DECISION SUPPORT SYSTEM FOR ORTHODONTIC TREATMENT NEED

A THESIS

BY

THANITA RUKYUTTITHAMKUL

Presented in Partial Fulfillment of the Requirements for the

Master of Science in General Dentistry

Srinakharinwirot University

May 2014

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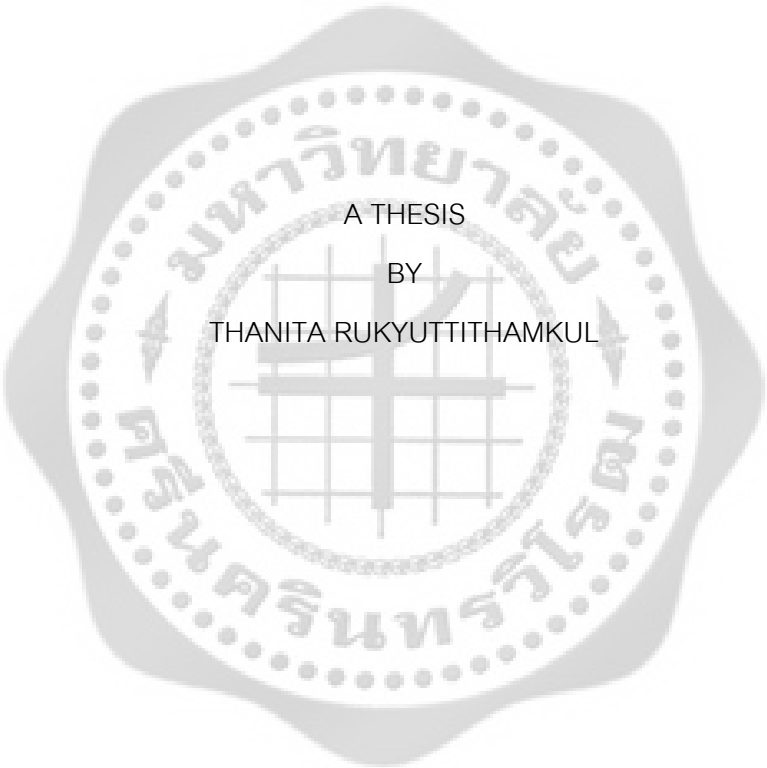

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AN ABSTRACT

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According to several studies conducted in Asia, the major malocclusion problems of permanent dentitions found in patients belong to orthodontic treatment needs (50 to 80%). Some degree of malocclusions can contribute to aesthetic and functional problems. Generally, at the initial stage, patients take general information and advice about orthodontic treatments from non-orthodontic dentists. After that, they transfer to the appropriate orthodontic treatment. The aforementioned path affects Thai orthodontists in terms of the burden of patients' referral; the patients are transferred without any referring documentation and may not need those orthodontic treatments. These experiences may raise patient's reluctance to invest their time and lose their money unnecessarily. This study aims to develop a decision support system for assessing the orthodontic treatment needs in permanent dentition patients by using a Bayesian Network (BN). A BN is used to describe the mutual relationships among multiple variables contributing to orthodontic treatment need. The data-sets were prepared from 401 pairs of study models. The BN was applied to learn algorithms base on the training data-sets in order to develop a decision support system for orthodontic treatment need using 5-fold cross-validation. Receiver operating characteristic curve analysis showed that the system was highly accurate in predicting the orthodontic treatment need; the area under the curve (AUC) was 0.80. This system was selected and developed into the software. To evaluate the developed system performance, there will be a comparison of dental diagnosis agreement between the developed system and 2 orthodontists, using new 20 volunteers. There was a high degree of the dental diagnosis agreement between the developed decision support system and the orthodontists (kappa index = 0.794).

ระบบช่วยในการตัดสินใจเพื่อการพยากรณ์ความจำเป็นในการรักษาทางทันตกรรมจัดฟัน

บทคัดย่อ

ของ

ธนิตา รักยุติธรรมกุล

เสนอต่อบัณฑิตวิทยาลัย มหาวิทยาลัยศรีนครินทรวิโรฒ เพื่อเป็นส่วนหนึ่งของการศึกษา

ตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต สาขาวิชาทันตกรรมทั่วไป

พฤษภาคม 2557

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จากหลายๆการศึกษาในทวีปเอเชีย พบชาวเอเชียมีปัญหาการสบฟันในฟันแท้ที่ผิดปกติ ซึ่งจำเป็นต้องได้รับการรักษามากถึง ร้อยละ 50-80 ซึ่งการสบฟันผิดปกติดังกล่าว ก่อให้เกิดปัญหาด้านความสวยงามและการทำงาน ทั้งนี้บุคลากรที่มักพบผู้ป่วยก่อนเพื่อที่จะให้คำแนะนำเบื้องต้น รวมถึงส่งต่อเพื่อรับการรักษาที่เหมาะสม คือ ทันตแพทย์ทั่วไปหรือทันตแพทย์สาขาอื่น ซึ่งบางครั้งพบปัญหาในการส่งต่อ เช่น ไม่มีเอกสารในการส่งตัว หรือบางครั้งผู้ป่วยที่ถูกส่งตัวไปแล้วไม่มีความจำเป็นต้องได้รับการรักษาทางทันตกรรมจัดฟัน ทำให้ผู้ป่วยเสียเวลา รวมถึงสิ้นเปลืองค่าใช้จ่ายในการเดินทาง การศึกษานี้จึงเกิดขึ้นโดยมีวัตถุประสงค์เพื่อสร้างระบบช่วยการพยากรณ์ความจำเป็นในการรักษาทางทันตกรรมจัดฟันในผู้ป่วยที่มีการสบฟันเป็นฟันแท้โดยใช้เทคนิคเบย์เซียนเน็ตเวิร์ค (Bayesian network, BN) เนื่องจากเป็นเทคนิคที่สามารถเชื่อมโยงความสัมพันธ์ของหลายๆปัจจัย ที่มีผลต่อการตัดสิน ความจำเป็นในการรักษาทางทันตกรรมจัดฟันได้ โดยขั้นตอนการพัฒนาระบบช่วยในการตัดสินใจใช้การสุ่ม 5 ครั้งจากข้อมูลแบบศึกษาจำนวน 401 คู่ ผลการศึกษาพบว่าระบบช่วยในการตัดสินใจนี้มีความถูกต้องในการประเมินความจำเป็นในการรักษาทางทันตกรรมจัดฟันในระดับสูง โดยพบพื้นที่ใต้กราฟอาร์โอซี (ROC, Receiver operating characteristic curve analysis) มีค่า 0.80 จากนั้นพัฒนาระบบไปเป็นซอร์ฟแวร์เพื่อความสะดวกในการใช้งาน ทำการประเมินความจำเป็นในการรักษาทางทันตกรรมจัดฟันในผู้ป่วยรายใหม่จำนวน 20 ราย เปรียบเทียบความสอดคล้องในการวินิจฉัยระหว่างระบบช่วยในการตัดสินใจที่พัฒนาแล้วนี้กับทันตแพทย์จัดฟัน 2 ท่าน พบมีความสอดคล้องในการประเมินความจำเป็นในการรักษาทางทันตกรรมจัดฟันในระดับสูง (kappa index = 0.794)

The thesis titled

" Decision support system for orthodontic treatment need "

by

Thanita Rukyuttithamkul

has been approved by the Graduate School as partial fulfillment of the requirements for the Master of Science degree in General Dentistry of Srinakharinwirot University.

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Thanita Rukyuttithamkul

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CHAPTER I
INTRODUCTION

Background and statement of the problem

According to several studies conducted in Asia, the major malocclusion problems of permanent dentitions found in patients belong to orthodontic treatment needs (50 to 80%)[1-6]. Some degree of malocclusions can contribute to aesthetic and functional problems[7,8]. Generally, at initial stage, patients had taken the general information, and advices about orthodontic treatments from non-orthodontic dentists[9]. After that, they were transferred to the appropriate orthodontic treatments. The mentioned evident affected Thai orthodontists in terms of the burden of patients' referral. Sometimes, patients were transferred to the other treatments without any referring documentations or incomplete data about their present malocclusion problems[10]. The patients in addition may not need those orthodontic treatments. Therefore, these evident may raise patient's reluctances with losing their time, and losing their money for unnecessary costs. The factors that may relate to this situation were stated by a number of orthodontists that non-orthodontic dentists may not have enough experiences. They also may lack of guidelines for a case selection[10]. Consequently, the index of orthodontic treatments have been developed to solve these problems. It used to allocate patients into categories of treatment needs[11]. Several indexes have been established for distinct purposes such as the use to determine the level of public health payment[12] or to evaluate treatment success[13]. The example for occlusal indexes which are used in various countries such as Handicaping Malocclusion Assessment Record (HMAR)[11], Index of Orthodontic Treatment Need (IOTN)[14], Peer Assessment Rating (Par index)[15,16], Treatment Priority Index (TPI)[17], Occlusal Index (OI)[18], Dental Aesthetic Index (DAI)[19], Index of Complexity, Outcome and Need (ICON)[20], and The Need for orthodontic Treatment Index (NOTI)[21]. Different details and the use of each index were established, though it can be claimed that all concerned factors have not been covered. Some indexes are used only for mixed or permanent dentition. Moreover, some indexes are complicated, especially for non-orthodontic dentists[22,23]. The orthodontic treatment need index has not been developed in Asia. Thus, indexes which were developed in Europe and America were instead applied.

Nowadays, it can be claimed that the relationship between orthodontic treatment needs of patients and non-orthodontic dentists has a great impact on the decision of receiving the orthodontic treatments[24-26]. Nonetheless, the appropriate information and referral steps were also found mistake[10].

Computer technology currently plays an important role in driving businesses such as engineering, marketing, management science, medical and dentistry. Bayesian Network (BN) or belief network is computer technology or machine learning technology, which was developed in 1980. BN has been used to assist understanding the causal relationship of multiple variables. Furthermore, BN is used as probabilistic model for predicting the outcome[27].

Since 1980, the studies of clinical decision support system have been conducted in order to support doctors and dentists in evaluating their case studies by employing computer technology. De Dombal *et al*[28] applied the probability theory from Bayesian Network to identify the symptoms such as stomachache in patients by using sensitivity, specificity and disease-prevalence statistics, stomachache probability was calculated from sign, symptom and laboratory test. Different types of stomachache were calculated and identified; namely appendicitis, diverticulitis, perforated ulcer, cholecystitis, small-bowel obstruction, pancreatitis, and non-specific abdominal pain. The computing system's overall diagnostic accuracy (91.8%) was significantly higher than most of senior members of the clinical teams to see each case (79.6%).

Suebnukarn *et al*[29], examined Thai population by using a Bayesian decision support model for the assessment of endodontic treatment outcome. The total sample size in this study was 8,783 cases. Receiver operating characteristic curve analysis (ROC) showed that the model was highly accurate (AUC = 0.902). The advantages of BN consisted of suitable for diagnosing and predicting diseases with complexities. These results may somewhat relate to each other that can be calculated condition independently and probability from database.

The BN has not been applied for orthodontics yet. Therefore, this study aims to develop decision support system by using the BN. The present study is focusing on the

assistance of non-orthodontic dentists to provide information and suggest to patients more effectively. Consequently, the referral of orthodontic treatments can be performed with the reference of documentations. The patients will be obtained the effective orthodontic treatments which reach to their appropriate needs.

Objectives

1. To develop a decision support system for assessing the orthodontic treatment needs in permanent dentition patients by using Bayesian Network

2. To develop a software of the decision support system for orthodontic treatment needs for patients

3. To evaluate the decision support system for orthodontic treatment needs in permanent dentition patients

Scope of study

Fifteen variables were selected as input data for BN modeling. They were chosen based on 3 orthodontic treatment need indexes (IOTN, DAI and ICON). In developmental step, the researcher examined fifteen variables from each 401 study casts aged between 18-24 years old. The developed decision support system then was used for the evaluation of the orthodontic treatment needs. There was compared between developed BN decision supported system and 2 orthodontists by using randomly selected 20 cases.

Advantages of the study

1. To predict orthodontic treatment needs

2. To use as referral document

3. To give the information to patients about their orthodontic treatment needs

CHAPTER II
LITERATURE REVIEW

Permanent dentition

1. Angle's classification[30]

Angle's classification is based on the classification of the first permanent molars. It is believed that the first permanent molars erupt under the lowest position of the key ridge. The position of the first permanent molars always appear as a constant position. Angle's classification can be classified into three groups:

1.1 Class I or neutrocclusion : The mesiobuccal cusp of the upper permanent first molar occludes with the mesiobuccal groove of the lower permanent first molar. The discrepancies of up to half a cusp width either way were also included in this category.

1.2 Class II or distocclusion : The mesiobuccal cusp of the lower permanent first molar occludes distal to the Class I position. This is known as a postnormal relationship.

1.3 Class III or mesiocclusion : The mesiobuccal cusp of the lower permanent first molar occludes mesial to the Class I position. This is also known as a prenormal relationship.

2. British Standards incisor classification[31]

2.1 Class I: The lower incisor edges occlude with or lie immediately below the cingulum plateau of the upper central incisors.

2.2 Class II: The lower incisor edges lie posterior to the cingulum plateau of the upper incisors. There are two subdivisions of this category.

2.2.1 Division I: The upper central incisors are proclined or of average inclination and overjet is increased.

2.2.2 Division II: The upper central incisors are retroclined. The overjet or minimal overjet can be increased.

2.3 Class III: The lower incisor edges lie anterior to the cingulum plateau of the upper incisors. The overjet is reduced.

Malocclusion problem in Asia

Table 1 Malocclusion problem in Asia

Authors	Years	Country	Sample size			Index used	Prevalence of malocclusion or moderate to very great need for orthodontic treatment
			Nationality	Age	Number		
Wang W, Zeng XL, Zhang CF, Yang YQ[1]	2012	China	Xia Dynasty in China	Alive 4000 years ago	56	-	Malocclusion : 27.60 %
Soh J, Sandham A[2]	2004	Singapore	Chinese	17-22	258	IOTN	78.70 %
			Malay	17-22	60	IOTN	81.60 %
			Indian	17-22	21	IOTN	70.90 %
Chu Ch, Choy BH, Lo EC[3]	2009	China	Chinese	18-27	120	IOTN	80.00 %
Shivakumar KM, Chandu GN, Subba Reddy VV, Shafiulla MD[4]	2009	India	Indian	12-15	1000	DAI	19.9 %
Bhardwaj VK, Veeresha KL, Sharma KR[5]	2011	India	Indian	16-17	622	DAI	20.42 %
Zheng YL *et al.*[6]	2012	China	Chinese	12-13	335	ICON	58.21 %

In such a vast and diverse country such as China and India, there is the existence of a large variation of malocclusion's prevalence. This includes the variations of ethnicity, nutrition status, religious beliefs, and dietary habits[32].

Index for orthodontic treatment needs

The Development of Indexes

A great number of indexes of orthodontic treatment needs have been developed since the 1960 when Dracker had developed HLDA index (Handicapping labio-lingual deviations index)[33]. There had been concerning about numerous indexes developing during the year 1960 – 1971. These orthodontic treatment needs indexes include the Treatment Priority Index (TPI) developed by Gardner[17], the HMAR index developed by Salzman[11], and the OI index developed by Summers[18]. In 1992, the Par index[15,16] and the NOTI index[21] were developed. The latest new index were introduced in 1998, the ICON index[20], which is currently universally accepted, widespread used in Europe, and also used extensively in Thailand[34]. Moreover, the DAI index developed in 1986[19] and the IOTN index developed in 1989[9] were also widely used in Thailand[35-37].

Requirements of an ideal index

Table 2 The ideal index properties (WHO)[38]

No	Properties
1	Classification is expressed by a finite scale with definite upper to lower limits; running by progressive gradation from zero (Absence of disease), to the ultimate point (end stage).
2	The index should be equally sensitive throughout the scale.
3	The score should correspond closely with the clinical importance of the disease stage it presents.
4	Index value should be amendable to statistical analysis.
5	The classification must be reproducible.
6	The index should also be simple, accurate and yield itself to modification.
7	The examination procedure should require a minimum of judgment.
8	The index should be simple enough to permit the study of a large population without undue cost in time or energy.
9	The examination required should be performed quickly, to evidence a group variation.
10	The index should be valid during time.

All indexes should be consisted of a number of characteristics, however the most important of which are as following:[12,22,39]

1. Validity of the present study: Referring to the ability of an index that can be used to measure the treatments.

2. Reproducibility or reliability: Consist of the ability to reproduce the same rating or scores when the subject needs to reexamine by the same or different examiner.

3. Ease of use: Allowing the rapid recording by both trained dentists and possibly non-dental personnel.

4. Accepted by the dentists and related people.

The IOTN

The IOTN was primarily used in Great Britain. It was developed by Brook and Shaw[14] to serve their purposes to develop a valid and reproducible index of orthodontic treatment priority. It can be divided into 2 parts which are the aesthetic component and the dental health component. In the aesthetic component, the observer is meant to score the severity of the malocclusion in comparison with the image scale 1-10 (Figure 1), the worst smile is scored as 10 and the perfect smile is scored as 1. The patients' situation are rated with a series of photo 1-4, mean the treatment on aesthetic grounds are not required, photo 5-7 are borderline, and photo 8-10 mean the orthodontic treatment are strongly recommended.

In the dental health component (Table 3), only the worst feature of the occlusion is scored. Consideration dental problems such as the missing, overjet, crossbite, displacement and overbite were mentioned. Traits are graded from 1 (no need for treatment) to 5 (very great need for treatment).

In 1995, Rishmond studied[40] the relationship between the index of orthodontic treatment needs and consensus opinions among 74 dentists. The results suggested good to very good degree of intra and inter-examiner reliability (kappa test = 0.60 – 0.98) of which corresponded to some studies[14,41,42]. The panels of 74 examiners were regarded to aesthetics as a greater need for treatment than dental health. All of examiners were trained to use the index. In addition, Cooper *et al*.[43] investigated whether the IOTN was reliable over the time. Despite of the temporal changes in the separate occlusal traits, the results showed

that the dental health components were reliable over time between the ages of 11-19 year-old patients. Nevertheless, Sukthawee *et al.*[36] studied the relationship between wanted and needed for orthodontic treatment in 12- 14 year-old-students in Songkla. It was found that the aesthetic component of IOTN index presents low reliability when applying in mixed dentition.

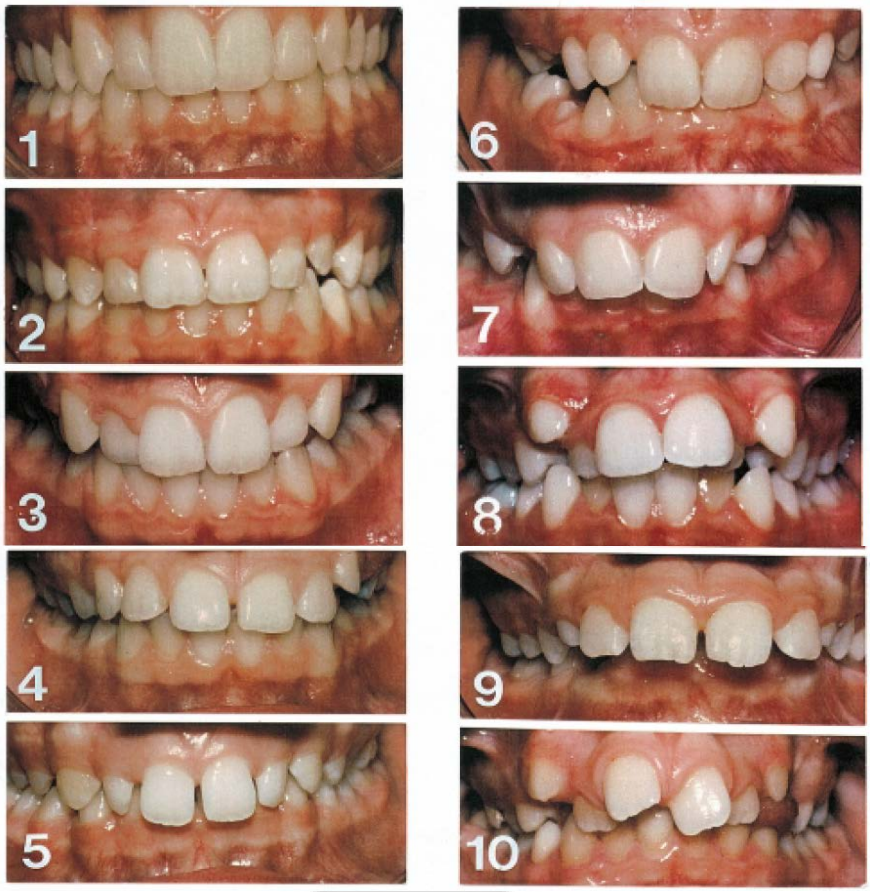

Figure 1 The aesthetic Component

Beglin *et al.*[44] found the validity to evaluate the great need for treatment by considering sum of sensitivity and specificity. It was evaluated as 1.781 in the dental health components and 1.746 in the aesthetic component. The validity to evaluate as the very great need for treatment is 1.743 in the dental health component and 1.481 in the aesthetic component.

There are some details presented in the dental health components. Crowding anterior teeth will only be considered to evaluate in the aesthetic component[45]. Sometimes,

there is no correspondence between two components. The dentists were likely to regard dental health as a greater need for treatment than aesthetics component[36]. Consequently, faults can be occurred in the evaluating of the treatments. Thus examiners need to pay high attention with treatments. The well-trained is strongly required for examiners[45].

Table 3 The dental health component

Grades and criteria	
Grade 5 (Very great need of treatment)	
5•i	Impeded eruption of teeth (except for third molars) due to crowding, displacement, the presence of supernumerary teeth, retained deciduous teeth and any pathological cause.
5•h	Extensive hypodontia with restorative implications (more than 1 tooth missing in any quadrant) requiring pre-restorative orthodontics.
5•a	Increased overjet greater than 9 mm.
5•m	Reverse overjet greater than 3-5 mm with reported masticatory and speech difficulties.
5•p	Defects of cleft lip and palate and other craniofacial anomalies.
5•s	Submerged deciduous teeth.
Grade 4 (Great need of treatment)	
4•h	Less extensive hypodontia requiring pre-restorative orthodontics or orthodontic space closure to obviate the need for a prosthesis.
4•a	Increased overjet greater than 6 mm, but less than or equal to 9 mm.
4•b	Reverse overjet greater than 3-5 mm with no masticatory or speech difficulties.
4•m	Reverse overjet greater than 1 mm but less than 3-5 mm with recorded masticatory and speech difficulties.
4•c	Anterior or posterior crossbites with greater than 2 mm discrepancy between retruded contact position and intercuspal position.
4•l	Posterior lingual crossbite with no functional occlusal contact in one or both buccal segments.
4•d	Severe contact point displacements greater than 4 mm.

Table 3 The dental health component (continued)

Grades and criteria	
4•e	Extreme lateral or anterior open bites greater than 4 mm.
4•f	Increased and complete overbite with gingival or palatal trauma.
4•t	Partially erupted teeth, tipped and impacted against adjacent teeth.
4•x	Presence of supernumerary teeth.
Grade 3 (Moderate need of treatment)	
3•a	Increased overjet greater than 3-5 mm, but less than or equal to 6 mm with incompetent lips.
3•b	Reverse overjet greater than 1 mm, but less than or equal to 3-5 mm.
3•c	Anterior or posterior crossbites with greater than 1 mm, but less than or equal to 2 mm discrepancy between retruded contact position and intercuspal position.
3•d	Contact point displacements greater than 2 mm, but less than or equal to 4 mm.
3•e	Lateral or anterior open bite greater than 2 mm, but less than or equal to 4 mm.
3•f	Deep overbite complete on gingival or palatal tissues, but no trauma.
Grade 2 (Little need of treatment)	
2•a	Increased overjet greater than 3-5 mm, but less than or equal to 6 mm with competent lips.
2•b	Reverse overjet greater than 0 mm but less than or equal to 1 mm.
2•c	Anterior or posterior crossbite with less than or equal to 1 mm discrepancy between retruded contact position and intercuspal position.
2•d	Contact point displacements greater than 1 mm but less than or equal to 2 mm.
2•e	Anterior or posterior open bite greater than 1 mm but less than or equal to 2 mm.
2•f	Increased overbite greater than or equal to 3-5 mm without gingival contact.
2•g	Pre- or post-normal occlusions with no other anomalies (includes up to half a unit discrepancy).
Grade 1 (No need of treatment)	
1•	Extremely minor malocclusions including contact point displacements less than 1 mm.

The ICON

The ICON was developed in 1998 by 97 orthodontics in European and North America[20]. This index incorporates with features of both IOTN index and Par index . The ICON index consisted of 5 parts separately. The following were scored and then will be multiplied by its weight (Table 4). The first part was aesthetic component of IOTN. The other 4 parts were malocclusion evaluation such as spacing, crossbite, openbite and buccal segment relationship. The total summary reflected a pretreatment score, which reproduced the needs for the treatment requirements. More than 43 scores indicated a demonstrable need for treatments.

In 2006, Louwerse *et al*.[46] found the high degree of intra-examiner reliability of the calibrated orthodontist, kappa value = 0.89. The study was corresponded to Zheng YL *et al*.[6] found that degree reliability of the calibrated orthodontist were higher than non-calibrated orthodontist, kappa value = 0.81. Inter-examiner reliability were also in the high score, kappa value = 0.93. In these 2 studies, the examiners were orthodontists.

Table 4 Component, score and weight of the ICON

Component	Score						
	0	1	2	3	4	5	Weigth
1. Aesthetic assessment	Score 1 to 10						7
2. Upper arch crowding	< 2mm	2.1 to 5 mm	5.1 to 9 mm	9.1 to 13 mm	13.1 to 17 mm	>17 mm	5
Upper spacing	< 2mm	2.1 to 5 mm	5.1 to 9 mm	> 9 mm		Impacted tooth	5
3. Crossbite	No crossbite	crossbite					5
4. Incisor open bite	Edge to edge	< 1mm	1.1 to 2 mm	2.1 to 4 mm	> 4 mm		4
Incisor overbite	< 1/3 lower incisor coverage	1/3 to 2/3 coverage	2/3 up to Fully covered	Fully covered			4
5. Buccal segment Antero-Posterior	Cusp to embrasure only Class I, II or III	Any cusp relation up to but not including cusp to cusp	Cusp to Cusp				3

Firestone *et al*.[47] and Louwerse *et al*.[46] studied the validity assessment and determination of the cutoff value for the ICON. It was found that the ICON suggested higher cutoff score than 43. It can be described as the need of treatments at the accuracy of 1.799 and 1.79 respectively. However, Zheng *et al*.[6] studied 335 casts of 12-13 years-old Chinese students. All examiners were orthodontist who worked in west China school of Stomatology, the department of orthodontics. The study found that if the ICON scores of 43, the treatment will be needed. The validity of ICON score was 1.43, a low degree. The best validity was compared with gold standard. It was found the significantly results at a cutoff point of 29, and the validity was 1.71.

The lower cutoff point may be related with the high prevalence of bimaxillary protrusion. The molar relationship is usually class I, with the incisor overjet and overbite being normal. However, facial aesthetics are not well perceived. The treatment complexity outcome and need are not comparable with the ICON score in this scenario. It would be more appropriate to consider bimaxillary protrusion separately when applying ICON.

The DAI

DAI was developed by Cons *et al*. in 1968[19]. DAI is an orthodontic treatment need index which is particularly sensitive to occlusal conditions that have the potential for causing psychological or social dysfunction (Table 5). Boley gauge or Tongue blade is recommended to use in measuring of this index.

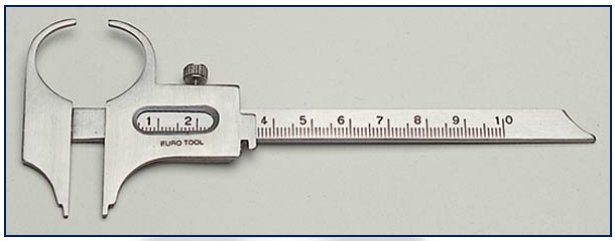

Figure 2 Boley gauge

Table 5 Component and weights of Dental aesthetic index

Dental aesthetic index components	Weights
No. of missing incisor, canine, or premolar teeth in maxillary and mandibular arches	6
Crowding in the incisal segments (no. of segments crowded)	1
Spacing in the incisal segments (no. of segments spaced)	1
Midline diastema in millimeters	3
Largest anterior irregularity on the maxilla in millimeters	1
Largest anterior irregularity on the mandible in millimeters	1
Anterior maxillary overjet in millimeters	2
Anterior mandibular overjet in millimeters	4
Vertical anterior open bite in millimeters	4
Antero-posterior molar relation; largest deviation from normal either left or right, 0=normal, 1=1/2cusp either mesial or distal, 2=one full cusp or more either mesial or distal	3
Constant	13
Total	DAI Score

The regression equation for obtaining a DAI score is the sum of (10 components x weights) + 13 (constant number). The DAI consisted of four stages of malocclusion severity as following, 1) score<25 is no or slight treatment need, 2) score 26-30 is elective treatment, 3) score31-35 is treatment highly desirable, and 4) score>35 is treatment mandatory. In 1997, DAI was adopted by World Health Organization for dental health survey[48], modified to use CPI probe (Community Periodontal Index probe) that makes the index more convenience to apply. Nonetheless, the CPI probe scales are 3 mm. differentiate from each other, thus it leads to the difficulty of measurement and it sometimes need to be estimated[45].

Figure 3 Community Periodontal Index probe

Cardoso *et al*.[49] investigated 131 study models, all examiners were orthodontic. The examination of the study was 30 days interval. The intra-examiner reliability and evaluation resulted in an intraclass correlation coefficient of 0.89. Correspond to the study from Otuyemi and Noar[50] that studied on 30 study models. They found the intra-examiner reliability evaluation in the spearman's rank correlation coefficient of 0.96, which is acceptable.

Cardoso *et al*.[49]studied of 131 study models that were examined by 3 orthodontic. The DAI score cutoff at 25 (elective treatment need) with the high degree validity of 1.05 were claimed, considered both sensitivity and specificity. The DAI score cutoff at 31 (treatment highly desirable) means treatment should be provided with the accuracy of 1.09, which was lower than other study[44]. Beglin *et al*.[44] considered 170 study models, they found

the accuracy of examination was indicated at 1.765. This was because they calibrated the specialists before started the study to make the study more effective.

The index was developed mainly on the aesthetic, thus the abnormal of incisors are principally concerned. Consequently, the examination of posterior teeth would be only considered on anterior–posterior molar relationship, which different from the ICON index that considered crossbite, openbite and missing of posterior teeth[45]. The DAI does not identify cases with deep overbites that impinge on gingival tissue[5]. DAI has been developed as a screening tool for permanent dentitions. It is unsuitable for assessment during the mixed dentition stage[51,52]. However, the DAI has some benefits such as simply to use, less time consuming, and can be easily used for training the other relative personnel. It can be suggested to the preliminary of patient screening and epidemiological studies[45,53].

Every index has its own characteristics, which may be somewhat the same or different considering to other indexes. However, the issue that has not been maintained is the patients' needs and their perceptions of occlusion conditions. One study[39] had suggested the patients to observe their occlusion conditions in a mirror then they could compare with the aesthetic component scores of the IOTN index (Figure 1) by themselves. The patients there fore could discuss with orthodontic dentists for appropriate treatments. Also the patients would clearly see the improvements after they received the treatments.

Bimaxillary protrusion

Ricketts[54] had described the characteristic of bimaxillary protrusion:

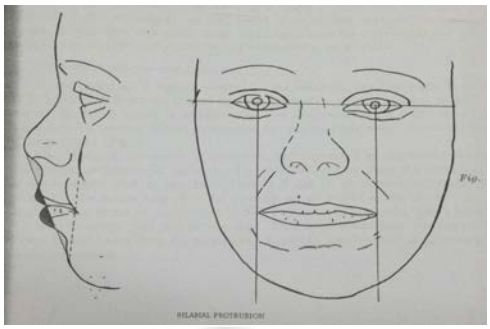

Figure 4 Characteristic of bimaxillary protrusion

The lower lip extends 5 mm beyond E plane and full lip thickness ahead of C plane, dashed line. It is noticed that mouth is as wide as pupil planes. Patient's occlusion was good. Nevertheless the facial aesthetics are not well perceived.

The study from Lamberton *et al.*[55] determined the nature and occurrence of bimaxillary protrusion in 75 students who lived in Chiang Mai, Thailand. The average age was 22 years old.

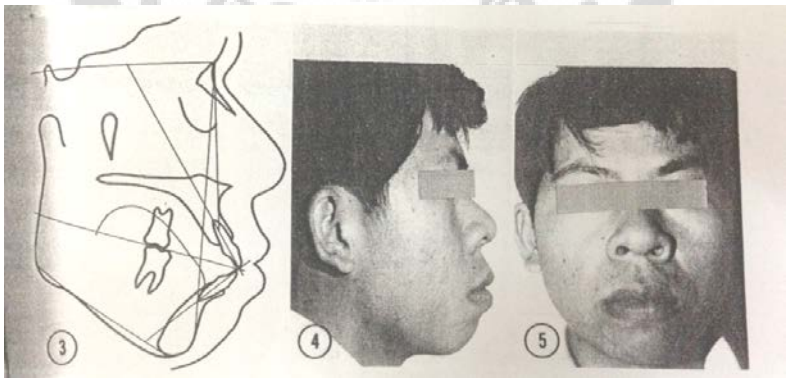

Figure 5 Facial profile of bimaxillary protrusion patient in Thailand

In many cases, the profile as shown by the E plane indicated that the lips of Thai protrude more. This is because in the profile of Thai when compared with the Caucasian is less prominent about 3-4 mm (Figure 5).

Bayesian network

BN is a computer program that innovated to assist patient deciding to obtain as a treatment. BN can be used to describe the relationship between many concerned factors when receiving the treatment, thus BN is widely used in many medical applications such as diagnosis and treatment plan[28,56,57]. In orthodontic application, parameters of dental occlusion will be replaced by node. The relationship between those steps will be replaced by arrow. Each node will be presented the conditional probability. Below was the table that described the probability of the parameters relative to the arrowhead (Figure 6).

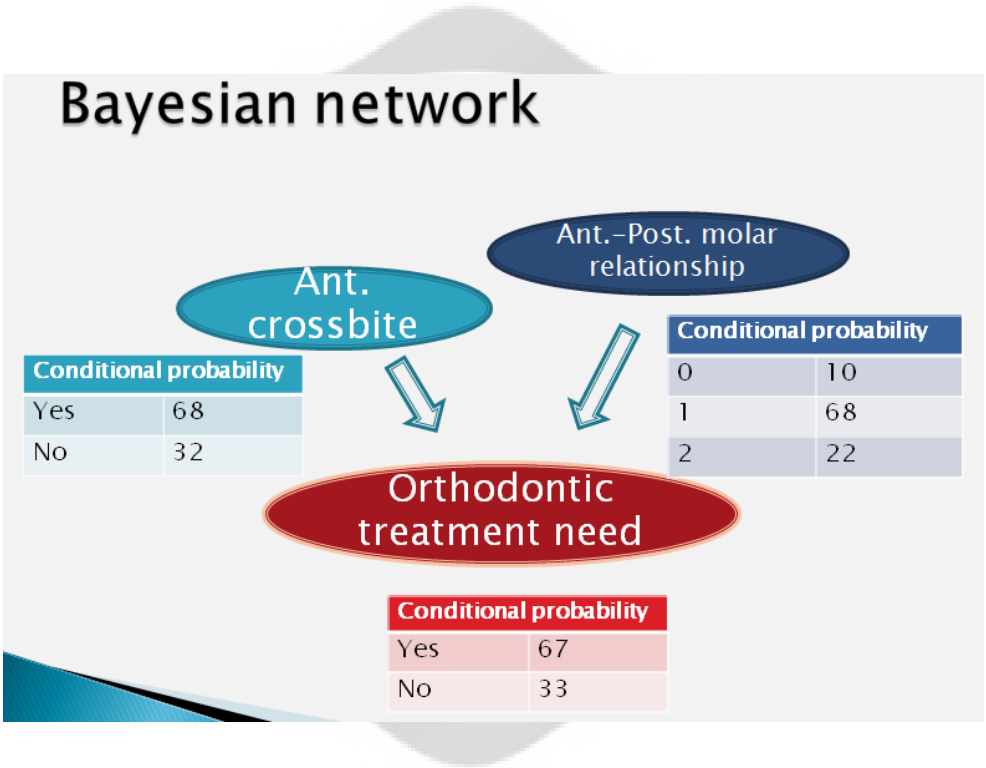

Figure 6 A simple Bayesian network

BN learning system can be divided into 2 parts[29].

1. Structural learning : the algorithm that was used to learn the structure of the network was the Necessary Path Condition (NPC) algorithm. It belongs to the class of constraint-based learning algorithm. The basic idea of these algorithms is use with the statistical test to derive a set of conditional independence and dependence statements. The algorithm performs the following steps:

- Statistical tests for conditional independence are performed for all pairs of variables.

- The condition independences between each pair of variables were found. An undirected link is added. The results undirected graph is referred to the learned structure skeleton.

- Colliders, a pair of links directed such that they meet in node. The node ensure no directed cycles occur.

- Finally, directions are enforced for those links, whose direction can be derived from the colliders identified and the conditional independences found.

2. Parametric learning : An Expectation – Maximization (EM)[58] was used to find maximum likelihood estimates of parameters. EM alternated between performing an expectation (E) step and a maximization (M) step. When E step is computing an expectation of the likelihood by including the latent variables and M step is computing the maximizing the expected likelihood found on the E step and the process was repeated.

Advantages of Bayesian network[29,59]

1. It can be used in prediction of outcome such as an incidence of disease though some parameters are missing.

2. It can be applied to identify the relationship between two nodes and can be used to describe the probability of parameters that related to the arrowhead.

Dentists and population's proportion in Thailand

All orthodontists were collected from the membership lists in Thai association of Orthodontics are 471 persons[24], updated in Dec 4th 2012. They were Thai population are 64,076,033 persons[25], updated in Dec 31st 2011, so the proportion of orthodontist and population in Thailand are 1:136,043.

The data from Office of the registrar, department of the administration show the proportion of dentists in Thailand and population are 1:6,400[26], updated in July 2010.

The study indicated that non-orthodontic dentists have more distribution and more close relationship with orthodontic patients, as a consequence they are important person for using in the oral health care program as well as dental occlusion promotion, increase occlusion efficiency and decrease other oral disease risk factors.

CHAPTER III

MATHERIALS AND METHODS

Target population

Aged 18-24 years old, 401 cases for develop the decision support system

Aged 18-24 years old, 20 cases for evaluate the developed decision support system

The samples

The samples who participate in this study are 18-24 years old. All of them live in Bangkok, Thailand (N = 4,566,561).[60] The participants were screened to participate in this study according to the following inclusion criteria:

Inclusion criteria

- Aged 18-24 years old
- Need to be in general good health
- Agree to participate in this study
- No history of alginate allergy
- No history of temporomandibular disorder

Exclusion criteria

- Unwilling to participate in this study
- Those who have alginate allergy history
- Those who have temporomandibular disorder history

Before participate in this study, the samples were asked to sign an informed consent. The procedure of this study was approved by Ethics committee of Dentistry Faculty, Srinakharinwirot University.

Sample sizes

1. Sample sizes in this study will be calculated by using Taro Yamane[61] formula as follows:

$$n_0 = N/ (1+ Nd^2)$$

n = Sample size

N = Population size

d = The error of sampling

This study allows the error of sampling on 0.05[59] so; the sample size shows as follows;

$$n_0 = 4,566,561/ [1+ 4,566,561(0.05)^2]$$

$$= 399.97 \approx 400$$

2. Sample sizes[62] will be evaluated with the developed decision support system, comparing with the accuracy between BN model and orthodontists.

$$n = (Z_\alpha + Z_\beta)^2 Ó^2 / (X_1 - X_0)^2$$

Z_α = 1.96 (Two tails)

Z_β = 1.28

$Ó^2$ = 50

X_1 = accuracy in BN(pilot) = 186% (sensitivity+specificity)

X_0 = accuracy in orthodontist = 175%[6, 44]

thus; the sample sizes' calculation formula is showed below;

$$n = (1.96 + 1.28)^2(50) / (186 - 175)^2$$

$$= 8.67 \approx 9$$

Materials and Methods

1. Development the decision support system for orthodontic treatment needs in permanent dentition patients by using Bayesian Network.

The system overview was shown in figure 7. In this study, the decision support system refers to the methods of Cios and Moore[63].

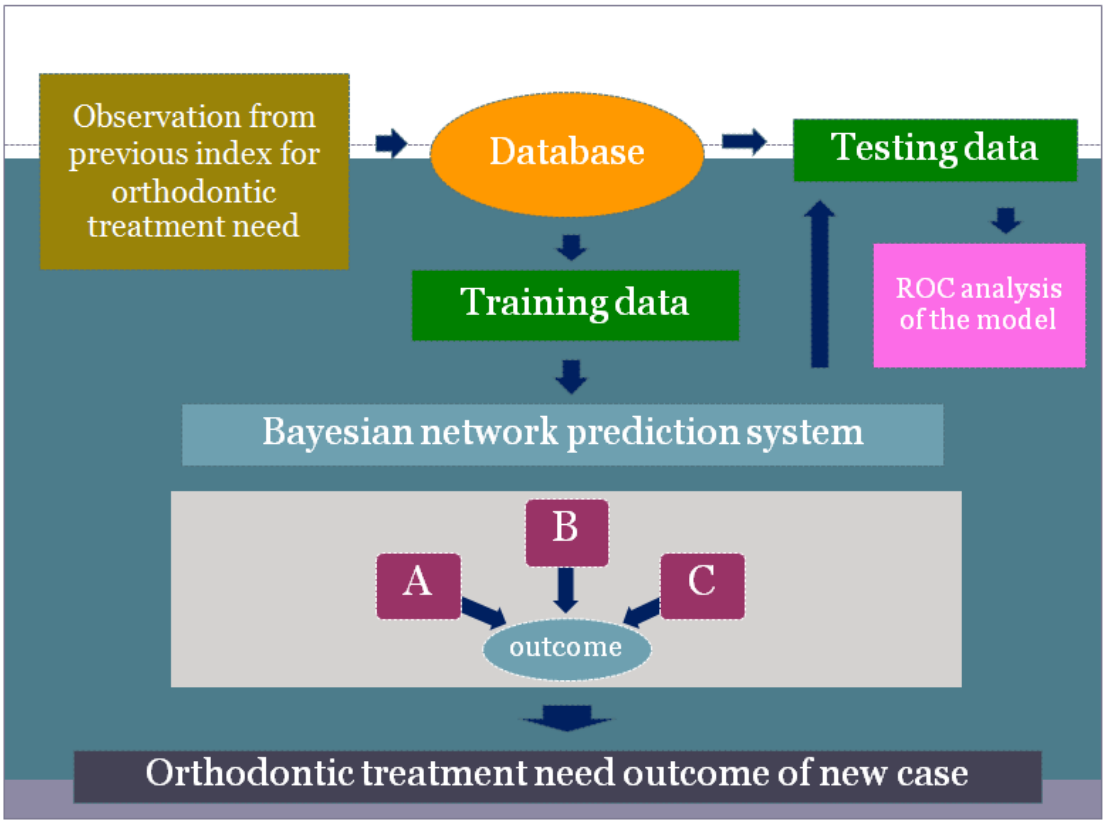

Figure 7 System overview, the process of data preparation and analysis to model performance testing

The research procedure was developed by the reviewing of related English language articles in terms of "orthodontic treatment need index". The reviewing was gained from the previous to present studies. After, reviewing the related literature, the researcher has found 3 most popular indexes consist of IOTN, DAI and ICON. This study found 15 variables which affected the orthodontic treatment plans, consist of missing, overjet, overbite, anterior open bite, posterior open bite, diastema, anterior crossbite, posterior crossbite, anterior displacement, posterior displacement, supernumerary tooth, ectopic

eruption, anterior-posterior molar relationship, upper lip to E-line and lower lip to E-line. Table 6 summarized the variables and their states extracted from the included articles. The researcher examined 15 variables in 401 pairs of study models from 18-24 year-old patients (Figure 8 to 11). 226 pairs of study models were the orthodontic treatment needs patients. They were treated in Orthodontic Clinic, faculty of dentistry, Srinakharinwirot University, during year 2003 to 2013. 175 study models of patients who were not need orthodontic treatment, were also examined. All data were computed and prepared in excel format.

The researcher used BN as a system to measure the patients' necessary of orthodontic braces. In a BN, each variable was modeled as a node and the causal relationship between two variables which may be represented as a directed arc. Each node included a condition probability table which was described the probabilities of each values of this node, given the conditions of its parents. The algorithm used to learn the structure of the network was the Necessary Path Condition (NPC) algorithm. An Expectation-Maximization (EM)[58] was used to find maximum likelihood estimates of parameters. The data were classified into 5 groups by using random sampling. Each 80% were used in turn for training. The remainder, 20% were used for testing the structure and parameter of the decision support system. The procedure was repeated 5 times resulting with 5 candidate decision support systems.

The researcher used sensitivity, specificity and accuracy to evaluate the performance of the system. To evaluate the accuracy of a probabilistic model, the area under the receiver operating characteristic curve (ROC) was employed. The area under the curve (AUC) represents an overall performance of the decision support model with 1.0 for a perfect test and 0.5 representing a model with a no discriminating capacity[64].

Table 6 Variables and states extracted from the included articles

	Variables	Unit	States
1.	Missing	Tooth	The number of absence upper and lower teeth but exclusion criterias are; [19] - Missing tooth but no space remains and teeth have tight contact - Replace space from missing tooth with fix prosthesis - Prolong retention of deciduous teeth and missing the permanent teeth
2.	Overjet	mm.	The horizontal distance between midlabial side of incisal edge of upper central incisor and midlabial side of incisal edge of lower central incisor - Edge to edge = 0 - Cross bite = no data
3.	Overbite	mm.	The vertical distance between incisal edge of upper central incisor and incisal edge of lower central incisor.
4.	Anterior openbite	mm.	The largest distance between incisal edge of the upper incisor and of the lower incisor
5.	Posterior openbite	mm.	The largest distance between tip cusp of the upper molar and of the lower molar
6.	Diastema	mm.	The distance between upper central incisors
7.	Anterior crossbite	Yes/No	Crossbite in anterior teeth.
8.	Posterior crossbite	Yes/No	Crossbite in posterior teeth
9.	Anterior displacement	mm.	The largest distance between contact points of the adjacent teeth in upper and lower anterior teeth
10.	Posterior displacement	mm.	The largest distance between contact points of the adjacent teeth in upper and lower posterior teeth

Table 6 Variables and states extracted from the included articles (continued)

	Variables	Unit	States
11.	Supernumerary tooth	Yes/No	Supernumerary tooth
12.	Ectopic eruption	Yes/No	Ectopic eruption
13.	Anterior-posterior molar relationship		0 = Normal occlusion 1 = Half part of mesiobuccal cusp of the lower permanent first molar occludes distal or mesial to the normal position 2 = All part of mesiobuccal cusp of the lower permanent first molar occludes distal or mesial to the normal position
14	upper lip to E line	mm.	The most prominent distance from upper lip to E line
15	Lower lip to E line	mm.	The most prominent distance from lower lip to E line

Figure 8 Anterior openbite measurement

Figure 9 Anterior displacement measurement

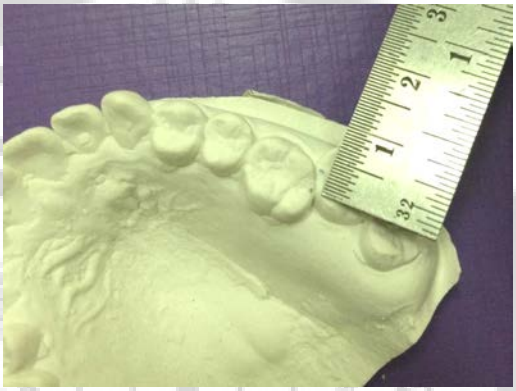

Figure 10 Posterior displacement measurement

Figure 11 Upper lip to E-line and lower lip to E-line measurement

2. Development a software of the decision support system for orthodontic treatment need in permanent dentition patients

The researcher selected the system that gives the highest performance for development into software.

3. Evaluation the developed decision support system for orthodontic treatment need in permanent dentition patients

After development into software, this developed decision support system was compared with orthodontists predictions. This study used new randomized 20 cases to comparison of the dental diagnoses accuracy with 2 orthodontists. The Kappa statistic was used to test the statistic significance of the agreement between orthodontists and developed decision support system.

CHAPTER IV
RESULTS

Data sets

The data contained 15 variables affecting the orthodontic treatment need from 401 pairs of study models were shown in Table 7 and 8. 226 pairs of study models were from the orthodontic treatment need patients. 66 males and 160 females were treated in an orthodontic clinic, Faculty of Dentistry, Srinakharinwirot University, during year 2003 to 2013. Another 175 pairs of study models were from patients who do not need to be treated in the orthodontic, 55 males and 120 females. The value of missing data was left empty (N/A). This empty data was fed to the training algorithms, which manage missing data using the EM algorithms.

Table 7 The results in 226 orthodontic treatment need patients

No	Missing	Overjet	Overbite	Ant. Open*	Post. Open*	Diastema	Ant. Cross*	Post. Cross*	Ant Dis*	Post Dis*	Supernum*.	Ectopic eruption	Ant-Post Molar*	Up* lip To E-line	Lo* lip To E-line
1	0	2	1	N/A	0	0	N	N	2	2	N	N	0	2	3
2	0	0	N/A	1	0	0	N	N	2	1.5	N	N	0	N/A	N/A
3	0	3.5	3	0	0	0	N	N	2	1	N	N	1	-2	1
4	0	1.5	0.5	0	0	0	N	N	3	0	N	N	1	N/A	N/A
5	0	2	1	0	0	1	N	N	4.5	0	N	N	1	N/A	N/A
6	4	3	3.5	1	3	0	N	N	4	0	N	Y	2	N/A	N/A
7	0	5	4	0	0	0	N	N	3.5	0	N	N	1	0	0
8	0	7.5	5	0	0	0	N	N	4	0	N	N	1	N/A	N/A
9	0	2	7	0	0	0	N	N	2	3	N	N	1	N/A	N/A
10	0	8	4	0	0	0	N	N	6	2	N	N	2	N/A	N/A
11	0	3	7	0	0	0	N	N	3	4	N	N	0	N/A	N/A

*Note : Ant.Open = Anterior Openbite, Post.Open. = Posterior Openbite, Ant.Cross. = Anterior Crossbite, Post.Cross. = Posterior Crossbite, Ant.Dis. = Anterior Displacement, Post.Dis. = Posterior Displacement, Supernum = Supernumerarytooth, Ant-Post Molar = Anterior-Posterior Molar relationship, Up lip to E-line = Upper lip to E-line, Lo lip to E-line = Lower lip to E-line

Table 7 The results in 226 orthodontic treatment need patients (continued)

No	Missing	Overjet	Overbite	Ant. Open*	Post. Open*	Diastema	Ant. Cross *	Post. Cross *	Ant Dis *	Post Dis*	Supernum *.	Ectopic eruption	Ant-Post Molar*	Up* lip To E-line	Lo* lip To E-line
12	0	4	4	0	0	0	N	N	0	0	N	N	0	2.5	4
13	0	1.5	3.5	0	0	0	N	N	0	1	N	N	2	2.5	1.5
14	0	7	4	0	0	0	N	N	5	5	N	Y	2	N/A	N/A
15	0	6	4.5	3	5	1	N	N	5	4	N	N	2	N/A	N/A
16	3	2	3	0	0	0	N	Y	4	4	N	N	1	N/A	N/A
17	0	2	1	3	1	0	Y	N	8	3	N	Y	1	N/A	N/A
18	2	4	4	0	0	0	N	N	0	3	N	N	N/A	N/A	N/A
19	0	3	8	0	0	0	N	Y	1	6	N	N	0	6	7
20	0	5	5.5	0	0	0	N	N	3	0	N	N	2	2	2
21	0	7	3.5	0	0	0	N	Y	7	1	N	N	2	N/A	N/A
22	0	N/A	1	2	2	0	Y	Y	4	3	N	N	2	-4	1
23	0	1.5	2	1.5	0	0	N	N	4	1	N	N	0	N/A	N/A
24	0	N/A	0	0	3	1	Y	N	7	2	Y	Y	2	N/A	N/A
25	0	4	5	0	1.5	0	N	N	0	2	N	N	2	-2	0
26	0	3	5	0	0	2	N	Y	3	6	N	N	0	N/A	N/A
27	0	1.5	1.5	0	2	0	N	Y	5	3	N	N	2	N/A	N/A
28	0	8	4	0	0	0	N	N	2	2	N	N	2	N/A	N/A
29	2	5	3.5	0	2	2	N	N	0	2	N	N	0	0	0.5
30	0	4	2.5	1.5	0	0	N	Y	3	1	N	N	N/A	2	3
31	0	3.5	4	0	0	0	Y	Y	7	8	N	Y	1	N/A	N/A
32	0	2	3.5	0	0	2.5	N	N	0	3	N	N	2	N/A	N/A
33	1	3	2	0	0	0	N	N	2	2	N	Y	N/A	N/A	N/A
34	0	8	5	0	0	0	N	N	5	5	N	N	0	N/A	N/A
35	0	2	1.5	0	0	0	N	N	2.5	3	N	N	1	N/A	N/A
36	4	6	5	N/A	1.5	0	N	N	4	0	N	Y	2	N/A	N/A
37	0	3.5	2	2.5	0	0	N	N	2.5	1	N	Y	1	0.5	3
38	1	6.5	2.5	1	3	0	N	N	5	6	N	Y	2	N/A	N/A
39	0	6	4	0	0	0	N	N	4	1	N	Y	0	N/A	N/A
40	1	3.5	2.5	0	0	0	N	N	2	2	N	Y	2	N/A	N/A

*Note : Ant.Open = Anterior Openbite, Post.Open. = Posterior Openbite, Ant.Cross. = Anterior Crossbite, Post.Cross. = Posterior Crossbite, Ant.Dis. = Anterior Displacement, Post.Dis. = Posterior Displacement, Supernum = Supernumerarytooth, Ant-Post Molar = Anterior-Posterior Molar relationship, Up lip to E-line = Upper lip to E-line, Lo lip to E-line = Lower lip to E-line

Table 7 The results in 226 orthodontic treatment need patients (continued)

No	Missing	Overjet	Overbite	Ant. Open*	Post. Open*	Diastema	Ant. Cross *	Post. Cross *	Ant Dis *	Post Dis*	Supernum *.	Ectopic eruption	Ant-Post Molar*	Up* lip To E-line	Lo* lip To E-line
41	0	2	0	1	0	0	N	N	1	1.5	N	N	0	N/A	N/A
42	0	1	0	0.5	0	1	N	N	0	0	N	N	0	N/A	N/A
43	1	N/A	N/A	0	0	0	Y	N	3	1	N	N	1	-1	1
44	1	3	2.5	1	0	2	N	N	8	2	N	Y	0	3	4.5
45	0	2	3	0	0	0	N	N	3	2	N	N	0	N/A	N/A
46	0	2	1.5	0	0	3	N	N	1	3.5	N	N	2	N/A	N/A
47	0	1.5	4	0	0	0	N	N	9	1	N	Y	0	-1	-1
48	0	4.5	4.5	0	0	0	N	N	3	2	N	N	0	N/A	N/A
49	0	5	2	0	0	0	N	N	0	3	N	N	0	2	1
50	0	1.5	2	0	2	0	N	N	0	0	N	N		4	5
51	1	2.5	0	0.5	2	1.5	N	Y	2	2.5	N	N	0	N/A	N/A
52	0	3	N/A	0	1.5	0	N	Y	0	0	N	N	2	N/A	N/A
53	0	3.5	2	0	0	0	N	Y	4	6	N	N	0	0.5	1.5
54	0	7.5	1.5	0	0	1	N	N	5	0	N	N	0	0.5	1
55	0	5.5	5.5	0	0	0	N	N	2	2	N	N		N/A	N/A
56	0	N/A	N/A	0	0	0	Y	N	7	4	N	Y	2	-2	-1
57	1	2.5	2	0	0	2.5	Y	N	1	2	N	Y	0	1.5	2.5
58	1	N/A	N/A	0	0	0	Y	N	3	2	N	N	2	N/A	N/A
59	0	N/A	N/A	1.5	0	0	Y	Y	8	3	N	Y	1	-2	1.5
60	0	5	5	0	0	0	N	N	3	1.5	N	N	0	N/A	N/A
61	0	9	2.5	0	0	3	N	N	3.5	2	N	N	1	N/A	N/A
62	0	4	2	0	2	0	N	Y	6	5	N	Y	2	N/A	N/A
63	0	7.5	4	0	0	0	N	Y	4	6	N	Y	0	N/A	N/A
64	0	6	3	0	0	0	N	N	3	2	N	N	0	N/A	N/A
65	0	3	3.5	0	0	0	N	N	3	6	N	N	2	0	-0.5
66	0	5	0	3	0	0	N	N	4.5	0	N	N	1	2.5	4
67	0	4	5	0	0	0	N	N	2	3.5	N	N	1	N/A	N/A
68	0	2.5	1	2	3	0	Y	N	3	5	N	N	2	N/A	N/A
69	0	6	4	0	0	0	N	N	5	1.5	N	N	1	0	0

*Note : Ant.Open = Anterior Openbite, Post.Open. = Posterior Openbite, Ant.Cross. = Anterior Crossbite, Post.Cross. = Posterior Crossbite, Ant.Dis. = Anterior Displacement, Post.Dis. = Posterior Displacement, Supernum = Supernumerarytooth, Ant-Post Molar = Anterior-Posterior Molar relationship, Up lip to E-line = Upper lip to E-line, Lo lip to E-line = Lower lip to E-line

Table 7 The results in 226 orthodontic treatment need patients (continued)

No	Missing	Overjet	Overbite	Ant. Open*	Post. Open*	Diastema	Ant. Cross *	Post. Cross *	Ant Dis *	Post Dis*	Supernum *.	Ectopic eruption	Ant-Post Molar*	Up* lip To E-line	Lo* lip To E-line
70	0	8.5	3.5	0	2	0	N	N	3	4	N	N	0	N/A	N/A
71	0	0	0	2	1.5	0	Y	Y	4	5	N	N	0	N/A	N/A
72	0	2.5	1.5	0	0	0	N	N	1.5	3	N	N	1	N/A	N/A
73	0	5	4	0	0	0	N	N	2	2.5	N	N	N/A	-1	0
74	0	4	1.5	2	0	2	N	N	1.5	2.5	N	N	0	N/A	N/A
75	0	5	2.5	0	0	0	N	N	4.5	1.5	N	N	2	1	3
76	0	3	3.5	0	0	0	N	N	3	3	N	N	1	0	1
77	0	11	1	3	0	0	N	N	4	2.5	N	N	0	2.5	3.5
78	0	5	4	0	0	1	N	Y	2	1.5	N	N	0	N/A	N/A
79	0	3	1.5	0	0	2	N	N	4	3	N	N	1	N/A	N/A
80	2	5.5	5	0	0	0	N	Y	0	4.5	N	N	0	N/A	N/A
81	0	5.5	1	1.5	0	0	N	Y	4.5	2	N	N	2	1.5	4.5
82	0	7	6	0	0	0	N	N	3	0	N	N	0	N/A	N/A
83	0	N/A	2	0	0	0	Y	Y	9	5	N	N	2	0	3
84	0	10	5.5	0	0	0	N	Y	5	2	N	N	0	N/A	N/A
85	2	5	3	0	0	0	N	N	2	2	N	Y	1	N/A	N/A
86	1	5	5	0	0	0	N	N	4	2.5	N	N	0	3	5
87	0	6.5	3.5	0	0	0	N	N	3	1	N	N	0	N/A	N/A
88	1	2.5	2.5	3.5	0	0	Y	N	6.5	4	N	Y	0	N/A	N/A
89	1	7.5	3.5	0	0	0	N	Y	3.5	4	N	N	2	N/A	N/A
90	0	5	3.5	0	0	1	N	Y	0	2.5	N	N	0	N/A	N/A
91	0	6	2	0	0	0	N	Y	3.5	4	N	N	0	N/A	N/A
92	0	3.5	1.5	0	0	0	N	N	3	1.5	N	N	2	N/A	N/A
93	0	6	3	3	0	0	N	N	4	0	N	N	0	N/A	N/A
94	0	5.5	2	0	0	0	N	N	2	0	N	N	0	2	3
95	1	2.5	1.5	1	0	0	Y	N	5	1	N	N	2	N/A	N/A
96	0	N/A	N/A	0	0	0	Y	N	5	2	N	Y	2	N/A	N/A
97	0	5	4	2	0	0	N	N	5	2	N	N	0	N/A	N/A
98	0	4.5	5.5	0	0	0	N	N	3	2	N	N	1	N/A	N/A

*Note : Ant.Open = Anterior Openbite, Post.Open. = Posterior Openbite, Ant.Cross. = Anterior Crossbite, Post.Cross. = Posterior Crossbite, Ant.Dis. = Anterior Displacement, Post.Dis. = Posterior Displacement, Supernum = Supernumerarytooth, Ant-Post Molar = Anterior-Posterior Molar relationship, Up lip to E-line = Upper lip to E-line, Lo lip to E-line = Lower lip to E-line

Table 7 The results in 226 orthodontic treatment need patients (continued)

No	Missing	Overjet	Overbite	Ant. Open*	Post. Open*	Diastema	Ant. Cross*	Post. Cross*	Ant. Dis *	Post Dis *	Supernum *.	Ectopic eruption	Ant-Post Molar*	Up* lip To E-line	Lo* lip To E-line
99	0	5.5	2	0	0	0	N	N	3	2	N	N	0	N/A	N/A
100	0	6	3	0	0	0	N	N	5	1.5	N	N	2	N/A	N/A
101	0	2.5	2	0	0	2	N	N	0	3	N	N	1	-2.5	-2
102	0	9	6.5	0	0	0	N	N	3	3	N	N	N/A	N/A	N/A
103	0	5.5	3.5	0	0	0	N	Y	3	3	N	N	1	N/A	N/A
104	0	7	4	0	0	0	N	Y	3	5	N	N	0	N/A	N/A
105	0	4	3	0	1	0	N	Y	4	5	N	N	0	N/A	N/A
106	0	7.5	3.5	0	3	0	N	N	1	1.5	N	N	2	N/A	N/A
107	0	4.5	4	0	0	0	N	N	3.5	3	N	N	0	N/A	N/A
108	0	6	5	0	0	1.5	N	N	4	0	N	N	0	N/A	N/A
109	2	6.5	3.5	2	0	0	N	N	7	8	N	N	N/A	N/A	N/A
110	4	1.5	4.5	0	2	0	N	N	3.5	1.5	N	N	2	-0.5	0
111	0	N/A	N/A	0	0	0	Y	N	4	2	N	N	0	-1	0
112	0	7.5	3	0	0	0	N	N	5	1.5	N	Y	1	N/A	N/A
113	0	7.5	3.5	0	0	0	N	N	4.5	0	N	N	0	N/A	N/A
114	0	1.5	1.5	0	0	0	Y	N	5	1	N	N	2	-2.5	0
115	1	N/A	N/A	0	2	0	Y	Y	0	0	N	N	0	N/A	N/A
116	0	10	4	0	0	0	N	N	3	3	N	N	1	N/A	N/A
117	1	N/A	N/A	0	0	1	Y	N	4	3	N	N	2	0.5	2
118	0	7	6	0	0	0	N	N	3	2	N	N	1	N/A	N/A
119	0	3.5	2.5	3	0	0	N	Y	2	3.5	N	N	0	N/A	N/A
120	0	2	2.5	0	0	0	N	N	3	4	N	Y	0	2	3
121	0	5	3	0	0	0	N	N	1.5	1.5	N	N	0	N/A	N/A
122	0	4	5	0	0	0	N	N	5	1	N	N	0	N/A	N/A
123	0	3	2	2	1.5	0	Y	N	4	2.5	N	Y	0	-1	0
124	0	10	5	0	0	1	N	N	0	3	N	N	1	N/A	N/A
125	2	5	3	0	0	2.5	Y	Y	3.5	3.5	N	N	1	N/A	N/A
126	1	4	1.5	0	0	1.5	N	N	3	3	N	Y	0	0.5	2.5
127	0	6	1	0	0	0	N	N	4	2	N	N	2	2.5	4

*Note : Ant.Open = Anterior Openbite, Post.Open. = Posterior Openbite, Ant.Cross. = Anterior Crossbite, Post.Cross. = Posterior Crossbite, Ant.Dis. = Anterior Displacement, Post.Dis. = Posterior Displacement, Supernum = Supernumerarytooth, Ant-Post Molar = Anterior-Posterior Molar relationship, Up lip to E-line = Upper lip to E-line, Lo lip to E-line = Lower lip to E-line

Table 7 The results in 226 orthodontic treatment need patients (continued)

No	Missing	Overjet	Overbite	Ant. Open*	Post. Open*	Diastema	Ant. Cross *	Post. Cross *	Ant Dis *	Post Dis*	Supernum *.	Ectopic eruption	Ant-Post Molar*	Up* lip To E-line	Lo* lip To E-line
128	0	7	2.5	0	0	2	N	N	6	7	N	N	1	-1	3
129	0	2.5	1.5	0	0	2	N	Y	1	3	N	N	0	N/A	N/A
130	0	3.5	1	1.5	0	0	Y	N	5	3	N	N	2	N/A	N/A
131	0	3.5	1	0	0	0	N	N	3	2	N	N	0	N/A	N/A
132	2	7	4.5	0	0	3.5	N	N	10	2	N	Y	2	-2	0.5
133	1	4	1.5	1	0	0	Y	N	3.5	1.5	N	N	0	N/A	N/A
134	0	4.5	4	0	0	0	N	N	3	3.5	N	N	0	3	1.5
135	0	8	4	0	0	0	N	Y	3	5	N	N	0	3	5
136	0	N/A	N/A	0	0	0	Y	Y	7	3	N	Y	1	-2.5	-2
137	2	3.5	3	0	1	1.5	N	Y	2.5	2	N	N	N/A	N/A	N/A
138	0	3.5	2	0	3	1.5	N	Y	3	6	N	N	1	N/A	N/A
139	0	4	4.5	0	0	0	N	N	3	2	N	N	0	0.5	1
140	0	7.5	5	0	0	0	N	N	4	1	N	N	1	N/A	N/A
141	1	2.5	2.5	0	0	2.5	N	Y	4	4	N	Y	1	0	0.5
142	0	8	3.5	1.5	1.5	0	N	N	4	3.5	N	N	2	-4	-2
143	0	2.5	4.5	0	0	0	N	N	2.5	3	N	N	2	N/A	N/A
144	0	4	2.5	0	0	0	N	N	3	0	N	N	0	N/A	N/A
145	1	4	3.5	0	0	0	N	N	4	1.5	N	N	0	1	2
146	2	5	1.5	0	0	0	N	Y	2.5	2	N	N	2	N/A	N/A
147	1	10	3	0	0	0	N	Y	3.5	0	N	N	0	N/A	N/A
148	0	3	5	2	0	0	N	N	5	2	N	N	1	2.5	4
149	0	5	3.5	0	0	2	N	N	3	3	N	N	0	N/A	N/A
150	0	2.5	2	1	0	0	N	Y	2	0	N	N	0	N/A	N/A
151	0	5	4.5	1.5	2	0.5	N	N	5	5	N	Y	2	0.5	1
152	0	2	1.5	2	1.5	2.5	Y	N	0	5	N	N	1	-1.5	0
153	2	5.5	5.5	0	0	0	N	N	1.5	0	N	N	1	0.5	0.5
154	0	5	3	0	0	0	N	Y	2.5	2	N	N	1	N/A	N/A
155	0	3.5	5	0	0	0	N	N	3	0	N	N	0	N/A	N/A
156	0	5	3.5	0	0	0	N	N	3.5	2.5	N	N	0	-2	0

*Note : Ant.Open = Anterior Openbite, Post.Open. = Posterior Openbite, Ant.Cross. = Anterior Crossbite, Post.Cross. = Posterior Crossbite, Ant.Dis. = Anterior Displacement, Post.Dis. = Posterior Displacement, Supernum = Supernumerarytooth, Ant-Post Molar = Anterior-Posterior Molar relationship, Up lip to E-line = Upper lip to E-line, Lo lip to E-line = Lower lip to E-line

Table 7 The results in 226 orthodontic treatment need patients (continued)

No	Missing	Overjet	Overbite	Ant. Open*	Post. Open*	Diastema	Ant. Cross *	Post. Cross *	Ant Dis *	Post Dis*	Supernum *.	Ectopic eruption	Ant-Post Molar*	Up* lip To E-line	Lo* lip To E-line
157	0	4.5	4.5	0	0	0	N	Y	3	0	N	N	1	N/A	N/A
158	0	3	1	0	0	0	Y	N	5.5	3.5	N	N	0	N/A	N/A
159	0	3.5	4	0	0	0	N	N	2	3	N	N	N/A	N/A	N/A
160	0	N/A	N/A	0	0	0	Y	N	4	2	N	N	2	N/A	N/A
161	0	4	3	0	0	0	N	N	3	2	N	N	1	N/A	N/A
162	1	5	2	0	2	0	N	Y	3	6.5	N	N	0	N/A	N/A
163	1	1	0	0	0	0	Y	N	4	3	N	N	2	N/A	N/A
164	3	0	0	1	0	N/A	Y	N	1	2	N	N	1	N/A	N/A
165	0	4.5	3	0	0	0	N	Y	4.5	5	N	N	0	N/A	N/A
166	0	3.5	5.5	0	0	0	N	Y	2.5	3	N	N	2	N/A	N/A
167	0	6	3	0	0	0	N	N	1.5	1.5	N	N	1	2	3
168	2	2.5	2.5	0	0	0	N	N	0	3	N	N	1	N/A	N/A
169	0	6.5	4	0	0	2	Y	N	2.5	1	N	N	0	-1	0
170	0	7	5	0	2	0	N	N	5	5	N	N	1	N/A	N/A
171	0	N/A	N/A	0	2	1	Y	N	3	1	N	N	2	N/A	N/A
172	0	5	2.5	0	0	0	N	N	3	3.5	N	N	0	N/A	N/A
173	2	7	N/A	3.5	0	0	N	N	2	3	N	N	N/A	N/A	N/A
174	2	2	2.5	0	0	0	Y	N	2.5	0	N	N	0	N/A	N/A
175	0	1.5	2	3	0	0	Y	N	7	0	N	Y	0	N/A	N/A
176	0	3	4	0	0	0	Y	Y	4	3.5	N	N	1	N/A	N/A
177	0	5	5	0	0	0	N	N	4	0	N	N	2	N/A	N/A
178	0	N/A	N/A	0	0	0	Y	Y	3.5	5.5	N	N	2	N/A	N/A
179	0	6	3	0	0	0	N	N	3.5	0	N	N	1	N/A	N/A
180	0	5	3.5	0	0	2	N	Y	1	4	N	N	1	N/A	N/A
181	0	3	2	0	0	0	N	N	3	3	N	N	1	N/A	N/A
182	0	3	1	1	0	0	Y	N	5	0	N	N	1	0	1
183	0	2	0	1	0	0	Y	N	4	2.5	N	N	2	N/A	N/A
184	0	N/A	N/A	0	0	5	Y	N	10	5	N	Y	2	N/A	N/A

*Note : Ant.Open = Anterior Openbite, Post.Open. = Posterior Openbite, Ant.Cross. = Anterior Crossbite, Post.Cross. = Posterior Crossbite, Ant.Dis. = Anterior Displacement, Post.Dis. = Posterior Displacement, Supernum = Supernumerarytooth, Ant-Post Molar = Anterior-Posterior Molar relationship, Up lip to E-line = Upper lip to E-line, Lo lip to E-line = Lower lip to E-line

Table 7 The results in 226 orthodontic treatment need patients (continued)

No	Missing	Overjet	Overbite	Ant. Open*	Post. Open*	Diastema	Ant. Cross *	Post. Cross *	Ant Dis *	Post Dis*	Supernum *.	Ectopic eruption	Ant-Post Molar*	Up* lip To E-line	Lo* lip To E-line
185	0	3.5	N/A	1.5	1	0	N	Y	5	3.5	N	N	0	N/A	N/A
186	0	5.5	3	0	0	0	Y	N	1	0	N	N	0	N/A	N/A
187	0	2	N/A	1.5	0	0	Y	Y	2.5	2	N	N	2	N/A	N/A
188	0	3	4	0	0	0	N	Y	0	5	N	N	0	N/A	N/A
189	0	N/A	N/A	0	0	0	Y	N	5	0	N	Y	1	N/A	N/A
190	0	1.5	1	0	0	0	Y	Y	2	5	N	N	2	0	0.5
191	0	5.5	4	0	0	0	N	N	0	0	N	N	N/A	3	3.5
192	0	3	2.5	0	0	0	N	Y	2	3	N	N	N/A	N/A	N/A
193	0	4	0.5	1.5	0	0	N	N	3	4	N	N	0	2	3.5
194	0	7	5	0	0	0	N	N	3.5	3	N	N	1	N/A	N/A
195	0	5	3	0	0	0	N	Y	1.5	3	N	N	1	N/A	N/A
196	0	4	3.5	0	0	2.5	N	N	2	4	N	N	0	N/A	N/A
197	0	2	2	2	2	2.5	N	Y	3	3	N	N	1	N/A	N/A
198	0	4	3	0	0	0	N	N	3	2	N	N	1	N/A	N/A
199	0	0	0	0	0	0	N	N	3	8	N	N	0	N/A	N/A
200	0	8	4	0	0	2	N	N	4	3	N	N	0	N/A	N/A
201	0	7	4	0	0	0	N	N	2.5	3	N	N	0	N/A	N/A
202	0	5	3	0	0	2	N	N	2	0	N	N	0	-1	-0.5
203	0	7	4	0	2	0.5	N	Y	2	3	N	N	2	N/A	N/A
204	0	4	5	0	0	0	N	N	1.5	2	N	N	0	N/A	N/A
205	0	4	3	0	0	0	N	Y	3	3.5	N	N	1	N/A	N/A
206	0	4	4	0	0	0	N	N	4	2	N	N	1	N/A	N/A
207	0	4	1.5	0	0	0	Y	N	3	3	N	N	1	-0.5	1.5
208	0	4	1.5	0	0	0	N	N	4	1.5	N	N	1	N/A	N/A
209	1	7.5	4	0	0	0	N	N	2	2	N	N	1	N/A	N/A
210	0	4	3	0	0	2	N	N	1	5	N	N	0	N/A	N/A
211	0	4.5	4	0	0	2	N	N	3	3	N	N	0	N/A	N/A
212	0	4	1.5	0	0	0	N	Y	2	3.5	N	N	0	N/A	N/A
213	2	6.5	3.5	0	0	0	N	N	1.5	4	N	N	N/A	3.5	4

*Note : Ant.Open = Anterior Openbite, Post.Open. = Posterior Openbite, Ant.Cross. = Anterior Crossbite, Post.Cross. = Posterior Crossbite, Ant.Dis. = Anterior Displacement, Post.Dis. = Posterior Displacement, Supernum = Supernumerarytooth, Ant-Post Molar = Anterior-Posterior Molar relationship, Up lip to E-line = Upper lip to E-line, Lo lip to E-line = Lower lip to E-line

Table 7 The results in 226 orthodontic treatment need patients (continued)

No	Missing	Overjet	Overbite	Ant. Open*	Post. Open*	Diastema	Ant. Cross *	Post. Cross *	Ant Dis *	Post Dis*	Supernum *.	Ectopic eruption	Ant-Post Molar*	Up* lip To E-line	Lo* lip To E-line
214	0	5.5	4.5	0	0	0	N	N	5	2	N	N	0	N/A	N/A
215	0	6.5	4	0	0	0	Y	Y	4.5	5	N	N	1	N/A	N/A
216	0	6	2.5	0	1	0	N	Y	4	3	N	N	0	N/A	N/A
217	0	5	1.5	1.5	0	0	N	N	3.5	2.5	N	N	0	N/A	N/A
218	0	3.5	2	0	0	2	N	N	2	4	N	N	1	N/A	N/A
219	1	3	2.5	0	0	0	N	N	1.5	0	N	N	N/A	N/A	N/A
220	0	3	2	0	0	0	N	Y	2	6	N	N	0	N/A	N/A
221	0	4	2.5	0	0	0	N	Y	2	5	N	Y	1	N/A	N/A
222	1	5	4	0	0	0	N	N	2	2	N	N	N/A	N/A	N/A
223	2	2	3	0	0	0	N	Y	2	5	N	N	N/A	N/A	N/A
224	1	3	2.5	0	0	0	N	N	0	0	N	N	0	N/A	N/A
225	0	4	4	0	0	0	N	Y	4	2	N	N	0	N/A	N/A
226	1	5	4.5	0	0	0	N	N	4	3	N	N	0	N/A	N/A

*Note : Ant.Open = Anterior Openbite, Post.Open. = Posterior Openbite, Ant.Cross. = Anterior Crossbite, Post.Cross. = Posterior Crossbite, Ant.Dis. = Anterior Displacement, Post.Dis. = Posterior Displacement, Supernum = Supernumerarytooth, Ant-Post Molar = Anterior-Posterior Molar relationship, Up lip to E-line = Upper lip to E-line, Lo lip to E-line = Lower lip to E-line

Table 8 The results in 175 no orthodontic treatment need patients

No	Missing	Overjet	Overbite	Ant. Open*	Post. Open*	Diastema	Ant. Cross *	Post. Cross *	Ant Dis *	Post Dis*	Supernum *.	Ectopic eruption	Ant-Post Molar*	Up* lip To E-line	Lo* lip To E-line
1	0	2	2	0	0	0	N	N	0	0	N	N	0	-1.5	-1.5
2	0	2	2	0	0	0	N	N	0	0	N	N	0	1	3.5
3	0	3	3	0	0	0	N	N	0	2	N	N	0	N/A	N/A
4	0	3	2.5	0	0	0	N	N	0	1	N	N	1	-1	0
5	0	3	3	0	0	0	N	N	0	1	N	N	0	0	1
6	0	3	2	0	0	0	N	N	0	2	N	N	0	0	0.5
7	0	2	2.5	0	0	0	N	N	0	2	N	N	N/A	N/A	N/A
8	0	3	4	0	0	0	N	N	0	3	N	N	1	2	1.5
9	0	2	2.5	0	0	0	N	N	0	3	N	N	1	N/A	N/A
10	0	3	3	0	0	0	N	N	0	1	N	N	0	N/A	N/A
11	0	3	2.5	0	0	0	N	N	0	2	N	N	N/A	0	-0.5
12	0	2	3.5	0	0	0	N	N	0	3	N	N	0	-2	-1
13	0	2	2	0	0	0	N	N	0	0	N	N	0	N/A	N/A
14	0	3	2	0	0	0	N	N	0	2	N	N	0	N/A	N/A
15	0	1.5	1.5	0	0	0	N	N	0	2	N	N	0	1	1
16	0	2	3.5	0	0	0	N	N	1	1	N	N	0	N/A	N/A
17	0	3	3	0	0	0	N	N	0	3	N	N	0	N/A	N/A
18	0	2	3	0	0	0	N	N	0	2	N	N	0	2	3.5
19	0	3	1.5	0	0	0	N	N	0	0	N	N	N/A	1	2.5
20	0	2	2	0	0	0	N	N	0	2	N	N	N/A	0.5	1.5
21	0	2	1.5	0	0	0	N	N	0	0	N	N	1	N/A	N/A
22	0	3	3	0	0	0	N	N	1	2	N	N	0	N/A	N/A
23	0	3.5	3	0	0	0	N	N	0	1.5	N	N	N/A	N/A	N/A
24	0	2	3	0	0	0	N	N	0	0	N	N	N/A	1	0
25	0	2.5	2.5	0	0	0	N	N	0	0	N	N	N/A	N/A	N/A
26	0	3	1.5	0	0	0	N	N	0	0	N	N	0	N/A	N/A
27	0	2.5	1.5	0	0	0	N	N	1.5	0	N	N	N/A	0	1.5
28	0	3.5	3	0	0	0	N	N	0	0	N	N	N/A	1	2
29	0	4.5	3.5	0	1	0	N	Y	0	2.5	N	N	N/A	N/A	N/A

*Note : Ant.Open = Anterior Openbite, Post.Open. = Posterior Openbite, Ant.Cross. = Anterior Crossbite, Post.Cross. = Posterior Crossbite, Ant.Dis. = Anterior Displacement, Post.Dis. = Posterior Displacement, Supernum = Supernumerarytooth, Ant-Post Molar = Anterior-Posterior Molar relationship, Up lip to E-line = Upper lip to E-line, Lo lip to E-line = Lower lip to E-line

Table 8 The results in 175 no orthodontic treatment need patients

No	Missing	Overjet	Overbite	Ant. Open*	Post. Open*	Diastema	Ant. Cross *	Post. Cross *	Ant Dis *	Post Dis*	Supernum *.	Ectopic eruption	Ant-Post Molar*	Up* lip To E-line	Lo* lip To E-line
30	0	2.5	3	0	0	0	N	N	0	1.5	N	N	1	N/A	N/A
31	0	3.5	2.5	0	0	0	N	N	0	0	N	N	0	3	1
32	0	2.5	2	0	0	0	N	N	0	0	N	N	1	N/A	N/A
33	0	3.5	1.5	0	0	0	N	N	0	0	N	N	0	N/A	N/A
34	0	2	3	0	0	0	N	N	0	0	N	N	N/A	N/A	N/A
35	0	4.5	2.5	0	0	0	N	N	0	0	N	N	N/A	-1	0
36	0	2.5	1.5	0	0	0	N	N	0	0	N	N	N/A	N/A	N/A
37	0	3	2.5	0	0	0	N	N	0	2	N	N	1	N/A	N/A
38	0	2.5	2	0	0	0	N	N	0	0	N	N	1	0	1
39	0	2.5	1.5	0	0	0	N	N	0	2	N	N	0	N/A	N/A
40	0	2	2.5	0	0	0	N	N	1	0	N	N	N/A	-2	0
41	0	2.5	2.5	0	0	0	N	N	0	3	N	N	N/A	N/A	N/A
42	0	4	3	0	0	0	N	N	0	0	N	N	N/A	0.5	1.5
43	0	3	3.5	0	0	0	N	N	0	3	N	N	N/A	-2	-1
44	0	3	1.5	0	0	0	N	N	0	2	N	N	N/A	-2	0
45	0	3	3.5	0	0	0	N	N	2	2	N	N	N/A	1	3
46	0	2.5	3	0	0	0	N	N	0	2	N	N	N/A	0	0.5
47	0	3	3	0	0	0	N	N	0	0	N	N	N/A	0	1
48	0	1.5	2	0	0	0	N	N	0	2	N	N	N/A	0	0
49	0	2.5	3	0	1	0	N	N	0	1	N	N	N/A	N/A	N/A
50	0	2.5	4	0	0	0	N	N	0	2	N	N	N/A	1	2
51	0	3	2.5	0.5	0	0	N	Y	0	1	N	N	N/A	N/A	N/A
52	0	3.5	3.5	0	0	0	N	N	0	0	N	N	1	N/A	N/A
53	0	3.5	3.5	0	0	0	N	N	0	0	N	N	N/A	1	1
54	0	3.5	2	0	0	0	N	N	1	1.5	N	N	N/A	N/A	N/A
55	0	4.5	2.5	0	0	0	N	N	0	2	N	N	N/A	-1.5	0
56	0	2.5	2	0	0	0	N	N	0	2.5	N	N	N/A	N/A	N/A
57	0	3.5	3	0	0	0	N	N	0	2	N	N	N/A	0	1
58	0	2.5	2.5	0	0	0	N	N	0	1	N	N	0	-0.5	0

*Note : Ant.Open = Anterior Openbite, Post.Open. = Posterior Openbite, Ant.Cross. = Anterior Crossbite, Post.Cross. = Posterior Crossbite, Ant.Dis. = Anterior Displacement, Post.Dis. = Posterior Displacement, Supernum = Supernumerarytooth, Ant-Post Molar = Anterior-Posterior Molar relationship, Up lip to E-line = Upper lip to E-line, Lo lip to E-line = Lower lip to E-line

Table 8 The results in 175 no orthodontic treatment need patients (continued)

No	Missing	Overjet	Overbite	Ant. Open*	Post. Open*	Diastema	Ant. Cross *	Post. Cross *	Ant Dis *	Post Dis*	Supernum *.	Ectopic eruption	Ant-Post Molar*	Up* lip To E-line	Lo* lip To E-line
59	0	4	4.5	0	0	0	N	N	0	2	N	N	N/A	N/A	N/A
60	0	2	4	0	0	0	N	N	1	1	N	N	N/A	0	0
61	0	4	3	0	0	0	N	N	0	3	N	N	0	-2	-1
62	0	3	4.5	0	0	0	N	N	0	0	N	N	0	N/A	N/A
63	0	4.5	5	0	0	0	N	N	0	0	N	N	N/A	N/A	N/A
64	0	4	4	0	0	0	N	N	0	2	N	N	0	1.5	0
65	0	2.5	2.5	0	0	0	N	N	0	3	N	N	1	N/A	N/A
66	0	2.5	3	0	0	0	N	N	0	3	N	N	0	N/A	N/A
67	0	4	2	0	0	0	N	N	0	1.5	N	N	0	0	3
68	0	3.5	4.5	0	0	0	N	N	1	1.5	N	N	0	N/A	N/A
69	0	3	2	0	0	0	N	N	0	0	N	N	0	N/A	N/A
70	0	2.5	2	0	0	0	N	N	0	0	N	N	1	0	1
71	0	3.5	3	0	0	0	N	N	0	2	N	N	N/A	N/A	N/A
72	0	3	2.5	0	0	0	N	N	0	0	N	N	0	N/A	N/A
73	0	2.5	1.5	0	0	0	N	N	0	0	N	N	N/A	1	1.5
74	0	3	2.5	0	0	0	N	N	0	1	N	N	N/A	N/A	N/A
75	0	3.5	1.5	0	0	0	N	N	0	0	N	N	N/A	N/A	N/A
76	0	2	3.5	0	0	0	N	N	0	0	N	N	N/A	N/A	N/A
77	0	3.5	2.5	0	1	0	N	N	0	1	N	N	N/A	N/A	N/A
78	0	4	3	0	0	0	N	N	0	2	N	N	0	0.5	1.5
79	0	2	2	0	0	0	N	N	0	2.5	N	N	N/A	N/A	N/A
80	0	4	3	0	0	0	N	N	0	0	N	N	N/A	N/A	N/A
81	0	2.5	3	0	0	0	N	N	0	0	N	N	N/A	0	1
82	0	4	4	0	0	0	N	N	1	1	N	N	N/A	N/A	N/A
83	0	2.5	2	0	1	0	N	N	0	3	N	N	N/A	N/A	N/A
84	0	3	1.5	0	0	0	N	N	0	0	N	N	0	N/A	N/A
85	0	2.5	2	0	0	0	N	Y	0	1	N	N	0	0	-1
86	0	2.5	2.5	0	0	0	N	Y	0	0	N	N	0	N/A	N/A
87	0	3	3	0	0	0	N	N	0	0	N	N	0	-1.5	-1

*Note : Ant.Open = Anterior Openbite, Post.Open. = Posterior Openbite, Ant.Cross. = Anterior Crossbite, Post.Cross. = Posterior Crossbite, Ant.Dis. = Anterior Displacement, Post.Dis. = Posterior Displacement, Supernum = Supernumerarytooth, Ant-Post Molar = Anterior-Posterior Molar relationship, Up lip to E-line = Upper lip to E-line, Lo lip to E-line = Lower lip to E-line

Table 8 The results in 175 no orthodontic treatment need patients (continued)

No	Missing	Overjet	Overbite	Ant. Open*	Post. Open*	Diastema	Ant. Cross *	Post. Cross *	Ant Dis *	Post Dis*	Supernum *.	Ectopic eruption	Ant-Post Molar*	Up* lip To E-line	Lo* lip To E-line
88	0	3	3	0	0	0	N	N	0	0	N	N	0	N/A	N/A
89	0	2.5	2.5	0	0	0	N	N	0	1.5	N	N	0	N/A	N/A
90	0	4	4	0	0	0	N	N	1.5	0	N	N	N/A	-2	1.5
91	0	3	1.5	0	0	0	N	N	0	1.5	N	N	N/A	-1	0
92	0	3	2	0	0	0.5	N	N	0	1.5	N	N	0	0	0
93	0	3	1.5	0	0	0	N	N	0	0	N	N	0	0.5	1.5
94	0	4	3	0	0	0	N	N	0	1	N	N	N/A	N/A	N/A
95	0	2	2	0	0	0	N	N	2	2	N	N	0	N/A	N/A
96	0	2.5	2	0	0	0	N	N	0	2	N	N	0	N/A	N/A
97	0	4	4	0	0	0	N	N	0	2	N	N	0	N/A	N/A
98	0	4	3	0	0	0	N	N	0	0	N	N	0	N/A	N/A
99	0	4	3.5	0	0	0	N	N	0	3	N	N	N/A	N/A	N/A
100	0	2.5	2.5	0	0	0	N	Y	0	2	N	N	0	N/A	N/A
101	0	3.5	2	0	1	0	N	N	0	1.5	N	N	N/A	N/A	N/A
102	0	3	1.5	0	0	0	N	N	0	3	N	N	N/A	N/A	N/A
103	0	2.5	2	0	0	0	N	N	2	3	N	N	0	N/A	N/A
104	0	3	2.5	0	0	0	N	N	0	2	N	N	N/A	N/A	N/A
105	0	3	2.5	0	0	0	N	N	0	1.5	N	N	N/A	N/A	N/A
106	0	3	1.5	0	0	0	N	N	1.5	1.5	N	N	1	N/A	N/A
107	0	3	4	0	0	0	N	N	0	2	N	N	0	N/A	N/A
108	0	4	3.5	0	0	0	N	N	0	1.5	N	N	0	N/A	N/A
109	0	1.5	2	0	0	0	N	N	0	2	N	N	N/A	N/A	N/A
110	0	2.5	4	0	0	0	N	N	1	3	N	N	N/A	N/A	N/A
111	0	3	3.5	0	1	0	N	N	0	2.5	N	N	N/A	N/A	N/A
112	0	4	4	0	0	0	N	N	0	3	N	N	0	2	1
113	0	4	2	0	0	0	N	N	2	1	N	N	0	0	0
114	0	3	2	0	0	0	N	N	0	0	N	N	0	N/A	N/A
115	0	2.5	3.5	0	0	0	N	N	0	0	N	N	N/A	N/A	N/A
116	0	3.5	3	0	0	0	N	N	0	2	N	N	N/A	N/A	N/A

*Note : Ant.Open = Anterior Openbite, Post.Open. = Posterior Openbite, Ant.Cross. = Anterior Crossbite, Post.Cross. = Posterior Crossbite, Ant.Dis. = Anterior Displacement, Post.Dis. = Posterior Displacement, Supernum = Supernumerarytooth, Ant-Post Molar = Anterior-Posterior Molar relationship, Up lip to E-line = Upper lip to E-line, Lo lip to E-line = Lower lip to E-line

Table 8 The results in 175 no orthodontic treatment need patients (continued)

No	Missing	Overjet	Overbite	Ant. Open*	Post. Open*	Diastema	Ant. Cross *	Post. Cross *	Ant Dis *	Post Dis*	Supernum *.	Ectopic eruption	Ant-Post Molar*	Up* lip To E-line	Lo* lip To E-line
117	0	3.5	3	0	0	0	N	N	0	0	N	N	0	N/A	N/A
118	0	3.5	1.5	0	0	0	N	N	0	1.5	N	N	N/A	N/A	N/A
119	0	3.5	1.5	0	0	0	N	N	0	2.5	N	N	1	N/A	N/A
120	0	4	2	0	1	0	N	N	0	1.5	N	N	0	N/A	N/A
121	0	2.5	2	0	0	0	N	N	0	1	N	N	1	N/A	N/A
122	0	4	4	0	0	0	N	N	0	1.5	N	N	1	N/A	N/A
123	0	4	3	0	0	0	N	Y	0	1.5	N	N	0	N/A	N/A
124	0	2.5	3	0	0	0	N	N	0	0	N	N	0	N/A	N/A
125	0	2.5	2	0	0	0	N	N	1	0	N	N	0	0	0.5
126	0	3	2	0	0	0	N	N	2	2	N	N	0	2.5	2.5
127	0	2.5	4.5	0	0	1	N	Y	1	2	N	N	0	0	0.5
128	0	3	3	0	0	1	N	N	1	2.5	N	N	0	2.5	1
129	0	4	2.5	0	0	0	N	N	0	1.5	N	N	0	-1.5	-1.5
130	0	3	2.5	0	0	0	N	N	0	2	N	N	0	0	3.5
131	0	2.5	3	0	0	0	N	Y	2	2	N	N	0	0	2.5
132	0	4	4	0	0	0	N	N	0	2	N	N	1	1	0.5
133	0	2	2.5	0	0	0	N	N	1	2	N	N	1	0	0.5
134	0	4	2.5	0	0	0	N	N	1	3	N	N	0	0.5	3.5
135	0	2.5	2.5	0	0	0	N	N	1	0	N	N	0	1.5	1
136	0	4	4	0	0	0	N	N	2	2	N	N	0	-1	0
137	0	3.5	2	0	0	0	N	N	2	2	N	N	1	1	3
138	0	3.5	3	0	0	0	N	N	2	1	N	N	1	-1	1
139	0	3.5	2.5	0	0	0	N	N	1	1	N	N	0	2	2.5
140	0	4	4	0	0	0	N	N	1.5	2.5	N	N	1	0	0.5
141	0	2.5	3.5	0	0	0	N	Y	1	1	N	N	1	0.5	3
142	0	3	2.5	0	0	0	N	N	1	0	N	N	0	2	0.5
143	0	3	3	0	0	0	N	N	1	2	N	N	0	0	1
144	0	2.5	2.5	0	0	0	N	N	0	1	N	N	0	0.5	1
145	0	3.5	3	0	0	0	N	N	1.5	0	N	N	0	1	0.5

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Table 8 The results in 175 no orthodontic treatment need patients (continued)

No	Missing	Overjet	Overbite	Ant. Open*	Post. Open*	Diastema	Ant. Cross *	Post. Cross *	Ant Dis *	Post Dis*	Supernum *.	Ectopic eruption	Ant-Post Molar*	Up* lip To E-line	Lo* lip To E-line
146	0	3	3.5	0	0	0	N	N	1	3	N	N	0	-2	0
147	0	3	3	0	0	0	N	N	0	0	N	N	0	1	0
148	0	3	3.5	0	0	0	N	N	1	2	N	N	0	-2	0
149	0	2.5	3	0	1	0	N	N	1	3	N	N	0	-1	-1.5
150	0	2.5	3	0	0	0	N	Y	1	2	N	N	0	-1	0
151	0	2	2.5	0	0	0	N	N	1	1	N	N	1	0	1
152	0	3	1.5	0	0	0	N	Y	1	1	N	N	0	-1	1
153	0	3	3	0	0	0	N	N	0	2	N	N	N/A	-0.5	0
154	0	4	4.5	0	0	0	N	N	0	1	N	N	N/A	N/A	N/A
155	0	3	3	0	0	0	N	N	0	1	N	N	N/A	-0.5	0
156	0	4	4	0	0	0	N	N	0	0	N	N	0	N/A	N/A
157	0	3	1.5	0	0	1	N	N	0	0	N	N	1	N/A	N/A
158	0	3	2.5	0	0	0	N	N	2	0	N	N	1	N/A	N/A
159	0	3	2	0	0	0	N	N	2	0	N	N	0	N/A	N/A
160	0	3	3.5	0	0	0	N	N	1	2	N	N	0	0	2
161	0	3.5	4	0	0	0	N	N	1	4	N	N	0	-1.5	-0.5
162	0	3	2.5	0	0	0	N	N	0	2	N	N	1	0.5	1.5
163	0	3	2.5	0	0	0	N	N	0	4	N	N	N/A	0	0
164	0	4	3	0	1	0	N	N	0	0	N	N	N/A	0.5	1.5
165	0	3	2	0	0	0	N	N	1	3.5	N	N	1	0	1
166	0	2	2.5	0	0	0	N	N	0	0	N	N	N/A	N/A	N/A
167	0	2	2.5	0	0.5	0	N	N	0	1	N	N	N/A	N/A	N/A
168	0	3.5	3	0	0	0	N	N	0	2	N	N	0	N/A	N/A
169	0	4	4	0	0	0	N	N	0	0	N	N	0	N/A	N/A
170	0	4	4.5	0	0	0	N	N	0	2	N	N	0	N/A	N/A
171	0	3	3	0	0	0	N	N	0	2	N	N	0	N/A	N/A
172	0	3	2.5	0	0	0	N	N	0	0	N	N	1	N/A	N/A
173	0	3	2	0	0	1	N	N	1	2	N	N	0	N/A	N/A
174	0	4	2	0	0	0	N	N	0	2	N	N	0	N/A	N/A
175	0	3.5	2.5	0	0	0	N	N	1	2	N	N	1	N/A	N/A

*Note : Ant.Open = Anterior Openbite, Post.Open. = Posterior Openbite, Ant.Cross. = Anterior Crossbite, Post.Cross. = Posterior Crossbite, Ant.Dis. = Anterior Displacement, Post.Dis. = Posterior Displacement, Supernum = Supernumerarytooth, Ant-Post Molar = Anterior-Posterior Molar relationship, Up lip to E-line = Upper lip to E-line, Lo lip to E-line = Lower lip to E-line

Development BN decision support systems

BN was used as a system to measure the patients' necessary of orthodontic braces. The structure along with the conditional probability distribution of the BN was built up using training data-sets obtained from study models and lateral face picture measurement (Figure 12, 13). Figure 12 shows a directed acyclic graph representing cause-effect relationships among 15 variables. Figure 13 shows the conditional probability distribution of BN that was built up using one training data set. Each node contains a conditional probability table (CPT) that explains probabilistic relationships among all variables. The node bars display normalized conditional probabilities compatible with the given state and condition on the evidence, normalized to have a maximum value of 100.

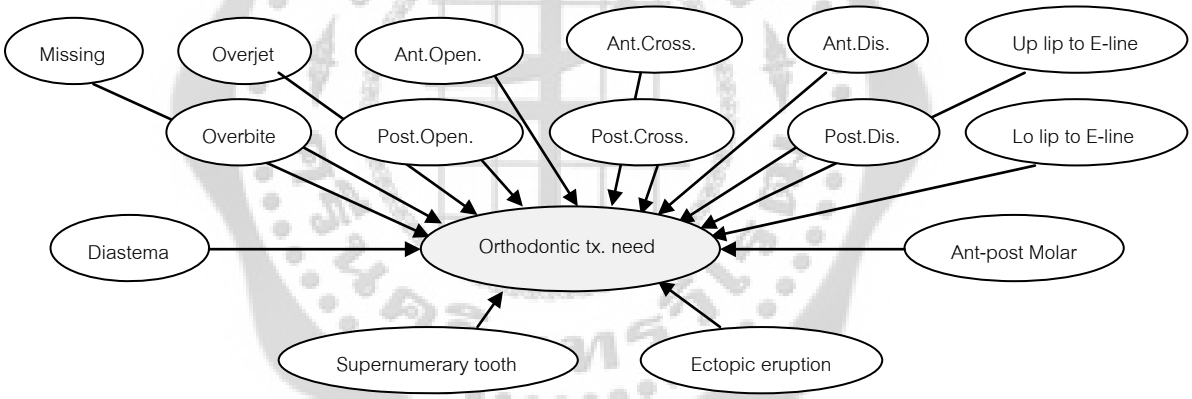

Figure 12 A BN representing the possible relationships among factors influencing orthodontic treatment needs. Each arc indicates a causal relationship

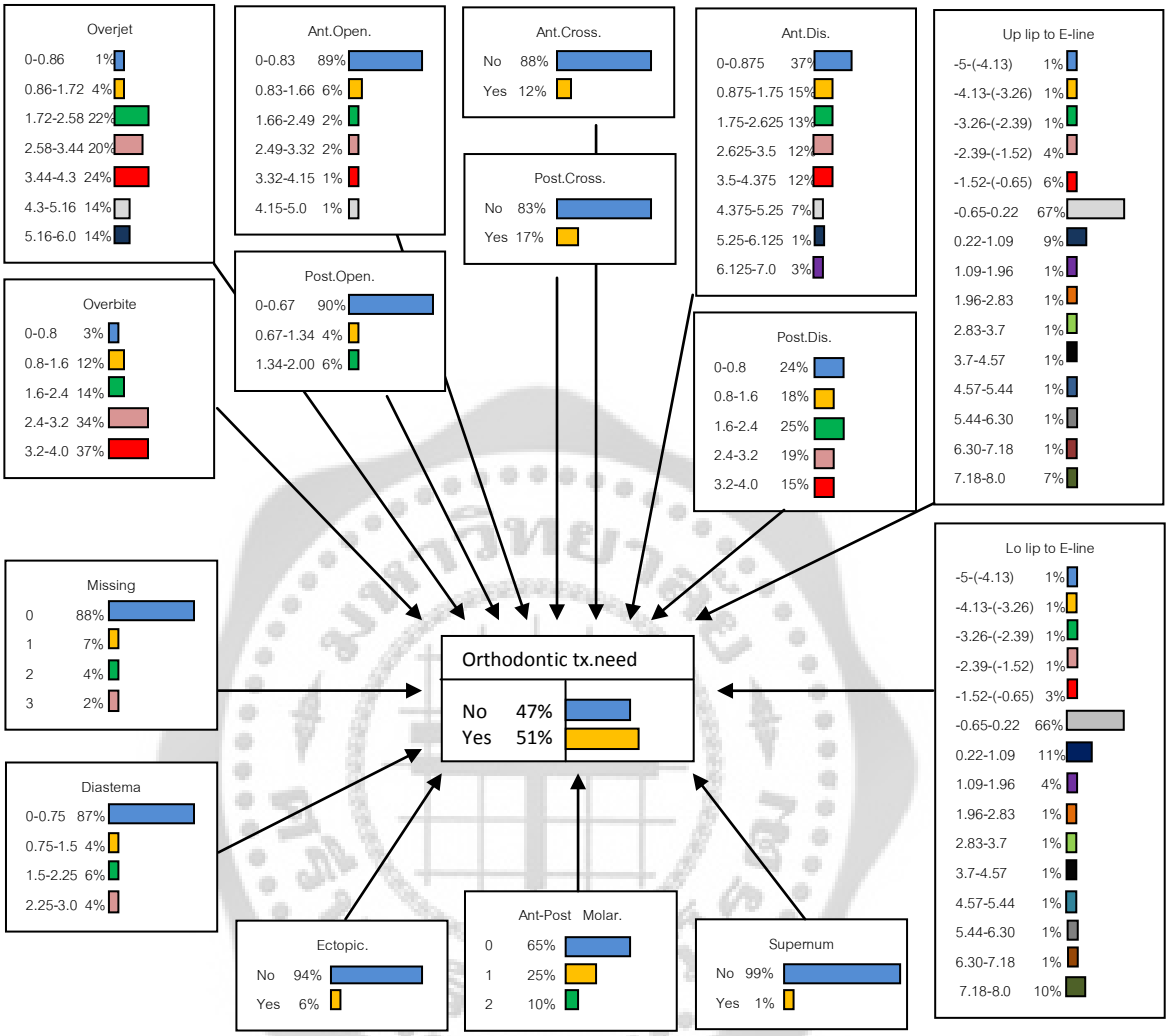

Figure 13 Condition probability distributions on all node after learning

The performance of all candidate decision support systems

The data were classified into 5 groups by using random sampling, resulting with 5 candidate decision support systems. Performance of those candidate decision support systems were shown in Table 9, an average score of specificity, sensitivity and accuracy were 97.50%, 94.48% and 94.75% respectively.

Table 9 Specificity, sensitivity and accuracy

	Specificity	Sensitivity	Accuracy
Data sampling no. 1	1	0.939394	0.95
Data sampling no. 2	1	0.947368	0.9625
Data sampling no. 3	0.9375	0.957447	0.9375
Data sampling no. 4	1	0.942308	0.9625
Data sampling no. 5	0.9375	0.9375	0.925
Average	0.975	0.9448034	0.9475
(%)	(97.50%)	(94.48%)	(94.75%)

The data sampling, which gived the highest performance (the specificity, sensitivity, accuracy were 100%, 94.74% and 96.24% respectively), was selected and developed with the software. Receiver operating characteristic curve analysis showed that the system was highly accurate in predicting the orthodontic treatment need; the area under the curve was 0.80 (Figure 14).

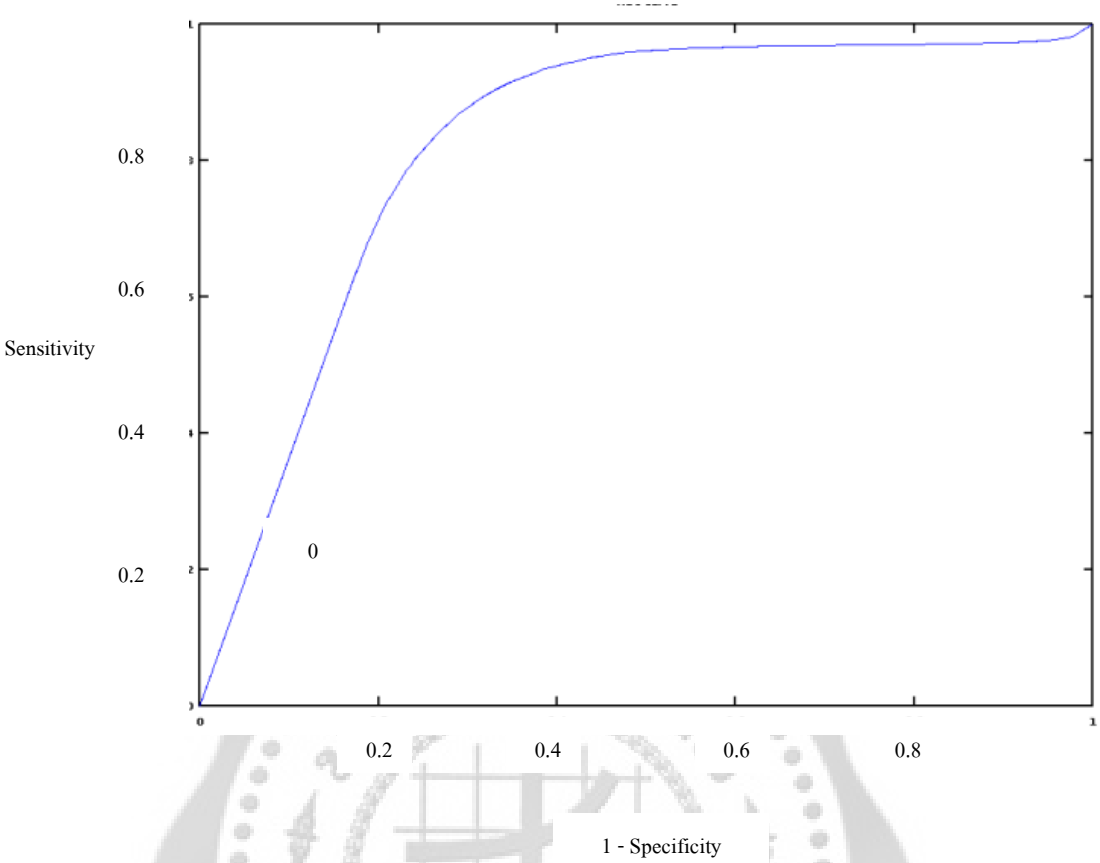

Figure 14 The area under the curves of the proposed system

Development the software of decision support system for orthodontic treatment need

Figure 15a showed the appearance of dental care after developed into software and uploaded in computer system. After pressing the dental care button, it showed 15 variables' box where user could fill in. These 15 variables consist of both descriptive texts and pictures (Figure 15b). The result will be showed automatically when pressed the output button.

(a)

(b)

Figure 15 Soft ware forms

Point of intersection of this study was 0.5. Any diagnosis were higher than 0.5, it was considered to be the conclusion of that patient. For example, the oral and facial examination were Missing = 0, Overjet = 2, Overbite = 0, Ant.Open = 5, Post.Open. = 0, Diastema = 0, Ant.Cross. = No, Post.Cross. = Yes, Ant.Dis. = 2.5, Post.Dis. = 3.5, Supernum = No, Ectopic eruption = No, Ant-Post Molar = 2, Up lip to E-line = None, Lo lip to E-line = None. After the data was filled completely, the dentists pressed the output button. The result showed that the rate of orthodontic treatment need was 0.91491, and no need to be treated in orthodontic was 0.08509 (Figure 16). In summary, this patient needed orthodontic treatment.

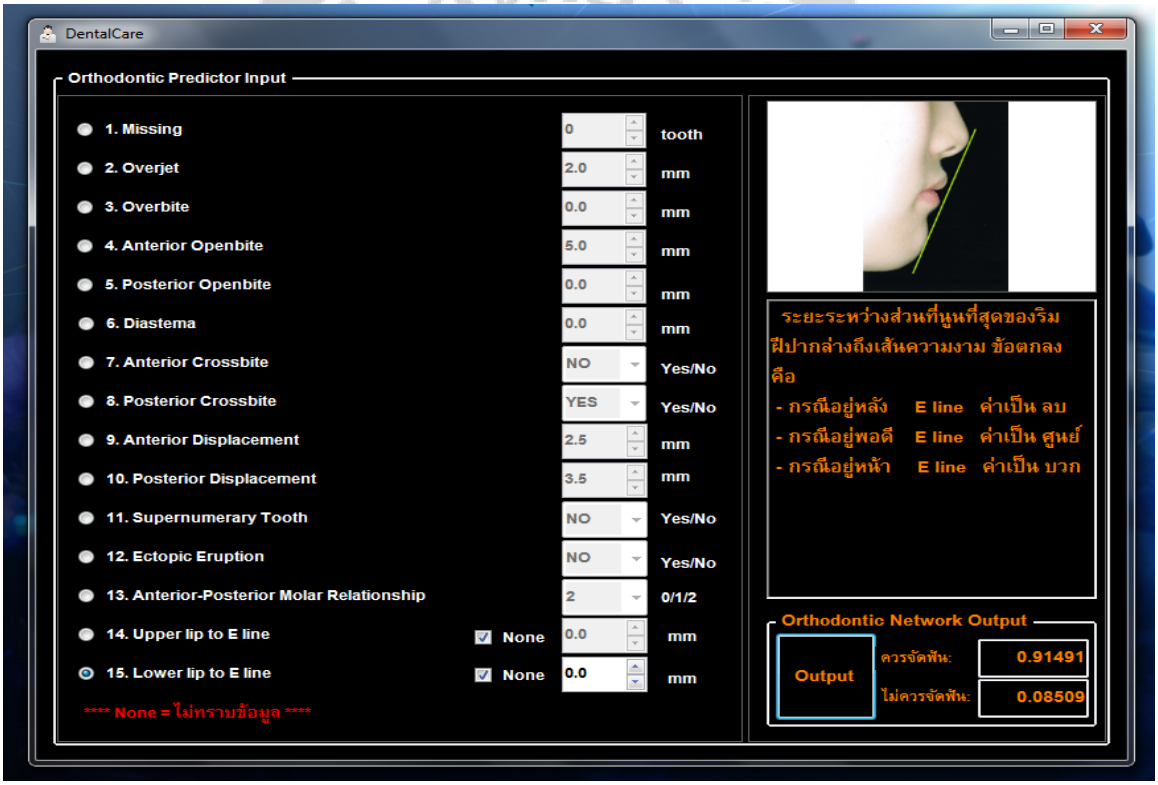

Figure 16 Example of predicting orthodontic treatment need in some patient

Evaluation the developed decision support system

The data from 20 random sampling volunteers were showed in table 10, 5 males and 15 females.

Table 10 The result of 15 variables in 20 volunteers

No	Missing	Overjet	Overbite	Ant. Open*	Post. Open*	Diastema	Ant. Cross *	Post. Cross *	Ant Dis *	Post Dis*	Supernum *.	Ectopic eruption	Ant-Post Molar*	Up* lip To E-line	Lo* lip To E-line
1	0	2.5	3.5	0	0	0	N	N	1	1	N	N	0	-1.5	-1
2	0	2.5	2	0	1	0	N	Y	3	2	N	N	N/A	-1	-0.5
3	0	3	2.5	0	0	0	Y	Y	5	2.5	N	N	1	-2	-1
4	0	1	2	0	0	0	N	N	1	1	N	N	0	-4	-1.5
5	0	3.5	2	0	0	0	N	N	2	2	N	N	1	0	2.5
6	0	2.5	6	0	0	0	N	N	1.5	0	N	N	N/A	0	-3
7	0	3.5	N/A	1	0	0	N	Y	0	2.5	N	N	1	2	3
8	0	3	5	0	0	0	N	Y	3	6	N	N	0	0	-1
9	0	3	4	0	0	0	N	N	1	1.5	N	N	0	-2.5	0
10	0	2.5	2.5	0	0	0	N	N	3	0	N	N	0	0.5	0
11	0	0	0	0.5	0	0	Y	Y	5	4	N	N	2	1.5	6
12	0	2	0	0	0	0.5	Y	Y	3	2	N	N	0	0	3
13	0	N/A	N/A	0	2	0	Y	Y	4	2.5	N	N	2	0	4.5
14	0	4	3	0	0	0	N	Y	3	6	N	N	2	0	1.5
15	0	4	3.5	0	0	0	N	Y	1.5	2.5	N	N	0	0	0
16	0	3.5	4	0	0	0	N	N	1	3	N	N	0	-1.5	-0.5
17	0	4	3	0	1	0	N	N	0	0	N	N	N/A	0.5	1.5
18	0	3	2	0	0	0	N	N	0	1	N	N	N/A	1	-1
19	0	3.5	2.5	0	0	0	N	N	2	2	N	N	0	0	-2
20	0	3	3	0	0	0	N	N	0	2	N	N	N/A	0	0.5

* Note : Ant.Open = Anterior Openbite, Post.Open. = Posterior Openbite, Ant.Cross. = Anterior Crossbite, Post.Cross. = Posterior Crossbite, Ant.Dis. = Anterior Displacement, Post.Dis. = Posterior Displacement, Supernum = Supernumerarytooth, Ant-Post Molar = Anterior-Posterior Molar relationship, Up lip to E-line = Upper lip to E-line, Lo lip to E-line = Lower lip to E-line

The diagnosis of orthodontic treatment need conducted by 2 dentists and the decision support system were showed in table 11.

Table 11 The diagnosis of orthodontic treatment need

No	Orthodontist no.1	Orthodontist no.2	Decision support system
1	No need	Need	No need = 0.93964
2	No need	Need	No need = 0.62823
3	Need	Need	Need = 0.52973
4	No need	No need	No need = 0.87731
5	No need	No need	No need = 0.85461
6	No need	No need	No need = 0.95588
7	Need	Need	Need = 0.76936
8	Need	Need	Need = 0.98527
9	No need	No need	No need = 0.94999
10	No need	No need	No need = 0.64333
11	Need	Need	Need = 0.99998
12	Need	Need	Need = 0.91719
13	Need	Need	Need = 1.00000
14	Need	Need	Need = 0.99925
15	No need	No need	No need = 0.78784
16	No need	No need	No need = 0.78784
17	No need	No need	No need = 0.99794
18	No need	No need	No need = 0.99598
19	No need	No need	No need = 0.89278
20	No need	No need	No need = 0.99694

The comparison of diagnosis agreement

Statistic used was Kappa coefficient or Kappa coefficient of Cohen

1. There was high degree of dental diagnosis agreement between orthodontist no.1 and orthodontist no.2 (kappa value = 0.794).

2. There was high degree of agreement between decision support system and orthodontist no.1 (Kappa value = 1.00).

3. There was high degree of agreement between decision support system and orthodontist no.2 (Kappa value = 0.794).

CHAPTER V
DISCUSSION

The study of Tarvit and Freer[65] found that the development of teeth affected occlusal abnormalities. The result showed that a patient had occlusal abnormalities as well as different in mixed and permanent dentition. Therefore, this study was conducted with people age 18 to 24 years old had definitely permanent teeth and usually needed for orthodontic treatment[66]. Therefore, it was very easy for the researchers to collect the data and can control another related factors. The sampling group was also participated well.

In this study, there were the adaptation of indexes used in Thailand and other countries with selected variables. Those indexes include 3 indexes (The IOTN, The ICON and The DAI) of which allowed the selection of 13 variables included missing, overjet, overbite, anterior open bite, posterior open bite, diastema, anterior crossbite, posterior crossbite, anterior displacement, posterior displacement, supernumerary tooth, ectopic eruption and anterior-posterior molar relationship. And those 3 indexes shared the similar variables: overbite, anterior open bite, diastema, anterior crossbite, anterior displacement and anterior-posterior molar relationship. This can be suggested that those indexes were focused on front teeth which can be seen when people smile or talk. In other words, people satisfaction was influenced by facial aesthetics[67-69].

Other variables were upper lip to E line, lower lip to E line being added in this study because several studies and articles suggested that bimaxillary protrusion greatly found in Asians[70-73]. Moreover, the study of Ricketts[54] indicated that bimaxillary protrusion patients needed to receive orthodontic treatment. According to the intra-oral examination, the researcher found that patient's occlusion was good despite that the patients' profiles as shown by E plane (A line drawn from the tip of the nose to the chin) protruded. And the study of Lamberton *et al.*[55] studied in 75 Thai bimaxillary protrusion patients, the age average was 22 years old. The result found that all patients' lip had been protruded more. However, the result of Thai and Caucasian was also different because Thai had less nose prominent that Caucasian about 3-4 mm.

Ten pictures that appeared in the IOTN and the ICON used to evaluate the need for orthodontic treatments were excluded. This was because the present method requires somewhat more discretion of the investigator[45]. These pictures were not consistent with the objectives of this research because they should be evaluated by orthodontic dentists, but this study focused on non-orthodontic dentists. Besides, these pictures could cause any mistakes even though it was measured by non-orthodontic dentist specialists or orthodontic dentists[74, 75, 40].

To evaluate the system, four performance measures were used: accuracy, sensitivity, specificity, and AUC. The accuracy of a classifier on a given test data set was measured as the percentage of test records that were correctly classified by the classifier. This measure showed the overall recognition rate of the classifier. The sensitivity of a classifier served as a statistical measure of how the classifier identified the positive cases correctly. The specificity of a classifier served as a statistical measure of how the classifier identified the negative cases correctly. The sensitivity and the specificity were useful when the accuracy of a classifier was not representative of its true performance. ROC curves are a useful visual tool for comparing different classification models. A ROC curve showed the trade-off between the true positive rate (or sensitivity) and the false positive rate (or 1-specificity) of a model. The vertical axis of a ROC curve represented the sensitivity, whereas the horizontal axis represented the 1-specificity. To assess the accuracy of a model, we computed the area under the ROC curve of a model which has values in the interval 0.0 - 1.0. The more AUC is closer to 1.0, the more accurate of model is.

From 5 candidate decision support systems showed that the highest performance were 100% specificity, 94.74% sensitivity, 96.24% accuracy and AUC 0.80. The results are consistent with the study of Choi *et al.*[76] who developed BN model for predicting breast cancer prognosis using 294,275 data. Their model showed high performance of specificity (58.3%), sensitivity (88.5%), accuracy (70.9%), and AUC (0.813). The study of Kahn *et al.*[77] who developed BN model for mammographic diagnosis of breast cancer by testing BN performance in 77 cases. Their model showed high performance of sensitivity (92%), specificity (88.5%) and AUC (0.881). Moreover, there were many studies evaluated BN model performance by using AUC only. For example, the development of BN to help

diagnose breast cancer by Robert *et al*.[78], the development of Bayesian belief network to help diagnose breast cancer by Wang *et al*.[79]. The AUC value of these 2 studies was 0.9585 and 0.89 respectively. After the software was developed, the system was evaluated by comparison of dental diagnosis agreement of 20 subjects between developed system and 2 orthodontists. The results presented the high degree of agreement between the predictions given by the orthodontists and the software. The present study was in addition consistent with the studies of Suebnukarn *et al*.[29] who developed BN model for assessment of endodontic treatment outcome. When compared the assessment by 3 endodontists, it showed high degree of agreement (kappa index = 0.793).

BN was a system which was widely used in many organizations. For example, Cofiño *et al.*[80] developed BN for probabilistic weather prediction. In medical issue, BN was used to help diagnose breast cancer,[76,77,78] determine the relationship between environment and gene to the occurrence of disease[81] or BN for predicting pregnancy by Corani *et al.*[82] BN is very attractive for medical diagnosis systems since they can be applied to make inferences in many cases when the input data is incomplete. This can be happened in several clinical settings when using BN with limited diagnostic decisions data, and the system can be revised later when data become available[79].

According to the study of Kitsahawong *et al.*[83], using The DAI. The result showed that the permanent tooth malocclusion population was 19.1% and they needed to be treated in orthodontic clinic. The study was corresponded to 4th national dental health survey conducted in Thailand, in 1994, using DAI. The result showed that 23.2% of 2,801 twelve year-old children had the malocclusion problem[84]. In addition, they needed orthodontic treatment and 21.8% were the population who lived in the rural area. As a consequence, the decision support system allows non-orthodontic dentists to use in evaluating and advising the patients appropriately. Even in rural area, where lack of orthodontic dentists, when patients have good occlusion, it can reduce the risk of other oral health problems. For example, dental caries[85] and gingivitis,[86, 87] which relate to tooth displacement and ectopic eruption. It can decrease the risk of anterior teeth injury, which related to anterior teeth more protrusion[88, 89].

Limitation of the study

The limitation of this study is lack of time, thus examination of 401 data in the process of system development is less than other studies. According to the study of Onisko *et al*.[90], the result showed that the more researcher got a data is the more diagnosis will be accurate. However, the performance of the system was in a high level (the specificity, sensitivity, accuracy are 100%, 94.74% and 96.24% respectively).

Suggestions for Further Study

1. The system should be developed to be more accurate by adding some data.

2. The system should be developed for orthodontic treatment need in mixed dentition.

3. The developed decision support system for orthodontic treatment need should be evaluated the dental diagnosis accuracy between general dentistry and orthodontists.

Conclusion

The results showed the examining 15 variables of the need for orthodontic treatment which was mainly focused on the dentist's perceptions. The patient's perceptions and their condition were not investigated. The decision support system is a useful tool that allows non-orthodontic dentists to evaluate and advise patients appropriately as well as the principles of medical with high accuracy comparable assessment. However, to be treated in orthodontic, patients should be treated after talking, exchange opinions and making decisions between patients and orthodontic dentist.

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APPENDIX

APPENDIX A

The comparison of diagnosis agreement

1. Degree of diagnosis agreement between orthodontist no.1 (OTN dent1) and orthodontist no.2 (OTN dent2)

OTN dent2 * OTN dent1

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
OTN dent2 * OTN dent1	20	100.0%	0	0.0%	20	100.0%

Count

		OTN dent1		
		จำเป็น	ไม่จำเป็น	Total
OTN dent2	จำเป็น	7	2	9
	ไม่จำเป็น	0	11	11
Total		7	13	20

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	Kappa	.794	.135	3.628	.000
N of Valid Cases		20			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Kappa value = 0.794 = There was high degree of agreement between orthodontist no.1 and Orthodontist no.2.

2. Degree of diagnosis agreement between decision support system (OTN system) and orthodontist no.1

OTN system * OTN dent1

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
OTN system * OTN dent1	20	100.0%	0	0.0%	20	100.0%

Count

		OTN dent1		Total
		จำเป็น	ไม่จำเป็น	
OTN system	จำเป็น	7	0	7
	ไม่จำเป็น	0	13	13
Total		7	13	20

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	Kappa	1.000	.000	4.472	.000
N of Valid Cases		20			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Kappa value = 1.00 = There was high degree of agreement between decision support system and Orthodontist no.1.

3. Degree of diagnosis agreement between decision support system and orthodontist no.2

OTN system * OTN dent2

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
OTN system * OTN dent2	20	100.0%	0	0.0%	20	100.0%

Count

		OTN dent2		
		จำเป็น	ไม่จำเป็น	Total
OTN system	จำเป็น	7	0	7
	ไม่จำเป็น	2	11	13
Total		9	11	20

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	Kappa	.794	.135	3.628	.000
N of Valid Cases		20			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Kappa value = 0.794 = There was high degree of agreement between decision support system and Orthodontist no.2.

APPENDIX B

บันทึกข้อความ

ส่วนราชการ ภาควิชาทันตกรรมอนุรักษ์และทันตกรรมประดิษฐ์ (คณะกรรมการพิจารณาจริยธรรมในการทำวิจัย) โทร. 15140

ที่ ศธ 0519.2.04/ - วันที่ 3 พฤษภาคม 2556

เรื่อง ขอแจ้งผลการพิจารณาโครงการวิจัยเพื่อขอคำรับรองคณะกรรมการพิจารณาจริยธรรมในการทำวิจัย

เรียน อ.ทพญ.ดร. ปิยรัตน์ ปิยสาธิต

ตามที่ ท่านนำเสนอโครงการวิจัย โครงการวิจัย เรื่อง โมเดลเพื่อการพยากรณ์ความจำเป็นในการรักษาทางทันตกรรมจัดฟัน เพื่อขอคำรับรองพิจารณาจากคณะกรรมการพิจารณาจริยธรรมในการทำวิจัย เมื่อวันที่ 29 เมษายน 2556 นั้น คณะกรรมการพิจารณาจริยธรรมในการทำวิจัย มีมติให้โครงการวิจัยของท่านผ่านการพิจารณาจริยธรรม โดยมีข้อแก้ไขเพิ่มเติม ดังนี้

1. ขอเสนอแนะให้แก้ไขชื่อเรื่องงานวิจัยเนื่องจากไม่สื่อถึงความหมายของการศึกษาครั้งนี้
2. แบบ ทวจ. 01 ข้อ 9.3.1 ขอให้ระบุจำนวนอาสาสมัครที่ใช้ในการศึกษา
3. แบบ ทวจ. 03 ข้อ 3 ขอให้ตัดข้อความ “ตลอดจนมีสิทธิ์ได้รับค่าทดแทนความพิการที่อาจเกิดขึ้นจากการวิจัยตามสมควร” ออก

ในการนี้ ขอให้ท่านทำบันทึกถึงประธานคณะกรรมการพิจารณาจริยธรรมในการ ทำวิจัย พร้อมข้อเสนอฉบับที่แก้ไขแล้วตามรายละเอียดข้างต้นจำนวน 1 ชุด มายัง กนกพร ปิ่นนาค ชั้น 11 ภายในวันที่ 9 พฤษภาคม 2556 เพื่อทางคณะกรรมการฯดำเนินการตรวจความถูกต้องครบถ้วนตามที่เสนอให้แก้ไขและดำเนินการออกใบรับรองจริยธรรมในลำดับถัดไป

จึงเรียนมาเพื่อโปรดทราบและดำเนินการต่อไป

(อาจารย์ทันตแพทย์หญิง ชื่นชีวิต ทองศิริ)
กรรมการและเลขานุการ
คณะกรรมการพิจารณาจริยธรรมในการทำวิจัย

แบบ ทวจ. 04-2554

คำอธิบายโครงการวิจัยสำหรับผู้ยินยอมตน

1. หัวข้อเรื่องที่จะทำการวิจัย

   ระบบเพื่อช่วยในการตัดสินใจความจำเป็นในการรักษาทางทันตกรรมจัดฟัน

2. ชื่อหัวหน้าโครงการวิจัย

   อ.ทพญ.ดร.ปิยรัตน์ ปิยสาธิต

3. สถานที่ทำการวิจัย

   คลินิกทันตกรรมชั้น 6 ภาควิชาทันตกรรมทั่วไป คณะทันตแพทยศาสตร์ มหาวิทยาลัยศรีนครินทรวิโรฒ

4. ทำไมจึงต้องมีโครงการวิจัยนี้

   เนื่องจากประชาชนทั่วไปมีความต้องการการรักษาทางทันตกรรมจัดฟันมากขึ้น และมักไปขอคำแนะนำกับทันตแพทย์ทั่วไป ซึ่งหลักเกณฑ์ในการพิจารณาความจำเป็นในการรักษานั้นมีมาก เช่น การสบเหลื่อมแนวดิ่ง การสบเหลื่อมแนวราบ การสบคร่อม การมีฟันซ้อนเก เป็นต้น จึงเป็นเรื่องยากสำหรับทันตแพทย์ทั่วไปที่จะให้คำแนะนำได้อย่างเหมาะสม จากการศึกษานี้ต้องมีการตรวจสภาพภายในช่องปาก พิมพ์ปาก แล้วตรวจวัดการสบฟันจากแบบพิมพ์ปากนั้น ซึ่งจะนำข้อมูลที่ได้มาใช้สร้างโมเดลในการพยากรณ์ความจำเป็นในการรับการรักษาทางทันตกรรมจัดฟัน เกิดประโยชน์ต่อคนไข้และทันตแพทย์ทั่วไป คือ เป็นแนวทางการให้คำแนะนำสำหรับทันตแพทย์ทั่วไป และคนไข้ได้รับคำแนะนำอย่างเหมาะสม

5. เหตุผลที่เชิญชวนให้ท่านเข้าโครงการวิจัย

   เพราะอยู่ในช่วงอายุที่เหมาะสม ฟันทุกซี่ในช่องปากเป็นฟันแท้ สามารถควบคุมปัจจัยได้หลายอย่าง เช่น สามารถมาทำการทดลองได้สะดวก ไม่เสียค่าใช้จ่ายที่ไม่จำเป็น สะดวกในการติดต่อและประสานงาน ข้อมูลที่ได้จะนำไปใช้สร้างและประเมินโมเดลเพื่อการพยากรณ์ความจำเป็นในการรักษาทางทันตกรรมจัดฟัน ซึ่งจะก่อให้เกิดประโยชน์แก่ผู้ป่วยรายอื่นๆต่อไป

6. วิธีการวิจัยที่เกี่ยวข้องกับท่าน

   การพิมพ์ปากในขากรรไกรบนและล่างด้วยวัสดุพิมพ์ปากอัลจิเนตที่ผสมกับน้ำในอัตราส่วน 1 : 1 จำนวน 1 ครั้ง รอยพิมพ์ที่ได้นำไปเทแบบด้วยปูนปลาสเตอร์ขาว แบบพิมพ์ที่ได้นำไปใช้ในการประเมินการสบฟัน

7. ระยะเวลาที่ท่านต้องอยู่ในโครงการวิจัย

   ทำการพิมพ์ปากจำนวน 1 ครั้ง ใช้เวลาประมาณ 10 นาที ทั้งนี้มีช่วงเวลาที่รัสดุพิมพ์ปากอยู่ในช่องปากเพียง 3 – 4 นาที

8. ประโยชน์ที่คาดว่าจะเกิดขึ้นทั้งต่อท่านและต่อผู้อื่นจากโครงการวิจัยนี้
   1. ทันตแพทย์ทั่วไปสามารถนำโมเดลเพื่อการพยากรณ์ความจำเป็นในการรักษาทางทันตกรรมจัดฟันที่พัฒนาแล้วนั้น ไปใช้ประกอบการให้คำแนะนำแก่ผู้ป่วยได้อย่างเหมาะสม
   2. ทันตแพทย์สามารถใช้เป็นเอกสารประกอบการพิจารณาส่งต่อ
   3. ผู้ป่วยทราบแนวโน้มความจำเป็นในการรับการรักษาทางทันตกรรมจัดฟันของตนเอง
9. ผลิตภัณฑ์หรือกระบวนการรักษาที่ท่านจะได้รับในการเข้าร่วมโครงการวิจัยนี้ได้รับการพิสูจน์แล้วว่าปลอดภัยและมีประสิทธิผลอย่างไร

   วัสดุพิมพ์ปากอัลจิเนตมีการใช้ทั่วไปในทางทันตกรรม เพื่อใช้ลอกเลียนรายละเอียดในช่องปาก มีความปลอดภัยสูง ก่อให้เกิดการแพ้น้อยมาก เมื่อผสมกับน้ำจะมีลักษณะเหลวเป็นครีมข้นแต่เมื่อเริ่มแข็งตัวจะนิ่มและหยุ่นคล้ายยาง ไม่ทำให้เกิดความเจ็บปวด มีกลิ่นที่ดี
10. การเข้าร่วมโครงการวิจัยนี้จะมีความเสี่ยงหรือความไม่สบายใดที่จะเกิดกับท่านได้บ้าง
    1. แพ้วัสดุพิมพ์ปาก
    2. กลืนวัสดุพิมพ์ปากลงคอ
    3. สำลักวัสดุพิมพ์ปากหรืออาเจียน
11. ทางเลือกในการรักษา หรือวิธีการตรวจวินิจฉัยอื่น ที่อาจเป็นประโยชน์แก่ท่าน

    ไม่มีการรักษาและการตรวจด้วยวิธีอื่น
12. ขอบเขตการดูแลรักษาความลับของข้อมูลต่าง ๆ ของท่าน

    ผู้วิจัยจะเก็บข้อมูลส่วนตัวของอาสาสมัครเป็นความลับ จะเปิดเผยเฉพาะผลสรุปการวิจัยเท่านั้น
13. กรณีเกิดอันตรายหรือผลไม่พึงประสงค์จากการศึกษาวิจัย ท่านจะได้รับการดูแลรักษาอย่างไรบ้าง

    กรณีเกิดอาการเจ็บปวดเนื่องจากเกร็งกล้ามเนื้อ เพราะใช้ระยะเวลาในการตรวจสภาพช่องปากนาน หรือจากการอ้าปากกว้างเกินไปขณะพิมพ์ปาก ผู้วิจัยยินดีให้การดูแลจนกระทั่งอาการดังกล่าวดีขึ้นเป็นปกติ
14. ท่านมีสิทธิ์ที่จะถอนตัวออกจากโครงการวิจัยได้ทุกเมื่อ โดยไม่กระทบต่อการดูแลรักษาที่พึงได้รับตามปกติ
15. ชื่อ ที่อยู่ และหมายเลขโทรศัพท์ของหัวหน้าโครงการวิจัยที่ท่านสามารถติดต่อได้โดยสะดวกทั้งในและนอกเวลาราชการ กรณีมีเหตุจำเป็น หรือฉุกเฉิน

    อ.ทพญ.ดร.ปิยรัตน์ ปิยสาธิต

    ที่อยู่ที่ทำงาน : ภาควิชาทันตกรรมทั่วไป คณะทันตแพทยศาสตร์ มหาวิทยาลัยศรีนครินทรวิโรฒ ถนนสุขุมวิท 23 เขตวัฒนา กรุงเทพฯ 10110

    โทรศัพท์ : 0-2649-5000 ต่อ 15116, 15092, 15854 หรือ 081-456-0680

ผ่านการรับรองการพิจารณาจริยธรรมการทำวิจัยในมนุษย์
คณะทันตแพทยศาสตร์ มหาวิทยาลัยศรีนครินทรวิโรฒ
เลขที่ ... วันที่ 9 พ.ค. 2554
ลงชื่อ ...
(เลขานุการคณะกรรมการพิจารณาจริยธรรมฯ)

แบบ ทวจ. 04-2554

16. โครงการวิจัยนี้ได้ผ่านการรับรองการทำวิจัยในมนุษย์จากคณะกรรมการพิจารณาจริยธรรมในการทำวิจัยของคณะทันตแพทยศาสตร์ มหาวิทยาลัยศรีนครินทรวิโรฒแล้ว เมื่อวันที่ 3 พ.ค. 2556

แบบ ทวจ. 03-2554

หนังสือให้ความยินยอมเข้าร่วมในโครงการวิจัย

เขียนที่ .....
วันที่.....

ข้าพเจ้า.....อายุ.....ปี อยู่บ้านเลขที่..... ถนน.....
หมู่ที่.....แขวง/ตำบล.....เขต/อำเภอ.....จังหวัด.....
ขอทำหนังสือนี้ให้ไว้ต่อหัวหน้าโครงการวิจัยหรือผู้แทนเพื่อเป็นหลักฐานแสดงว่า

ข้อ 1. ข้าพเจ้าได้รับทราบโครงการวิจัยของ อ.ทพญ.ดร.ปิยรัตน์ ปิยสาธิต และคณะผู้วิจัย เรื่อง ระบบเพื่อช่วยในการตัดสินใจความจำเป็นในการรักษาทางทันตกรรมจัดฟัน จากคำอธิบายโครงการวิจัยสำหรับผู้ยินยอมตน (ทวจ. 04) ที่แนบมานี้

ข้อ 2. ข้าพเจ้าได้รับการอธิบายจากผู้วิจัยเกี่ยวกับวัตถุประสงค์ของการวิจัย วิธีการวิจัย ประสิทธิภาพความปลอดภัย ประโยชน์ที่จะได้รับจากการวิจัยโดยละเอียด รวมถึงอาการ หรืออันตรายที่อาจเกิดขึ้น และแนวทางรักษาโดยวิธีอื่นอย่างละเอียด ข้าพเจ้ามีเวลาและโอกาสเพียงพอในการซักถามข้อสงสัยจนมีความเข้าใจอย่างดีแล้ว โดยผู้วิจัยได้ตอบคำถามต่างๆ ด้วยความเต็มใจไม่ปิดบังซ่อนเร้น

ข้อ 3. ข้าพเจ้าได้รับทราบจากผู้วิจัยแล้วว่าหากมีอันตรายใดๆ **อันเกิดขึ้นจากการวิจัยดังกล่าว** ข้าพเจ้าจะได้รับการรักษาพยาบาลจากคณะผู้วิจัย โดยไม่คิดค่าใช้จ่ายและจะได้รับค่าชดเชยรายได้ที่สูญเสียไปในระหว่างการรักษาพยาบาลดังกล่าว

ข้อ 4. ข้าพเจ้าได้รับทราบแล้วว่าข้าพเจ้ามีสิทธิ์จะบอกเลิกการร่วมโครงการวิจัยนี้ และการบอกเลิกการร่วมโครงการวิจัยจะไม่มีผลกระทบต่อการดูแลรักษาโรคที่ข้าพเจ้าจะพึงได้รับต่อไป

ข้อ 5. ข้าพเจ้าได้รับการรับรองจากผู้วิจัยว่าจะเก็บข้อมูลส่วนตัวของข้าพเจ้าเป็นความลับ จะเปิดเผยเฉพาะผลสรุปการวิจัยเท่านั้น

ข้อ 6. อ.ทพญ.ดร.ปิยรัตน์ ปิยสาธิต ซึ่งเป็นหัวหน้าโครงการวิจัยหรือผู้แทน ได้อธิบายเกี่ยวกับรายละเอียดต่าง ๆ ของโครงการตลอดจนประโยชน์ของการวิจัยรวมทั้งความเสี่ยงและอันตรายต่าง ๆ ที่อาจจะเกิดขึ้นในการเข้าร่วมโครงการนี้ ให้ข้าพเจ้าทราบ และตกลงรับผิดชอบตามคำรับรองในข้อ 3 ทุกประการ

ข้อ 7. ข้าพเจ้ายินยอมเข้าร่วมโครงการวิจัยนี้ ด้วยความสมัครใจ โดยมิได้มีการบังคับขู่เข็ญ หลอกลวงแต่ประการใด และจะให้ความร่วมมือในการวิจัยทุกประการ

ข้าพเจ้าได้อ่านและเข้าใจข้อความตามหนังสือนี้โดยตลอดแล้วเห็นว่าถูกต้องเจตนาของข้าพเจ้าจึงได้ลงลายมือชื่อไว้เป็นสำคัญพร้อมกับหัวหน้าโครงการวิจัยและต่อหน้าพยาน

ลงชื่อ.....ผู้ยินยอมตน
ตัวบรรจง (.....)

ข้าพเจ้าได้อธิบายถึงวัตถุประสงค์ของการวิจัย วิธีการวิจัย อันตรายหรืออาการไม่พึงประสงค์หรือความเสี่ยงที่อาจเกิดขึ้นจากการวิจัย รวมทั้งประโยชน์ที่จะเกิดขึ้นจากการวิจัยอย่างละเอียดให้ผู้ยินยอมตนตามนามข้างต้นได้ทราบและมีความเข้าใจดีแล้ว พร้อมลงนามลายมือเอกสารแสดงความยินยอมด้วยความเต็มใจ

ลงชื่อ.....ผู้ให้รายละเอียดการวิจัย
ตัวบรรจง (.....)
วันที่ ..... เดือน..... พ.ศ. .....

แบบ ทวจ. 03-2554

ลงชื่อ.....พยาน

ตัวบรรจง (.....)

วันที่ ..... เดือน..... พ.ศ. .....

VITAE

VITAE

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List of Presentation

Oral presentation

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