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Physicians' perspectives of adopting computer-assisted navigation in orthopedic surgery

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ABSTRACT

Objectives: Using Computer-assisted orthopedic navigation surgery system (CAOS) has many advantages but is not mandatory to use during an orthopedic surgery. Therefore, opinions obtained from clinical orthopedists with this system are valuable. This paper integrates technology acceptance model and theory of planned behavior to examine the determinants of continued CAOS use to facilitate user management.
Methods: Opinions from orthopedists who had used a CAOS for at least two years were collected through a cross-sectional survey to verify the research framework. Follow-up interviews with an expert panel based on their experiences of CAOS were conducted to reason the impacts of factors of the research framework.
Results: The results show that factors of "perceived usefulness" and "facilitating condition" determine the intention to continue using CAOS, and "perceived usefulness" was driving by "complexity of task" and "social influence". Additionally, support in practice from high-level managers had an influence on orthopedists' satisfaction after using a CAOS.
Conclusions: The aging population is accompanied by the increasing requirements for medical care and medical care attendant expenses, especially in total knee replacement. More precision and improvements on survivorship of patients' artificial joints are needed. This study facilitates suggestions in user management when encountering an obstacle in implementing a CAOS. Based on these findings, scientific and practical implications are then discussed.

1. Introduction

According to data from the World Health Organization (WHO), populations around the world are aging rapidly. It is estimated that by 2050, a total of 2 billion of the world's population will be above 60 years old, up from the 841 million today. The trend for population aging is accompanied by the increasing requirements for medical care and medical care expenses. Providing for these increasing requirements represents a challenge for health professionals worldwide. In Taiwan, according to official statistics from the Ministry of Health and Welfare, medical expenses for "diseases of the musculoskeletal system and connective tissue" in 2001 were 17.582 billion NTD for patients over 60 years old and would be double in the 2010s [1].

Among the musculoskeletal diseases, Osteoarthritis (OA) is one of the most common diseases in elderly people. OA patients tend to require total knee replacement (TKR), or a total knee arthroplasty (TKA), during the later stages of the disease. As the average life expectancy increases, the number of TKA patients is expected to increase [2]. When performing TKA surgeries, physicians make decisions according to their clinical experience traditionally. Because of this human factor, it is difficult to achieve 100% precision when cutting joints. Poor precision reduces the quality of a surgery and damages the physician's reputation; in such cases, the joint function of the OA patient might not be restorable. If a patient's knee implants loosen prematurely, a second TKA surgery must be performed, requiring additional medical resources [2]. Total hip arthroplasty (THA) can bring about complications – particularly leg length differences – that are becoming increasingly litigious [3].

Due to the importance of treatment of musculoskeletal diseases in orthopedics and traumatology, computer-assisted orthopedic

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navigation surgery system (CAOS) has emerged as a new and independent area [4]. CAOS will help to restore leg length without major complications [3] and make it possible to adjust component placement to the patient's anatomy [5]. The accuracy of leg length measurements can be less than 1 mm [6]. The increased safety for patients and surgeons is a critical consideration in recommending CAOS in trauma surgery [7]. The CAOS also enhances the quality of minimally invasive surgeries [8] such as "computer-assisted minimally invasive spinal surgery" is proved to be feasible and safe for treating Hangman fracture with the advantage of significantly reduced iatrogenic soft tissue injury [9]. Although the manual and CAOS methods are equal in function and quality-of-life scores in operation recovery [5], the CAOS can increase the precision of joint replacement surgeries, reduces patient pain, decreases additional medical expenses caused by inadequate surgeries, and improves survivorship of patients' artificial joints. In summary, CAOS could benefit patients to a greater extent than the manual techniques [10,11].

However, the cost of an orthopedic CAOS is considerably high. Depending on various functions and additional software applications, the price range is approximately from 200,000 to 300,000 USD [12]. The duration required for a CAOS-assisted surgery is approximately 30 min longer than that required for a traditional surgery. Although a CAOS procedure requires a substantial financial investment, reimbursements from national health insurance do not increase accordingly. In addition, patient's satisfaction in CAOS group was higher (86.7%) than conventional group (83.3%), however, there is no significantly statistic difference between two groups [13].

Previous studies on CAOS in medical institutions have focused predominantly on operative skills and applications [14], and few studies have described the willingness of orthopedists to use a CAOS and the related information technology. A method for evaluating the effects of using a CAOS and predicting the responses of its main users (orthopedists) could therefore be useful for such organizations. Hence, this study adopted a technology acceptance model (TAM) and the theory of planned behavior (TPB) to evaluate the intention of orthopedists to use a CAOS. The results of this study could form a reference for CAOS vendors and medical professionals in improving CAOS designs and operation methods, further promoting physician acceptance and benefits to patients.

2. Related work

2.1. Total knee arthroplasty and computer-assisted orthopedic navigation surgery

Typically, when a patient requires a TKA, the knee joint is already seriously deformed. Therefore, the primary purpose of TKA surgery is to replace damaged cartilage with artificial joint materials. During a TKA, the balance of the lower limb's muscle strength must be considered, and the direction of the mechanical axis must be determined as the reference for the cutting the surface of the joint. When a traditional TKA is performed, the surgeon estimates the direction of the mechanical axis based on clinical experience. This subjective decision may result in poor surgical precision and quality along with the high incidence of fat embolism because of the invasiveness of the intramedullary rods [15].

Loosening is one of the most common complications resulting from TKA [16]. In general, 5%–10% of patients need to undergo TKA again within 10–15 years [17]. One typical factor in artificial joint loosening is low positioning precision when implanting the artificial joint manually.

A CAOS integrates an optical (infrared or short-wave ray) positioning device and surgical instruments used in traditional surgeries. It can provide information on the positions of surgical instruments and cutting surfaces, and presents the data on a computer screen to facilitate high-precision cutting and accurate placement of an artificial joint. It can also guide the angles and positions of pedicle nails in spinal surgeries. Another function of CAOS is synchronous data recording to be reviewed after surgery. In summary, a CAOS can improve the position precision of artificial joint implantation, increase the duration of artificial joint use, reduce postoperative pain and medical expenses, and also provide clinical training materials for staff.

2.2. Theoretical foundation

CAOS is an information technology (IT)/information system (IS) application in orthopedic surgery. Previous studies related to user acceptance of IT/IS have provided theoretical base and suggested three major constructs: user group, characteristics of technology, and organizational context [18]. One of the earliest theory, the theory of reasoned action (TRA), predicts an individual's actual behavior The hypotheses of TRA argue that an individual's behaviors are rational and under the control of their own will.

A theory of planned behavior (TPB) based on the TRA was proposed by Ajzen [19]. Apart from subjective norm and attitude constructs, which influence behavioral intention, TPB added another construct: perceived behavior control (PBC). PBC was distinguished two dimensions- self-efficacy and facilitating condition [20,21].

Davis [22] used the TRA as the basis for building a technology acceptance model (TAM) to explain an individual's behavior in information technology acceptance. The TAM is one of the most commonly cited theories for explaining the theoretical base of user acceptance of information technology [23] and is an efficient tool for predicting users' behavioral intention to use an information system [24]. The TAM argues that an individual's attitude toward a new system is influenced by two factors: perceived usefulness (PU) and perceived ease of use (PEOU). PU was defined as an individual perception of the degree of work performance enhanced by using a specific new IT/IS. PEOU referred to the degree of effortlessness that an individual perceives to apply while using a specific new IT/IS. These two factors are also influenced by external factors, such as individual differences, system characteristics, and the environment.

3. Material and methods

3.1. Research framework and hypothesis development

CAOS is a new technology that will change orthopedists' current habitual practice. Therefore, we combined the TPB and TAM, which are robust theories in the behavioral intention of technology acceptance, as the theoretical foundations for the research framework of this study. Fig. 1 depicts this research model.

Referring to the described theories, previous related studies, and opinions from professional orthopedists, seven hypotheses on factors influencing CAOS use were constructed. Because orthopedic surgeries are complex and professional, we replaced job relevance with task complexity, which is more appropriate in our study. "Subjective norm" and "image", which are both related to views on self-awareness and are similar in meaning, were combined into "social influence;" the relationship between the previous two and the latter is then a second-order relational model. The associated hypotheses were proposed as follows.

H1. *"Complexity of task (surgery)" has a positive influence on "perceived usefulness of a CAOS."*