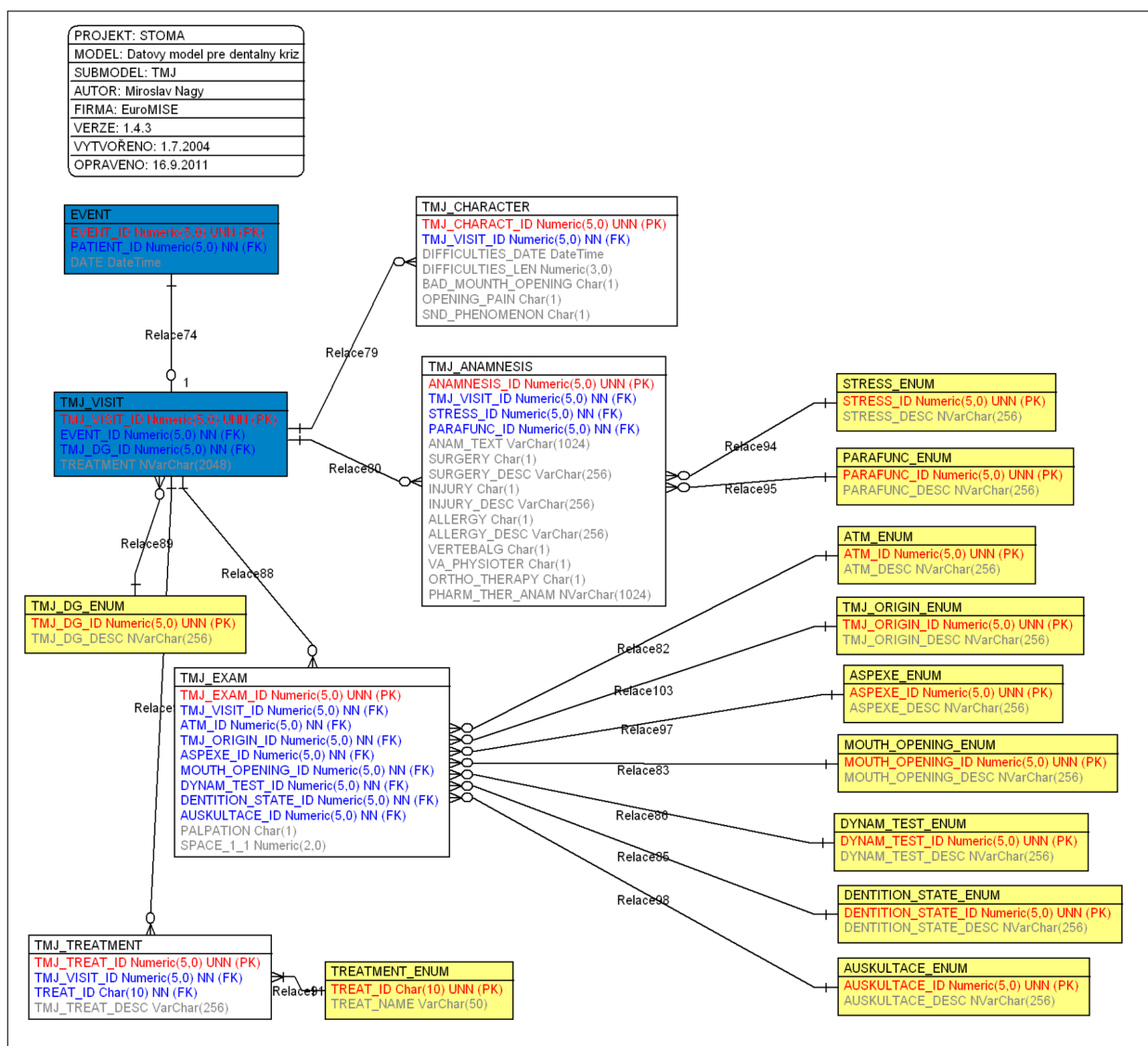


Figure 2: Relational data model for TMD.

2.3 Description of the Module for Diagnosis Assessment Support

The new version of the MUDRLite TMD form was simplified and in comparison to the former version the form was altered to match the examination process of the patient performed by the physician. Another major improvement of the TMD form is a custom component, defined by the MUDRLite system to enable the extension of the forms functionality in the sophisticated manner. In our case the form was enabled to propose a diagnosis based on data collected during the patient examination.

The new component, designed to support decisions of the physician in the form of diagnosis proposals, is based on the AAOP classification. For each diagnosis contained in this classification a logical formula was created, forming a set of implications. The assumptions of each implication are formed from parameters collected via the TMD form. If the conditions of a given implication are met then the

relevant diagnosis is added to the proposed diagnoses list and presented to the physician.

The MS Visual Studio .NET 2003 was used to develop the decision support component and the programming language used for this was C#. The component is connected to the MUDRLite system in the form of dll library.

3 Results

3.1 Knowledge Database for TMD

The whole knowledge base, which was created in the MUDR KB Editor application [6], has been completed and sorted according to the new findings and complies to a different logical system. It is now more oriented on the logical order during patient investigation (Fig. 1).

Figure 3: User interface window for TMD record in MUDRLite EHR.

3.2 Data Model

Before data conversion from the TMD knowledge database to the user application it was necessary to choose important modalities, which are essential for patient investigation. They have been transformed into a relational database model by using MUDRLite EHR (Fig. 2). This model represents relations among modalities and thanks to base on this database it is possible to create a form, which is integrated with the DentCross application.

3.3 Application with Automatic Diagnosis Statement for TMD

The form window for anamnestic and investigation data record is (as it was in the old version) a part of the DentCross application and could be opened from the main window. Better information structuring has been made with the respect to logical attitude by investigation and also restriction on important data has been made. Subsequently, separate windows have been added for imaging with description (e.g. RTG) and electronic face bow data (Fig. 3). As already mentioned, the diagnosis assessment is based on the modified AAOP classification and is executed by an automatic component, which is fixing this probable diagnosis in compliance with the patient investigation. This simplifies the therapy process for the physician, because of a very wide variety of TMD states and diagnoses.

Following therapy modalities are different. They are directly connected with the stated diagnosis and seriousness of presented symptoms. They could be conservative (soft diet, splint, non-steroid antillogistics, dry heat, isometric exercise etc.), miniinvasive (arthrocentesis, arthroscopy), surgical (operation with joint discus reposition, joint substitution) or combined.

4 Discussion

The entire EHR application for dentistry, the DentCross, seeks to provide a comprehensive recording options for the whole stomatognathic system. The comprehensive record is further complemented by the information that a voice control (ASR) further adds and backward interpretation of the record (TTS) by a computer. This allows quick control and contactless applications and data recording [6, 7].

Further expansion is aimed at trying to automate the process of diagnosis and thus a therapeutic plan. Our system is now complemented by the automatic speech recognition and clinically tested at a specialist department for TMD in the Faculty Hospital in Motol.

It should enable the less experienced dentists to perform quality evaluation of the patient with a record of all important data, not only anamnestic data. Then, based on these data, the diagnosis is established and is followed either by a treatment or by referral sent to a specialized

department for a too complicated condition of the case, which should be followed by a comprehensive therapy.

This objective has many pitfalls and should be further complemented and tested in particular. It should be noted that all the time at least basic knowledge of this issue by the dentist will be needed. The role of human factor in final decision making and control of automated applications will still be significant.

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