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Development of Expert System for AOSpine Thoracolumbar Spine Injury Classification: An Application for Healthcare Providers

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Abstract.

This article presents the development of expert system application that mimics the steps done by healthcare providers who are responsible for determining the type of spine injury by using the algorithm of AOSpine thoracolumbar spine injury classification. The expert system is capable of recommending the type of spine fracture; this recommendation done by the proposed expert system will facilitate the selection of treatment and referral of the patients to the specialized healthcare unit. The source of knowledge used in the proposed expert system was collected from various related literature studies and spine surgeons. The proposed expert system was evaluated by a group of spine surgeons at the spine unit, College of Medicine, Zagazig University, Egypt. The proposed expert system was then evaluated in terms of its functionality, usability, and reliability using the ISO/IEC 9126 software quality standards. The results showed that the proposed expert system was able to achieve the defined objectives of this study.

***Keywords*:** expert system, spine fractures, algorithm of AOSpine classification, healthcare providers, software evaluation.

1 INTRODUCTION

Spine Injuries cause serious problems, such as a substantial functional loss and a high mortality rate. The presentation of these injuries can vary based on the fracture pattern, stability, and associated neurologic injury. Because managing these spinal fractures is often predicted on these factors, a classification system that incorporates these variables is important to provide a common language for communicating plans. However, establishing a classification system with universal application and

use has been challenging [6]. The AOSpine thoracolumbar spine injury is a classification of spinal fractures, created by the AOSpine Association, to facilitate communication and encourage optimal treatment protocols to the spine community [2]. The spine surgeon and healthcare providers should follow a specific algorithm to apply the AOSpine thoracolumbar spine injury classification system. The current algorithm uses a meaningful injury classification and worldwide surgeon input to determine the recommendation of the initial treatment for thoracolumbar injuries, which offers a global accepted surgical algorithm for the treatment of thoracolumbar injuries [3]. However, there are no automated tools that can effectively provide a guide for the healthcare providers to facilitate the steps of the algorithm to reach the final diagnosis and offers a recommendation for the specific type of spine injury. Following the AOSpine algorithm may be confusing especially for emergency physicians, and general practitioner. Therefore, automating the algorithm steps of AOspine thoracolumbar spine injury is a good contribution.

The purpose of this article was to develop an expert system to mimic the steps done in the algorithm of AOSpine thoracolumbar spine injury classification. The expert system will recommend the type of spine fracture; this recommendation will facilitate the selection of treatment and referral of the patients.

The remainder of this paper is organized as follows. Section 2 provides an overview of expert systems and the required steps carried by physicians to apply the AOSpine thoracolumbar spine injury classification system. Section 3 describes the proposed expert system. Section 4, describes the evaluation of the proposed expert system and the conclusion.

2 BACKGROUND STUDY

2.1 Expert System

Expert System is subfield of Artificial Intelligence (AI). It is a computer program that simulates the decision and actions of expert that has facts and experience in a particular field [13, 16]. Human experts can be relieved from routine tasks and decreasing their workload by using expert system [5]. Expert systems have provided solutions to different problems especially in the medical field, from disease diagnosing [1, 7, 10] to monitoring and detection through wearable sensors [4, 8, 12, 9]. Expert system separates between the representation of knowledge about specific problem area (knowledge base) and the processing of this knowledge (inference engine) Thus, the knowledge is not encoded in conventional algorithms, but stored separately from the processing algorithm in a knowledge base [15]. Any expert system consists of user interface, knowledgebase, inference engine, and working space which contains facts used by the inference engine [14].

2.2 AOSpine Thoracolumbar Spine Injury

This is a common classification of spine fractures. In this classification, the physician should answer a number of questions based on different modalities of radiology including Xrays, Computerized Tomography (CT), and Magnetic Resonance Imaging (MRI) (need reference). Fig 1. Shows the manual algorithm done by the healthcare providers

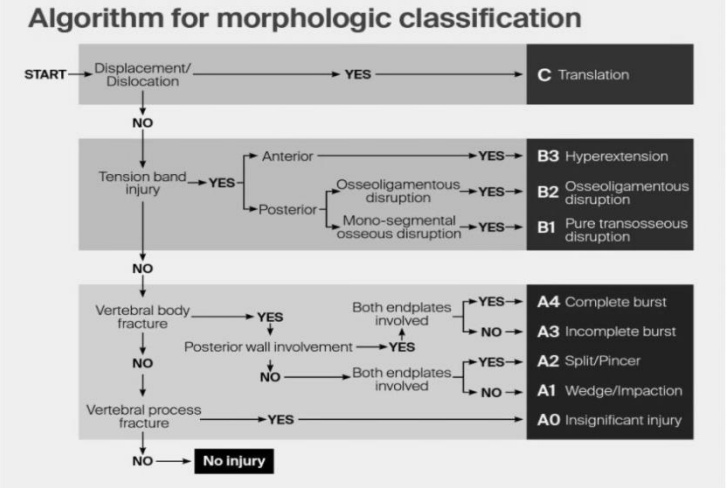


Figure 1. AOSpine thoracolumbar spine injury classification (adapted from [11])

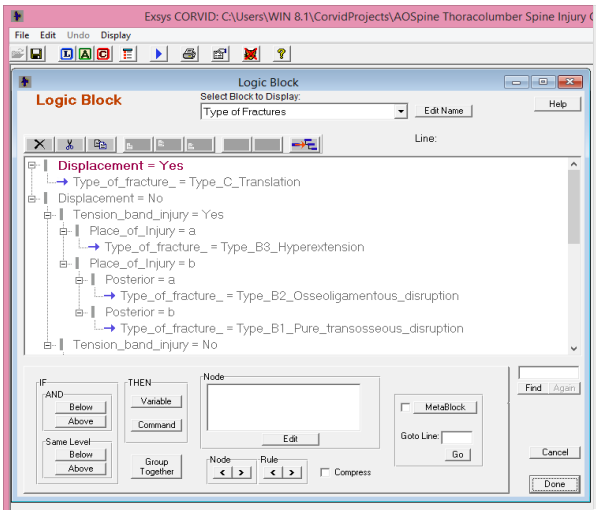
3 DEVELOPMENT OF THE EXPERT SYSTEM

Exsys Corvid was used to build the expert system. Corvid is a powerful and extensively proven tool for building interactive expert system applications online. It enables the expertise and the logic of decision-making process of the domain expert to be converted into an organized and structured form that can be used by the Corvid Inference Engine to dynamically drive interactive sessions that provide recommendation to the end user. The knowledge base of the proposed expert system consists of variables with their assigned values and a set of If-Then production rules reference to the AOSpine Thoracolumbar Spine Injury Classification. The variables used in this study are shown in Table 1.

Table 1. The variables with their assigned values

Variable name	List of values
Anterior	Yes –No
Both endplates involved	Yes- No
Place of Injury	Anterior- Posterior
Posterior	Osseoligamentous-

	Mono segmental osseous disruption
Posterior wall involvement	Yes- No
Tension band injury	Yes- No
Vertebral body fracture	Yes- No
Vertebral process fracture	Yes- No
Types of fracture	Type C: Type B3: Type B2: Type B1: Type A4: Type A3: Type A2: Type A1: Type A0:
Y	No injury



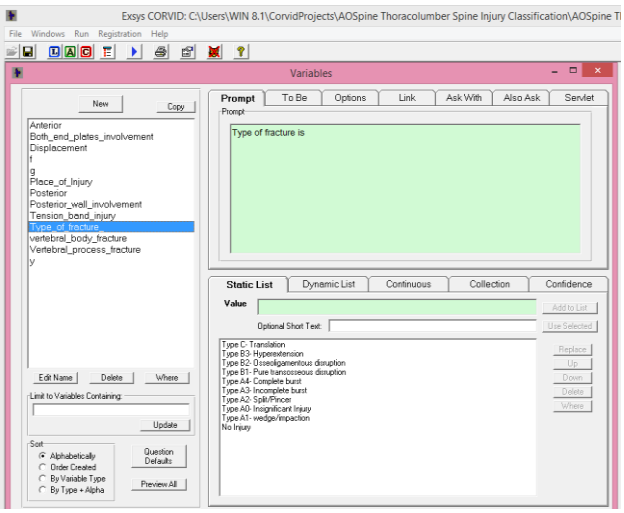


Figure 2: Stored variables with their assigned values. **Figure 3: The set of IF-THEN production rules.**

Fig. 2 and Fig. 3 show the knowledge base of the proposed expert system. In the proposed expert system, the user interface creates a URL to run the system. The URL depends on servlet runtime. The servlet runtime allows creating more complex end user interfaces in HTML and CSS. These can incorporate some of the "generic" replaceable parameters of the default templates or can be highly

customized in HTML for individual variable questions or results. Fig. 4, Fig. 5 and Fig.6 represent a sample of screenshots of the proposed expert system.

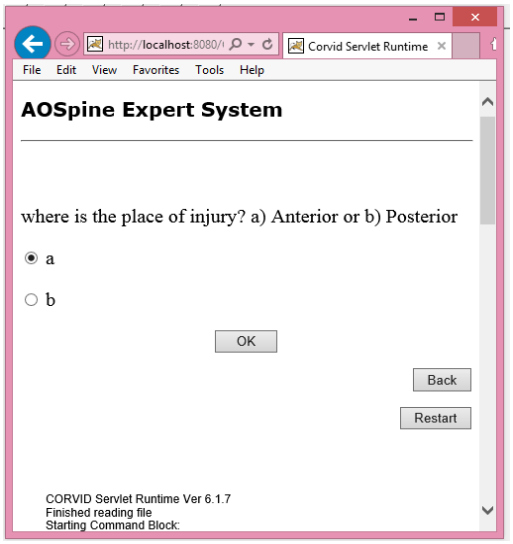


Figure 4. Screen asks about the tension band injury.

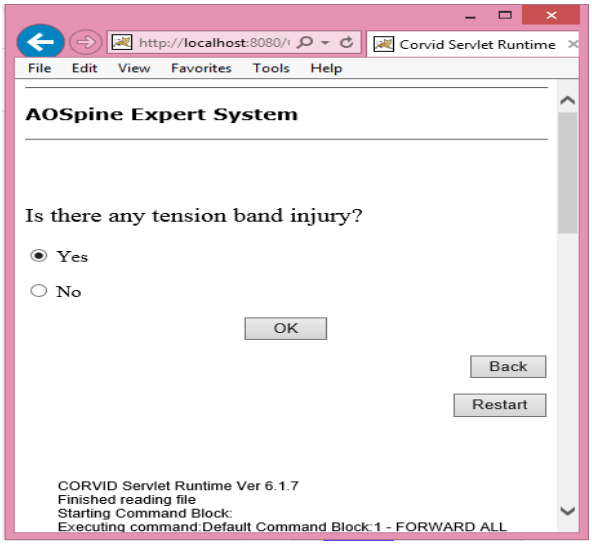


Figure 5. Screen asks about the place of injury.

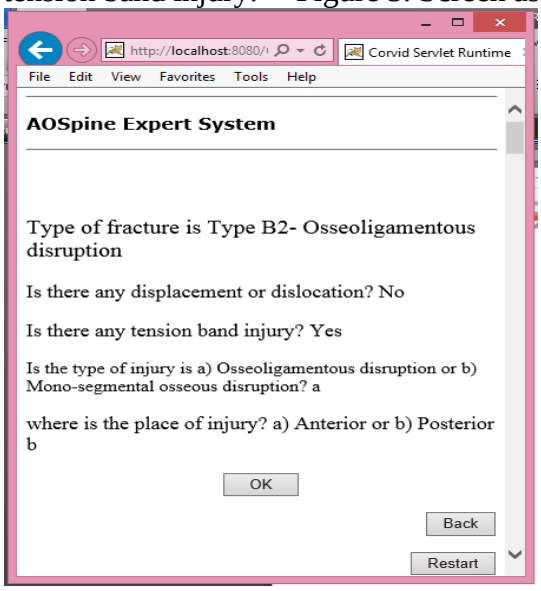


Figure 6. The expert system recommends the type of spine fracture with the explanation of the result.

4 EVALUATION AND CONCLUSION

The aim of this evaluation is to assess the functionality, usability and reliability of the proposed expert system using the ISO/IEC 9126 Software Quality Characteristics standard. The evaluation is done by spine surgeons. For this purpose, the questionnaire method was used a subjective evaluation methods. The questionnaire used a five-point Likert scale (1-5) ranging from “strongly disagree” to “strongly agree”. The questionnaire was answered by 14 spine surgeons at Spine Unit in College of

Medicine, Zagazig University, Egypt. The questionnaire consists of 11 questions. For each question, respondents were asked to circle the response which best described their level of agreement. Table 2 shows the results of the assessment with the average mean of 14 answers for each criteria. The result shows that respondents agreed with 4.6 mean average of the proposed expert system evaluation.

Table 2. The evaluation results of the proposed expert system.

Criteria	Result
Functionality	4.7
Reliability	4.1
Usability	5
Mean Average	4.6

The proposed expert system mimics the steps done in the AOSpine thoracolumbar spine injury classification system. It recommends the type of spine fractures based on a set of questions asked to the healthcare providers, who should answer after visualizing a different modality of radiology related to the patient. The proposed expert system could serve as a reference for future developers who are interested in developing a mobile expert system for recommending the type of spine fracture.

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