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Artificial Intelligence in Fracture Healing Diagnosis.

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ABSTRACT

Making computers to learn and make decisions is done at present especially in clinical conditions where the parameters used for diagnosis are vague. For example when poorly defined parameters are used in diagnosis in radiographic examination of tibia fracture healing. In recent past digital data in computers had made processing of data both simple and cheap. Data like electrical output from the fractured limb can be fed and a computer can be trained and then later tested for a new fracture case of unknown nature. This can give precise idea of the exact day of healing of the new fracture. This exploits the sharpness of the diagnosis with computers i.e using artificial intelligence , even with some lack of transparency. The main limitation is the lack of confidence on the clinician side. But the potential of artificial intelligence is more than it is used nowadays.
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INTRODUCTION

Tibia bone fractures are the common injuries and only so hence a good number of such patients are visiting hospitals every year. Many patients are immobilised in plaster and put to strict non weight bearing method of treatment .In early stage of the fracture treatment the diagnostic dilemma is when callus is still not seen in the radiographs. In recent times, diagnostic modalities have advanced from the days when fracture healing was diagnosed essentially on radiographs and clinical assessment only.

It is very common observation that by the time the definite radiological finding of bridging callus appears in radiographs, the fracture healing is almost complete. It is usually suggested that in the treatment of an undisplaced fracture of tibia, clinical examination of the leg for any abnormal mobility and a radiograph during every visit of patient is adequate for assessing and continuing the particular method of treatment.

The fracture patient who comes with inability to put weight in the fractured leg and pain in limb with restriction of movements of the entire limb is again put to a method of assessment of healing which believes that healing is still not over when actually healing is over. This is because radiographs show delayed appearance and is lagging behind the mechanical testing [1].

Modern diagnostic facilities include advanced use of CT and Technetium 99 scan in fracture healing assessment [2-5]. However recent works on electric monitoring can be still more useful. Compared to other methods the electrical method has less radiation. Here radiographs are needed only to confirm the position of implants like wires and if necessary during reapplication of any wires [6-10]. This method also has the possibility of electric energy to stimulate fracture healing. The fracture patient must be given the option and such electric diagnostic method must be tried in all cases who give consent and there is nothing to lose.

The presence of hazy radiographic appearance around the fracture site is thought to be the start of the healing by most orthopaedic surgeons in radiographs. Likewise the doctor to interfere waits for the absence of the clear-cut radiology of the appearance of no callus. This is especially done in later stage i.e waiting for a particular period of time which is needed to see callus in radiographs. The present method does not allow prediction of all fracture cases presented as to which one will not go for union, even in the first week of the treatment.

Due to a large number of parameter (factors) that will affect the fracture healing, there is usually an element of vagueness in deciding union and it is stochastic Electrical diagnostic studies in bone fracture healing were aimed to facilitate diagnosis of fracture healing even while it happens. Many studies in recent past in the case of fracture healing diagnosis have been continuously made with clinical implications. [6-10] This is with clinical side based application on patients and with use of fewer radiographs. However the end point of fracture healing or which exact day the fracture healed form which day onward the fractured limb can be loaded are not given by these studies.

Artificial Intelligence (AI) is a method of using data from different sources fed into a computer, training it and ultimately making it to learn the pattern of the data and come to a conclusion regarding the diagnosis. There has been a huge amount of data on AI and also machine learning suggesting the efficacy of the studies. Despite this, the number of clinical studies that use artificial intelligence is not very encouraging. The main reason is the unfamiliarity of the doctor physician or surgeon to the potential use of AI in clinical studies [11].

To cite Davis SC and Ovington LG in a review article on wound healing, “Owing to the clinician’s unfamiliarity with the current research and general understanding of such therapies , many patients receive only traditional treatment and remain unexposed to the potential benefits of the nontraditional.” [12].

Similarly the main limitations of AI in the current context are the unfamiliarity to the clinician. According to the available information on AI, a comprehensive and holistic approach is needed to address this problem. There must be a team work of doctor in collaboration with a computer engineer. There should also be clinical trials in using AI for the clinical studies and assessing the sharpness in the diagnosis. The use of AI needs to address few open ended questions with respect to its transparency, repeatability and robustness.

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In our experience we have not been able to duplicate the efficacy of AI. The current proof of evidence points to the direction undertaking research in the various methods of fracture healing assessment assisted with AI.

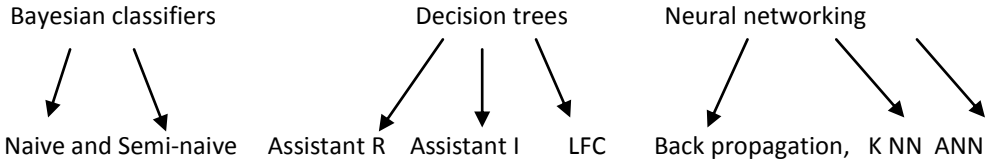
There are many limitations

- Differences in the injuries among different patients
- Choice of the type of the AI used
- Various other factors that affect fracture healing as in diabetes mellitus
- Sometimes quick healing confounding the research interpretation in certain patients
- Poor transparency and lack of familiarity already pointed out.

Of the main tools that were used in the AI , common methods are Bayesian classifier, neural networking and decision trees. We mainly dealt with electrical data with feed forward back propagation, artificial neural networking and Adaptive Neuro Fuzzy Inference System (ANFIS). These works are new and not treaded on in relation to the fracture healing diagnosis. Earlier, Igor Kononenko had classified machine learning for medical diagnosis. In his own words "AI is a part of computer science that tries to make computers more intelligent " [11].

To make computer learn and make decisions which clinical parameters used in diagnosis are vague. Ubiquitous presence of computers in digital type had made processing of data simple and cheap. The modus operandi is simple. We need to have a digital data in an inexpensive device to collect and store data. Such data collected are from many different machines. They are stored in information systems .So using machines which can also send electronic data to storage makes AI or Machine Learning (ML) easier. If such a machine is made to learn data of cases solved in the past which are fed to a computer to run a learning algorithm. Later if data of a new unusual patient can be fed to find the diagnosis. Such method can be of use in case if an inexperienced or junior specialist is seeing the case and deciding its management [11].

The following are few algorithms used



Classifiers: As seen above there are classifiers to study the data and classify it e.g. naive Bayesian classifier. When the question of its transparency rose, Kononenko had rectified it. [11]

Symbolic learning methods: These include decision trees and decision making. As seen from the figure 1, the functioning of the decision tree is like that of the human brain [11].

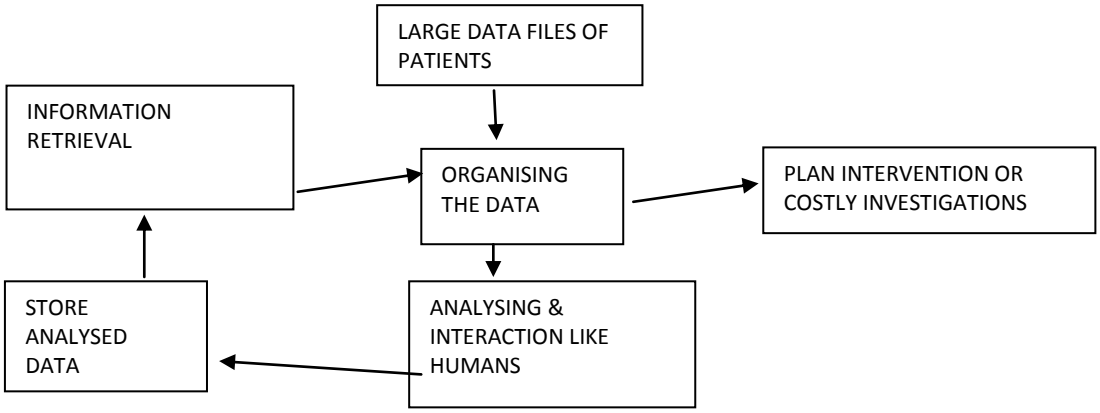


Figure 1: Scheme of the symbolic learning

Neural networking: Simple neural networking was used in case of mainly linear problems. There are a set of neurons or perceptrons .The single layer perceptrons are enough for neural use in linear problems. In complex problems with many factors involved, multi layered neural networking are used. This method found application in many of our papers. [13,14,15] Still as the transparency is lacking in the neural method, they are called the black boxes. [11]

Requisites of a good AI method

Few requisites are listed as the preferable properties of an AI system. The basic differences in requisites among the AI system are according to Kononenko's article. [11]These are briefly explained in table 1.

Table 1: Various AI methods and their properties.

Classifier → / Feature ↓	Naive / Semi Naive	Assistant R and Assistant I	Look forward Feature Construction	Back propagation	k Nearest Neighbour
Accuracy and performance	**Very Good**	**Good**	**Good**	**Very Good**	**Very Good**
Transparency of decision	Good	Very Good	Good	Poor	poor
Explaining ability	Very Good	Good	Good	Poor	Acceptable
Noise reduction	NO	Good	Good	No	No
Handling missing data	**Very Good**	**Acceptable**	**Acceptable**	**Acceptable**	**Acceptable**

Using AI will result in interesting links emerging from the data which otherwise the clinician would have never dreamt of. It may be observed in general that the lack of transparency reduces the acceptability of the AI methods. The classifiers are useful but a combination of classifiers is more useful[.11] We have made attempts to use as many methods as possible like neural network, feed forward back propagation, Adaptive Neuro Fuzzy Inference System, fuzzy and also modelling [13-15].

As it appears today the technical possibilities and potentialities of the AI is more than its day to day use in clinical side. The main reason is that the complexity that a clinician perceives when using AI methods. This, with the already existing list of machines in his clinical side. But when new modalities of treatment are introduced like alternate medicine and therapies which the allopathic doctor has no idea, the AI can be handy [12].

In one of our papers, by using modelling we gave predicted the healing period of a tibia fracture in humans . We arrived at a first-order mathematical model. Prediction of fracture healing period was done by one of the identified model parameters, namely, process gain. Also, mathematically, it is proved that once the fracture is fully united there is no capacitance across the fracture site, which is not reported before [13]. Elsewhere we have compared different AI methods in assessing tibia bone fracture [14]. In another work, we have used a new methodology for diagnosing fracture healing period using Adaptive Neuro Fuzzy Inference System (ANFIS), which is a hybrid fuzzy neural system. ANFIS is an expert system with six layers zero order Sugeno model. It exploits the merits of neural networks learning capability and Fuzzy logic ability to handle uncertainties using human based reasoning [15].

The clinician is a human being, he tends to think linearly, associating one data by one and expecting something to happen. Thus when classifiers are used in medical data set analysis, the process helps the clinician's thought process. From the table 1, it is clear that the problem with few methods like neural networking is poor transparency. But when all the classifiers are accurate and handling missing data what more is wanted from a clinician's side to accept it? We have tried ANN in our work; we have added fuzzy logic, modelling to the AI list [13-15]. As previously explained, the large number of patients can benefit only if the data analysis comprehensively and regularly done by automated method where the computer is already trained by earlier data.

CONCLUSION

Despite tremendous improvement in AI in last few decades, there is still no consensus in using the AI for medical diagnosis. Even though the ideal method of AI is still elusive, AI is here to stay. The potential of the AI methods are too much to be left out and not used. Mainly in any treatment decisions in fracture patients, there is a need for complete examination and repeated radiological investigations which can be hazardous. Using AI, clinician will definitely get the best possible decision for every single fracture patient.

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