COST AND EFFECTIVENESS ANALYSIS IN ORTHODONTIC TREATMENT WITH FIXED APPLIANCES IN ORTHODONTIC CLINIC, FACULTY OF DENTISTRY, MAHIDOL UNIVERSITY

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ABSTRACT

The aim of this study was to analyze the costs and effectiveness of fixed orthodontic treatment by closing loop mechanics and sliding mechanics in the Orthodontic Clinic of the Faculty of Dentistry, Mahidol University, in fiscal year 2005. Cost components of both methods of treatment in provider perspective were identified and valued in term of capital and recurrent costs. The study population was consisted of 3 parts: dental records, dental casts and panoramic radiographs of 47 complete cases aged 12-18 years at the start of the treatment with class I malocclusion. Most of the patients were treated during 1988-2004 by postgraduate students under supervision of the Orthodontic Department. The research tools consisted of data recording forms for costing, and record forms for scoring effectiveness. According to the criteria of the American Board of Orthodontics (ABO), scores was divided into 3 levels: good ($\leq$20), acceptable (21-30) and unacceptable (>30). Data were analyzed using t-tests for independent groups. Sensitivity analysis was performed to allow for uncertainty by testing whether plausible changes in the values of main variables affect the results of the analysis.

The results indicated that unit cost of fixed orthodontic treatment for closing loop mechanics and sliding mechanics was 36,810.04 baht at the average treatment duration 32.61 months, and 35,985.30 baht at the average treatment duration 34.36 months. The mean ABO score for the closing loop mechanics was 28.52 $\pm$ 4.71 compared with 26.50 $\pm$ 5.60 for the sliding mechanics. There was no significant difference in effectiveness scores between closing loop mechanics and sliding mechanics.

It was recommended that resource management strategies, especially the human resource management, should be reconsidered to decrease costs by having suitable working time allocations. Supervision to monitor treatment duration could be adjusted to reduce the treatment time. In terms of effectiveness, instructors should pay more attention to marginal ridge and contact point before having the appliance removed by the students.

KEY WORDS: COST/ EFFECTIVENESS/ ORTHODONTIC TREATMENT/ FIXED APPLIANCES

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การวิเคราะห์ต้นทุนและประสิทธิผลการรักษาทางทันตกรรมจัดฟันชนิดติดแน่น คลินิกทันตกรรมจัดฟัน คณะทันตแพทยศาสตร์ มหาวิทยาลัยมหิดล (COST AND EFFECTIVENESS ANALYSIS IN ORTHODONTIC TREATMENT WITH FIXED APPLIANCES IN ORTHODONTIC CLINIC, FACULTY OF DENTISTRY, MAHIDOL UNIVERSITY)

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บทคัดย่อ

การวิจัยครั้งนี้มีวัตถุประสงค์เพื่อวิเคราะห์ต้นทุนและประสิทธิผลการรักษาทางทันตกรรมจัดฟันชนิดติดแน่น ของคลินิกทันตกรรมจัดฟัน คณะทันตแพทยศาสตร์ มหาวิทยาลัยมหิดล ต้นทุนวิเคราะห์ในมุมมองของผู้ให้บริการ ปีงบประมาณ 2548 โดยศึกษาตามองค์ประกอบต้นทุน คือ ต้นทุนดำเนินการ และต้นทุนการลงทุน ซึ่งเป็นการวิจัยเชิงวิเคราะห์ กลุ่มประชากร ประกอบด้วย 3 ส่วน ได้แก่ แฟ้มประวัติ การรักษา แบบพิมพ์ฟันและฟิล์ม panoramic ของผู้ป่วยที่ได้รับการรักษาเสร็จสมบูรณ์ระหว่างปี พ.ศ. 2531-2548 ที่มีอายุก่อนการรักษาระหว่าง 12-18 ปี และมีลักษณะการสบฟันผิดปกติชนิดที่ 1 จำนวน 47 ราย เครื่องมือที่ใช้ในการวิจัยคือ แบบบันทึกข้อมูลตามองค์ประกอบต้นทุนและแบบบันทึกข้อมูลประสิทธิผลตามเกณฑ์ของ American Board of Orthodontics สำหรับระดับประสิทธิผลที่ใช้ในการวิจัยนี้กำหนดไว้ 3 ระดับ คือ ระดับดี น้อยกว่า 20 คะแนน ยอมรับ 21-30 คะแนน และไม่ยอมรับ มากกว่า 30 คะแนน สถิติที่ใช้ในการวิเคราะห์คือ การทดสอบเปรียบเทียบตัวแปรอิสระ โดยใช้ t-test การวิเคราะห์ความไวเป็นการดำเนินการเพื่อทดสอบการเปลี่ยนแปลงค่าของตัวแปรหลักที่มีผลกระทบต่อผลการวิเคราะห์

ผลการวิจัยพบว่าต้นทุนการรักษาทางทันตกรรมจัดฟันชนิดติดแน่นของผู้ป่วยที่ได้รับการรักษาเสร็จสมบูรณ์ด้วยวิธีการรักษาแบบ Closing loop mechanics เท่ากับ 36,810.04 บาทต่อราย ระยะเวลาการรักษาโดยเฉลี่ย 32.61 เดือน และแบบ Sliding mechanics เท่ากับ 35,985.30 บาทต่อราย ระยะเวลาการรักษาโดยเฉลี่ย 34.36 เดือน โดยมีระดับประสิทธิผลของวิธีการรักษาแบบ Closing loop mechanics และแบบ Sliding mechanics เท่ากับ 28.52 $\pm$ 4.71 และ 26.50 $\pm$ 5.60 ตามลำดับ ไม่พบความแตกต่างของประสิทธิผลการรักษาระหว่างวิธีการรักษาแบบ Closing loop mechanics และ Sliding mechanics ($p = 0.21$)

ข้อเสนอแนะจากการศึกษา ควรมีการนำกลยุทธ์การบริหารทรัพยากรไปใช้ในการลดต้นทุนโดยเฉพาะทรัพยากรบุคคล ควรให้มีชั่วโมงการทำงานที่เหมาะสม รวมทั้งควรพยายามลดระยะเวลาการรักษาคนไข้เสร็จสมบูรณ์ต่อรายลง สำหรับการปรับปรุงคุณภาพการรักษา อาจารย์ทันตแพทย์ควรจะให้ความสำคัญเป็นพิเศษในการควบคุมในส่วนของ marginal ridge และ contact point ก่อนที่จะอนุญาตให้นักศึกษาถอดเครื่องมือให้กับคนไข้

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CHAPTER I
INTRODUCTION

Background and rationale

Tooth and oral organ is a first part of the digestive system and is an important factor for social communication (www.yimsodsai.com, 2005). Malocclusion is not a disease but it is an important problem of Dental Public Health. Moreover, it is a predisposing factor to cause dental caries, periodontal diseases and apical root resorption from traumatic of the opposite tooth, which subsequently causes tooth loss (Taechapraserthvitaya, C., 2001). Fixed orthodontic treatment is used when space closure from tooth loss or extraction is needed and it is used to modify the severity of malocclusion in patients who have problems with facial growth, jaw, occlusion and function (Houston, W.J.B., 1992: 302 & Mitchell L., 1996: 174). There are several techniques in fixed orthodontic treatment but the most popular techniques are closing loop mechanics and sliding mechanics. Both techniques used the strength from arch wire, spring or elastic for bodily movement of the teeth to achieve a specified objective of orthodontic treatment such as good occlusion and efficient function.

Surveys of the Dental Public Health in 1983 and 2000 to 2001 in a group of 12-year-old children in Thailand, found the percentage of dental caries to be 45.8 and 57.3 respectively and in a 35 to 44 year group there was the tooth loss of 85.6 per cent. Crowding of the anterior teeth, which is one type of malocclusion, is correlated with the accumulation of plaque and calculus. Its consequence can cause dental caries and periodontal disease. Globally, most children have signs of gingivitis and, among adults, the initial stages of periodontal diseases, which may result in tooth loss, are found in 5-15% of most populations (World Oral Health Report, 2003: 5).

In 2002, 2003 and 2004 the number of new orthodontic patients received the fixed orthodontic treatments at the Orthodontic Clinic were 2475, 2770 and 2834 per year respectively (Annual report of Faculty of Dentistry, 2002-2004). Furthermore, it

was found that 2,294 persons were in the waiting list to receive treatment at the Orthodontic Clinic (Orthodontic Clinic, 2005).

Nowadays, fees for fixed orthodontic treatment is 30,000-40,000 baht per case for private practice (www.thaidentalnet.com, 2004) and 20,000 baht per case for government sector (Orthodontic Department, 1998). The orthodontic material is mostly imported product, which causes the high treatment fees. And since, the Ministry of Finance categorizes orthodontic treatment as cosmetic service, therefore orthodontic treatment can not be drawn as medical treatment expense (Comptroller General's Department, 2005 & Ministry of Finance, 1995). Recently, there was news about unsafe braces. Some merchants used unsafe materials to imitate the orthodontic appliances and sold to teenagers who thought braces were fashionable. This unsafe material contained lead and arsenic which could be harmful to humans. (Puntomvanich, P., 2004).

The government has recently reformed civil service system by using specific financial policy about strategic performance based budgeting, which consider the importance of outcome from the operation of organizations that are related with the suitable allocation of resource. It is agreed that public organizations would produce services within the given budget and the allocation of the budget depending on the capital per unit of production (www.bb.go.th, 2006). Furthermore, Royal Decree to be concerned with rules and method in management the best country in 2003 said that gave civil service part done the cost account in service section, which was calculated unit cost, and it was necessary would be taken limited resources used to gain the highest benefit to whole people. So, the organization then found problems about alternative of service. That, the dentist or medical staff and administrators would be facing with alternative problems in distribution limited resources to suitable service when comparing with used cost (Kamonrathanakul, P., 2000).

In recent years, the government has promoted public universities to be independent. In other words, the university will support itself without budget from the government. Therefore, the university has to utilize the limited resources at the highest benefit for the organization and customers. There are criteria for financial management such as budget planning, output costing, procurement management, asset management, financial and performance reporting and internal audit (Pannarunothai, S. &

Kongsawat, S., 2002). Moreover, Mahidol University was setting Mahidol University quality improvement policy that evaluated performance result for development not only education quality assurance but also service, that each institute would have quality standard or clearly indicator.

The important indicator for an effective operation is determined by the service cost (Laping, P., 2004). Therefore, it is very important for an organization to make a calculation of the service cost before entering into the strategic performance based budgeting (SPBB) (www.bb.go.th, 2006). Indicator to evaluate efficiency and effectiveness in performance is, for instance, unit cost of service (Kamonrathanakul, P., 2000). Nowadays, resource is limited budget, that if consider quantity and quality of only one procedure is insufficient in decision then necessary would be consideration with cost by used to techniques of economic such as cost-effectiveness analysis (Riwpaiboon, A., 2001).

Cost-effectiveness analysis is one of the techniques of economic evaluation, which involves assessing the outputs and outcomes of fixed orthodontic treatment, relative to the level of inputs and outputs to arrive at an indicator of the relative efficiency of fixed orthodontic treatment. The assessment of clinical performance is important at the individual, practice, institutional and national levels. It is a challenge not only to deliver high standards of treatment, but also to deliver the treatment at the lowest unit cost (Drummond, M.F., et al., 1997 and Creese, A. & Parker, D., 1994). An index such as the ABO index facilitates the assessment of cost-effectiveness. The ABO index is used to evaluate the quality of treatment results. It is important to consider not only occlusion but also cephalometric measurements, soft tissue posture, and functional factors in evaluating malocclusion severity and treatment outcomes (ABO, 2004). The economic principle is applied with medical knowledge to assess the value of money in each alternative way for allocating limited resources to orthodontic treatment. That is, it is the comparative analysis of alternative ways of action in terms of both their costs and effectiveness. The cost of orthodontic treatment is an important factor to use as basic information in decision making to use money efficiently and to save money (Kamonratanakul, P., 2000 and Tridech, P., 1998). That means the organization could improve services.

The Orthodontic Clinic at the Faculty of Dentistry, Mahidol University has never analysed the cost and effectiveness of fixed orthodontic treatment. This causes the administrators lack of information to assist in decision making for the management of the organization. The cost and effectiveness of fixed orthodontic treatment in this study will incorporate health economic principle as well as mission of organization and goals of orthodontic treatment, which are good occlusion and efficient function. The result of this study could be used as a tool in decision-making of the organization in order to gain the highest benefit to both the organization and organization's customers. Furthermore, the study result would reveal what will be the best treatment method at lowest unit cost. The result of the effectiveness could be used as a baseline showing the result of clinical performance of postgraduate students and be comparable to the international standard.

Research questions

1. How much was the unit cost of fixed orthodontic treatment using closing loop mechanics versus sliding mechanics?
2. What were levels of the effectiveness of fixed orthodontic treatment closing loop mechanics versus sliding mechanics?
3. Was there any difference in unit cost and effectiveness level of fixed orthodontic treatment between closing loop mechanics and sliding mechanics?

Research objectives

1. To analyse the cost and effectiveness of fixed orthodontic treatment using closing loop mechanics versus sliding mechanics.
2. To compare the unit cost and effectiveness of fixed orthodontic treatment between closing loop mechanics and sliding mechanics.

Scope of the research

This study used the samples from complete cases after fixed orthodontic treatment in the Orthodontic Clinic, which was divided into two parts as follows:

Part I: Cost was defined as the direct cost of fixed orthodontic treatment by analysing in the point of view of providers. Some data were collected from dental record at the completion and collected from fiscal year 2005 (October 1, 2004 – September 30, 2005). Cost was studied among patients treated with closing loop mechanics and sliding mechanics.

Part II: Effectiveness was studied from 1,025 complete cases of patients treated with fixed appliances by postgraduate students and under supervision of the orthodontic instructors of the Orthodontic Department and collected from dental record.

Limitation of the research

1. The samples of this study were purposely selected according to the inclusion criteria. The study was carried out at graduate clinic and on specific patient groups, so it could not be compared with other researches. Therefore, it should be careful when one uses this result.

2. The number of complete cases and competence of providers were difference for both treatment methods.

Operational definition

1. Fixed orthodontic treatment is the treatment given by orthodontists using fixed orthodontic appliance to move teeth into proper position and has its benefit over removable appliance to control bodily tooth movement.

2. Edgewise technique is a technique of orthodontic treatment with fixed appliance, which detains on teeth by bracket and band. An archwire is inserted into the slot of bracket and band to move teeth.

2.1 Closing loop mechanics is the mechanics of closing spaces by using loop archwires.

2.2 Sliding mechanics is the mechanics of closing spaces by using spring or elastic.

3. Malocclusion is considered based on the molar relationships, which are divided into three classes - class I, II and III. This study will investigate only class I malocclusion, the maxillary and mandibular first molar teeth have a normal cusp to fossa relationship, but there may be deviations in the arrangement of teeth intra arch, inter arch or both.

4. Goals of orthodontic treatment is good occlusion and efficient function.

5. Treatment results is outcome from treatment of each patient since at the beginning to complete treatment. In this study the treatment result was treated by postgraduate students in orthodontics.

6. Patient's record means folder to keep personal records and clinical records of patient. The folder consisted of examination record, treatment record, photos, panoramic radiographs and cephalometric radiographs.

7. Treatment duration means the duration of time to give treatment length since at the beginning to complete treatment (appliance removal).

8. Appliance removal is the process of removing all fixed orthodontic attachments from the teeth.

9. Co-operation of patient means compliance in appliance wear, appointment keeping and oral hygiene care.

10. Starting Age is age at start of treatment ranging from 12 to 18 years.

11. Malocclusion before treatment is the severity of malocclusion before treatment. For this study, ABO criteria is used.

12. Complete case is the patient after fixed orthodontic treatment by postgraduate students in the Orthodontic Clinic.

13. Cost and effectiveness analysis (CEA) means to analyse and compare cost and effectiveness of orthodontic treatment outcomes with closing loop mechanics and sliding mechanics.

14. Effectiveness is the evaluation of outcomes of orthodontic treatment comparing with goals of orthodontic treatment.

15. American Board of Orthodontics (ABO) is the organization, which is established to maintain the highest standards of clinical excellence in orthodontics.

16. Discrepancy Index (DI) is measured severity of malocclusion levels before treatment.

17. ABO index (ABOI) is the tool to assess the adequacy of their finished orthodontic results, the Board has established an Objective Grading System (OGS) to evaluate the final dental casts and panoramic radiographs.

18. Providers' cost means all expenses occurred from orthodontic treatment with fixed appliance of both treatment methods.

19. Cost classification is classified by inputs, which considered as a capital cost and recurrent cost.

20. Capital cost is depreciation cost of clinic renovation, durable articles and consultancies. In this study, the researcher set the durability for durable articles at 5 years and 8 years for dental durable articles and for clinic renovation at 20 years. The depreciation cost calculation is the straight line method.

21. Recurrent cost is occurred cost to follow of treatment quality which consists of labour cost and material cost.

21.1 Labour cost means expenses paid for officers of orthodontic treatment activities with fixed appliance in form of hard cash such as salaries, wages, remuneration of high position, child education fee, treatment expense and training expenses.

21.2 Material cost means all kinds of material accessories used in orthodontic treatment activities with fixed appliance and used in during treatment such as dental materials, office materials, public utility expense and maintenance expenses etc.

22. Total cost is the sum of the total capital cost and the total recurrent cost for treatment with closing loop mechanics and sliding mechanics.

23. Unit cost means average cost of fixed orthodontic treatment in one case for treatment with either closing loop mechanics or sliding mechanics.

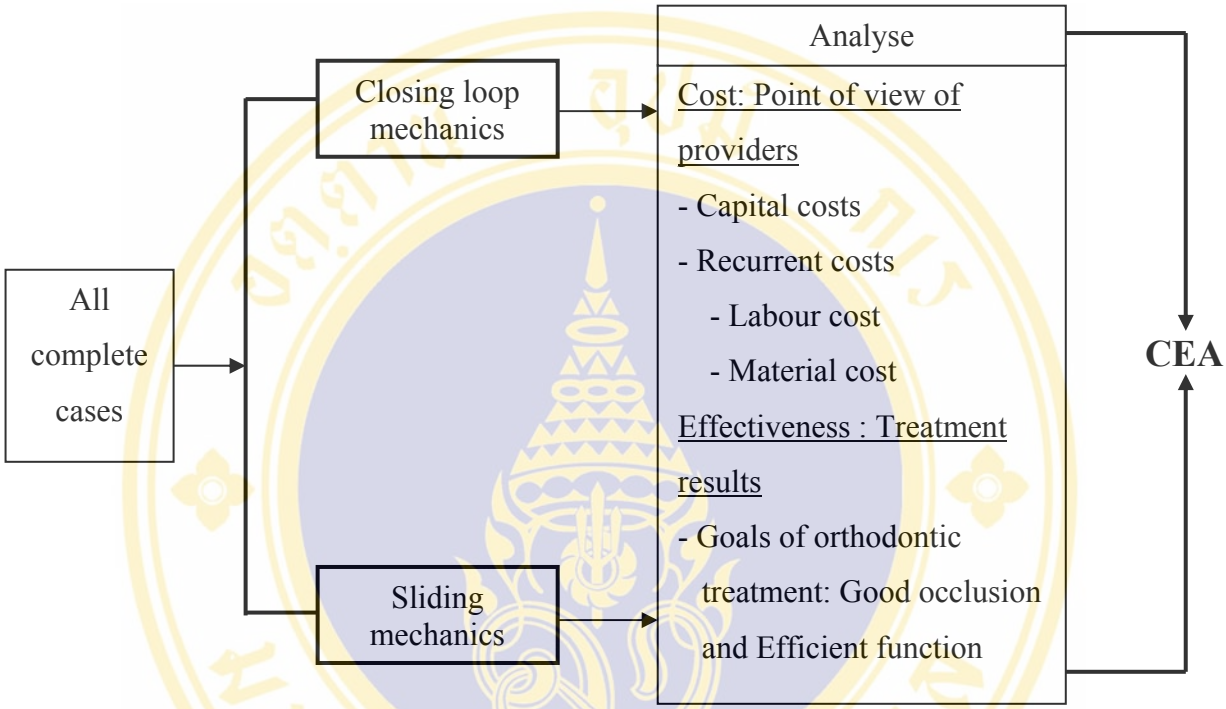


Figure 1 Cost and effectiveness analysis process

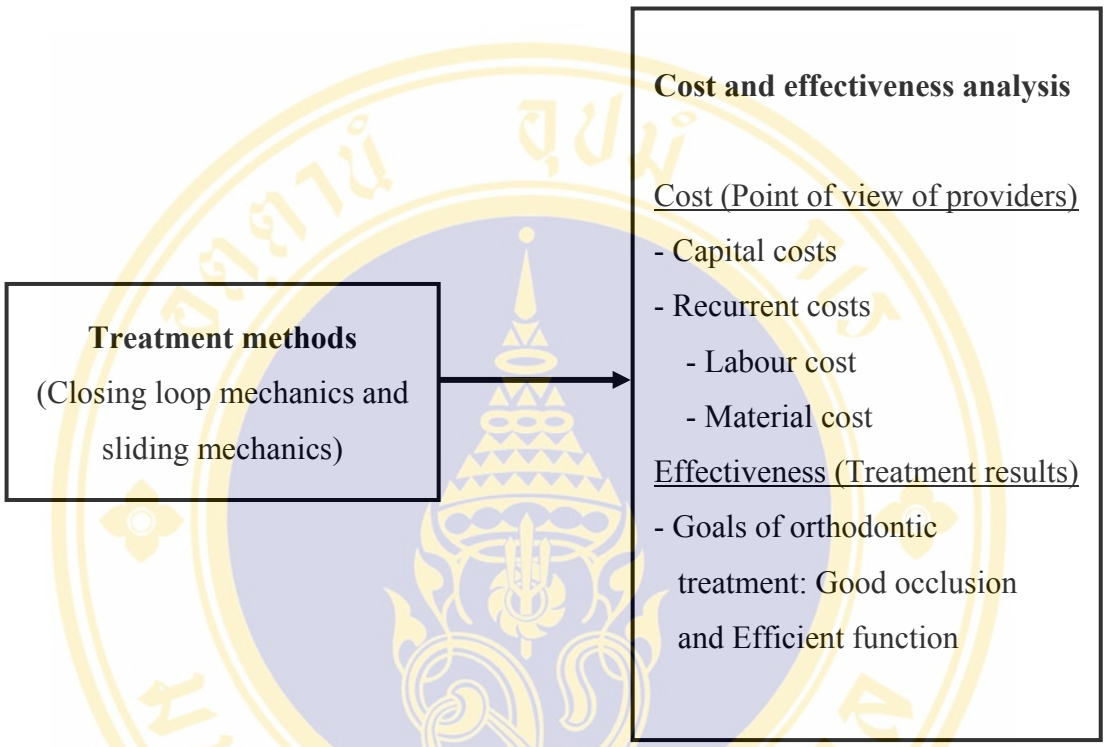


Figure 2 Conceptual framework

CHAPTER II
LITERATURE REVIEW

To study calculating cost and effectiveness of fixed orthodontic treatment in the Orthodontic Clinic of Orthodontic Department, Faculty of Dentistry, Mahidol University, the literature has covered ideas, theories information and related researches which were divided into five parts as follows:

1. Cost and effectiveness analyses
2. Cost and cost theory
3. Effectiveness evaluation
4. Orthodontic theory
5. Relevant researches

1. Cost and effectiveness analyses

Drummond, M.F., et al. (1997: 8-9) defines the economic evaluation as a set of analytic tools to assess the value for money of alternative ways of allocating limited resources to health care. Formally defined, it is 'the comparative analysis of alternative courses of action in terms of both their costs and consequence'. Therefore, the basic tasks of any economic evaluation are to identify, measure, value, and compare the costs and consequence of the alternatives being considered. These tasks characterize all economic evaluations, including those concerned with health services.

Drummond, M.F., et al. (1997: 10-11) and Pannarunothai, S. (2001: 85) had divided the full economic evaluation into four ways:

- Cost-minimization analysis
- Cost-effectiveness analysis
- Cost-utility analysis
- Cost-benefit analysis

Carrin, G. (1984: 90) defines cost-effectiveness analysis (CEA) as a method that enables the health researcher to determine the cheapest technique or system to meet a well defined quantified target, or to determine the optimal technique or system in order to maximize (or minimize) a particular non-quantified objective given a fixed budget.

Drummond, M.F., et al. (1997: 96) defines a cost-effectiveness analysis (CEA) as one form of full economic evaluation where both the costs and consequences of health programmes or treatments are examined.

Gold, M.R., et al. (1996: 26) defines the cost-effectiveness analysis (CEA) as a method designed to assess the comparative impacts of expenditures on different health interventions. Cost-effectiveness analysis can also be used in decision making by groups or individuals, but it is focused here on resource allocations at the societal level.

Creese, A. & Parker, D. (1994: 63); Tridech, P. (1994: 46) and Slothuus, U. (2000: 31) define the cost-effectiveness analysis as a technique to assist in decision making. A cost-effectiveness study involves assessing the gains (effectiveness) and resource input requirements (costs) of alternative ways of achieving a specified objective. The results in terms of cost per unit of effectiveness for each alternative and then comparing the cost-effectiveness of each alternative. The alternative with the lowest cost per unit of effectiveness is called the most “cost-effective” and is generally to be preferred on grounds of economic efficiency. (Pannarunothai, S., 2001: 85 and Kamonratanagul, P., 2000: 47) Cost-effectiveness analysis is designed to compare the costs and effects of two or more alternatives with similar objectives. The measure of effectiveness chosen should reflect as clearly as possible the main objective of the alternatives.

Creese, A. & Parker, D. (2000: 63) summarised steps of cost-effectiveness analysis, that five steps are required for every cost-effectiveness analysis. Stated in terms of a programme, they involve:

1. Defining the programme’s objectives;
2. Identifying the alternative ways to achieve those objectives;
3. Identifying and measuring the costs of each objective;
4. Identifying and measuring the effectiveness of each objective; and

5. Calculating the cost-effectiveness of each alternative and interpreting the results.

Jacobs, P. & Rapoport, J. (2002: 375) mentioned the formula for cost-effectiveness analysis is $(c_2 - c_1) / (q_2 - q_1)$. Where 1 and 2 refer to alternative interventions (e.g., conventional versus intensive treatment for diabetes), c is the cost per person, and q is the outcome.

The cost-effectiveness ratio (C/E ratio)

Jacobs, P. & Rapoport, J. (2002: 383) mentioned cost-effectiveness ratios that it can be calculated in three such ratios: cost per life saved, cost per life year saved, and cost per quality-adjusted life year saved.

Drummond, M.F., et al. (1997: 131-136); Gold, M.R., et al. (1996: 27) and Kaewsonthi, S. & Kamolratanakul, P. (1993: 177-181) explained cost-effectiveness ratio that the central measure used in CEA is the cost-effectiveness ratio. Implicit in the cost-effectiveness ratio is a comparison between alternatives. One alternative is the intervention under study, while the other is a suitably chosen alternative "usual care," another intervention, or no intervention. The cost-effectiveness ratio for comparing the two alternatives is the difference in their costs divided by the difference in their effectiveness, or C/E.

The C/E ratio is essentially the incremental price of obtaining a unit health effect (such as dollars per year, or per quality-adjusted year, of life expectancy) from a given health intervention when compared with an alternative. When the intervention under study is both more effective and less costly than the alternative. There are two basic ways to create cost-effectiveness ratios. For decision-making purposes, there are two ways to impose constraints to facilitate comparison of policy alternatives involving projects with different scales. One can only compute the ratio of the two measures as a basis for ranking alternative policies.

Cost-effectiveness measures involve computing for each alternative the ratio of the input to the output. Thus, they are measures of technical efficiency. As we discuss in the sections that follow, differences across policy alternatives in terms of scales of project, as well as the fact that cost-effectiveness measures often omit

important social costs and benefits, frequently make them poor measures of allocated efficiency.

In summary, this study analysed and compared cost and effectiveness of orthodontic treatment outcomes with closing loop mechanics and sliding mechanics.

Sensitivity analysis

Gold, M.R., et al. (1996: 249-250) explained sensitivity analysis that were fundamental to cost-effectiveness analysis. In a sensitivity analysis, some critical components in the calculation is changed by a meaningful amount or varied from worst case to best case, and the cost-effectiveness ratio was recalculated. The resulting difference in the ratio provides some indication of how sensitive the results might be to a substantial but not implausible change in that parameter. If the major results are insensitive to a reasonable variation in a parameter, then the analyst can be relatively sure that the conclusions are sensitive to which in a range of plausible values of a parameter is used, then the conclusions are not robust. If the results are sensitive to some variable over part of its plausible range then the analysis may provide some evidence about when the analyst should be concerned about the value for that parameter. If more precise data are not readily available, then the study cannot be considered definitive. But often sensitivity analysis is useful to focus attention to critical variables and thus to pose the question of whether the issues are sufficiently critical such that better or more data are needed.

Sensitivity analysis is an analysis in which the key assumptions and estimates are varied to determine how robust the results and conclusion are with respect to such changes. It indicates which, if any, of basic assumptions have a significant effect on the results. However, comprehensive economic evaluations will always include some sort of sensitivity analysis.

2. Cost and cost theory

This study explains about means of cost analysis, point of view, type of cost measurement, step of cost analysis and cost classification as follows:

2.1 Cost

McLean, R.A. (2003: 126) and Drummond, M.F., et al. (1990: 52) defines cost as overall values or prices of production plus an opportunity cost or cost from not using inputs in its best alternative use.

Jacobs, P. & Rapoport, J. (2002: 44) and Tridech, P. (1998: 37) define cost as the money outlay or expenditure that has been paid to the providers for their services.

Rayburn, L.G. (1993: 3) defines about cost that is measured the economic sacrifice made to achieve an organization's goal. For a product, cost represents the monetary measurement of resources used, such as material, labour and overhead. For a service, cost is the monetary sacrifice made to provide the service. Accountants generally use cost with other descriptive terms, such as historical, product, prime, labour, or material. Each of these terms defines some characteristics of the cost measurement process or an aspect of the object being measured.

Riwpaiboon, A. (2001: 2) and Tridech, P. (1998: 37) described cost as losing resources may be the value of benefit or the value of money for obtaining something needed. (The value of resource is used in producing process). (Deakin, E.D., et al., 1991: 4 and Reynolds, J., 1997: 96) Cost is a sacrifice of resources. Cost accounting is the field of accounting that measures, records, and reports information about costs.

2.1.1 Accounting cost

Amos, O.M. Jr. (1987: 401) defines accounting costs as the explicit costs incurred in production that involve direct payments for the inputs.

Rayburn, L.G. (1993: 3) defines cost accounting that is broad and extends beyond calculating product costs for inventory valuation, which government reporting requirements largely dictate. However, accountants do not allow external reporting requirements to determine how they measure and control internal organizational activities. In fact, cost accounting's focus is shifting from inventory valuation for financial reporting to costing for decision making. The main objective of cost accounting is communicating financial information to management for planning, controlling, and evaluating resources.

Cost analysis as a cost the accountants obtain the information from a variety of sources. Some of this information, such as vendor invoices, becomes the

basis for journal entries. Similarly, they use engineering time and motion studies, timekeepers' records, and planning schedules from production supervisors in cost analysis. Cost analysis techniques include breakeven analysis, comparative cost analysis, capital expenditure analysis, and budgeting techniques.

Drummond, M.F., et al. (1997: 52) mentioned cost analysis, that the analysis of the comparative costs of alternative treatment or health care programmes is common to all forms of economic evaluation.

2.1.2 Economic cost

Amos, O.M. Jr. (1987: 5, 401) defines economics as a social science that studies the allocation of resources to the production of goods and services used to satisfy consumers' unlimited wants. Economic costs are the opportunity costs incurred in production.

Creese, A. & Parker, D. (1994: 54) explained cost in view of economy is more than expenses for resources because some resources can be obtained with least or without cost such as donated medical supplies, volunteers, etc. If resources are used for one activity it may not be used in others such as the work of health volunteers.

Slothuus, U. (2000: 27-28) defines about measurement of cost in economics, the cost of an event is the highest valued opportunity necessarily forsaken. The usefulness of the concept of cost is a logical implication of choice among available options. Only if there were no scarcity of resources or no alternatives to choose between, would 'costs' and 'choice' be irrelevant. As a result, the value of an amount of available resources in a particular class of use is described by demand, in contrast to supply, which represents the value of the resources if they would have been used for other purposes.

Saweagnun, P. & Lakeuthai, P. (2001: 65-67) and Jacobs, P. & Rapoport, J. (2002: 382) defines economic costs that are equivalent to the combined value of resources used in an intervention.

Jacobs, P. & Rapoport, J. (2002: 382) mentioned economic cost that are subdivided into direct and lost productivity (also called indirect) costs. Direct costs are equivalent to the combined value of goods and services that are paid for. Indirect or

lost productivity costs are the costs of those services that embodied resources but were not paid.

2.2 Point of view

Pacharanamol, W., et al. (2001: 1-2); Pannarunothai, S. (2001: 67) and Kamolratanakul, P. (2000: 17) mentioned that to analyse the cost, it should be known what point of view we study, which divided into three group as follows:

2.2.1 Point of view of providers, i.e. service charges

2.2.2 Point of view of patients, i.e. all cost that the patient has to pay, including effects from the sickness

2.2.3 Point of view of society, which is the overall cost, such as environmental destruction and viewpoints of community towards public health services.

Providers' cost

1. Capital cost, i.e. land, buildings and material
2. Labour cost, i.e. salary, wages and overtime payment
3. Material cost, i.e. public utility and service material

Patients' cost

The patients' cost is from:

1. The cost in the form of money, i.e. vehicle expense, medical fee and food expense
2. The cost not in the form of money, i.e. journey expense

In summary in this study, the researcher scopes to analyse cost in view of provider that means all expenses occurred from orthodontic treatment with fixed appliance of both treatment methods.

2.3 Cost classification

Creese, A. & Parker, D. (1994: 5-9) mentioned about cost classification that to estimate a health programme's costs, classification of their components is necessary. Cost elements can be broken down in several ways, which will be illustrated below. A good classification scheme depends on the needs of the particular situation or problem, but three requisites apply:

- It must be relevant to the particular situation (of course);

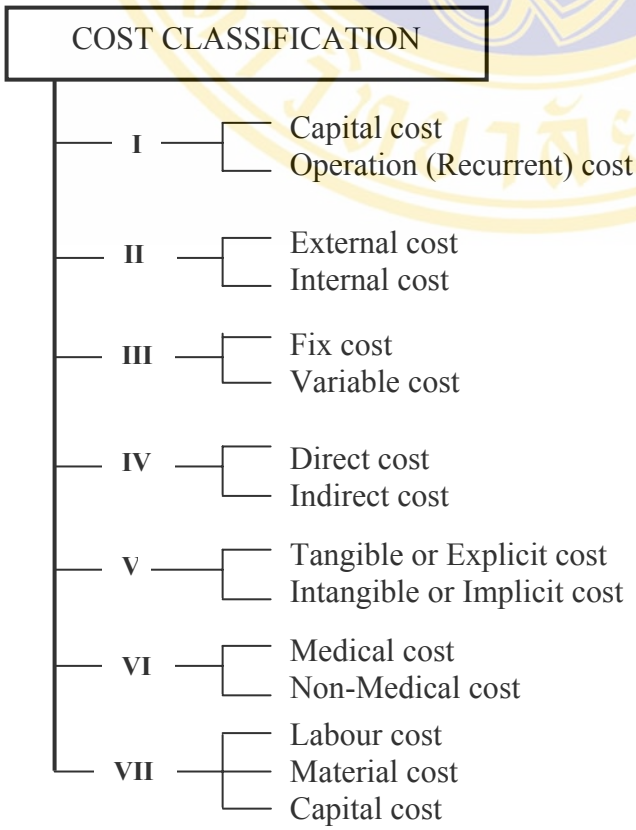
- The classes or categories must not overlap; and
- The classes chosen must cover all the possibilities.

McLean, R.A. (2003: 128) and Jacobs, P. & Rapoport, J. (2002: 103) explained costs that can be classified in several ways. First, costs are either direct or indirect. Direct costs are those incurred directly as a result of providing a specific good or service. Indirect costs are those that, although very real, cannot be tied directly to the patient's stay in the bed.

Drummond, M.F., et al. (1997: 52) summarised about the main categories of costs of health care programmes or treatments, these are the costs arising from the use of resources within the health sector, resource used by patients and their families, and resource used in other sectors. The particular range of costs included in a given study is likely to be decided upon as a result of considering.

Hanson, K. & Gilson, L. (1993: 21) mentioned about cost categories used vary from country to country, depending on the availability of resources and the structure of accounting systems.

Kamolratanakul, P. (2000: 22) described about cost classification depending objective and point of view evaluation are as follows:



Creese, A. & Parker, D. (1994: 5-9) summarised main type of cost-classification is by inputs. Inputs are considered as either recurrent items (those that are used up in the course of a year and are usually purchased regularly) and capital items (those that last longer than a year).

1. Classification of costs by input that is recommended for use in classifying costs by inputs is shown below.

1.1 Capital costs

1.1.1 Vehicles: Bicycles, motorcycles, four-wheel drive vehicles, trucks;

1.1.2 Equipment: Refrigerators, sterilizers, manufacturing machinery, scales, other equipment with unit cost (price) of $100 or more;

1.1.3 Buildings, space: Health centres, hospital, training schools, administrative offices, storage facilities;

1.1.4 Training, non-recurrent: Training activities for health personnel that occur only once or rarely.

1.2 Recurrent costs

1.2.1 Personnel (all types): Supervisors, health workers, administrators, technicians, consultants, casual labour;

1.2.2 Supplies: Drugs, vaccines, syringes, small equipment (unit cost of under $100);

1.2.3 Vehicles, operation & maintenance: Petrol, diesel, lubricants, tyres, spare parts, registration, insurance;

1.2.4 Building, operation & maintenance: Electricity, water, heating, fuel, telephone, telex, insurance, cleaning, painting, repairs of electricity, plumbing, roofing, and heating;

1.2.5 Training, recurrent (e.g. short, in-service courses);

1.2.6 Social mobilization, operation costs;

1.2.7 Other operating costs not included in above.

2. Other possible ways of classifying components are by:

- Function/activity;

- By organizational level (e.g. National, provincial, regional, district, community);

- By source of funds (e.g. national and local governments donors, non-governmental organizations, community groups, and individuals);

- By type of currency.

Hanson, K. & Gilson, L. (1993: 16) explained about capital and recurrent costs that the distinction between capital and recurrent costs is based on the expected life of the item. Items, which are used up during the course of the year, such as salaries and supplies, fall under the category of recurrent costs. Items, which are expected to last for more than one year (for example, buildings, vehicles and equipment) are generally viewed as capital costs and treated in a specific manner, and are excluded from this analysis.

Kaewsonthi, S. & Kamolratanakul, P. (1993: 140) classified that grouping and cost category can be made differently, up to the criteria.

The summary is as below:

1. Cost grouping by capital cost bearer.

1.1 Internal cost: This kind of cost occurs within the organization.

1.2 External cost: This kind of cost occurs outside the organization, such as cost in the community. This cost grouping is very important for public health planning and policy setting because it brings proper resource allocation.

2. Cost grouping by activity criteria.

2.1 Direct cost: This cost is the direct cost of the activity.

2.2 Indirect cost: This cost is not the direct cost of the activity, but it is the cost of additional activity. So, it is called indirect cost.

3. Cost grouping by expense criteria.

1.1 Explicit cost or tangible cost: This kind of cost is the paid expense of the activity.

1.2 Implicit cost: This kind of cost is the latent cost but it has to be calculated.

4. Cost grouping by medical criteria.

4.1 Medical cost: This cost is from direct medical services, such as allowance for staff, cost of vaccine, needles, syringes and others.

4.2 Non-medical cost: This cost is about supported medical services, such as fuel and vehicle expenses.

Kaewsonthi, S. & Kamolratanakul, P. (1993: 141-142) and McLean, R.A. (2003: 129) mentioned on economic cost analysis that cost by relations with product criteria, can be classified into three groups:

1. Fixed cost is the cost that is not changed through number of products (at least in a short term) such as cost for a building, lands and materials.

2. Semi fixed cost is the cost not related to number of products but can be changed following the number of products such as salary, wages.

3. Variable cost is the cost that all parts are related to amount of products such as cost for non-reusable materials e.g. cotton, chemical solutions, sides, etc.

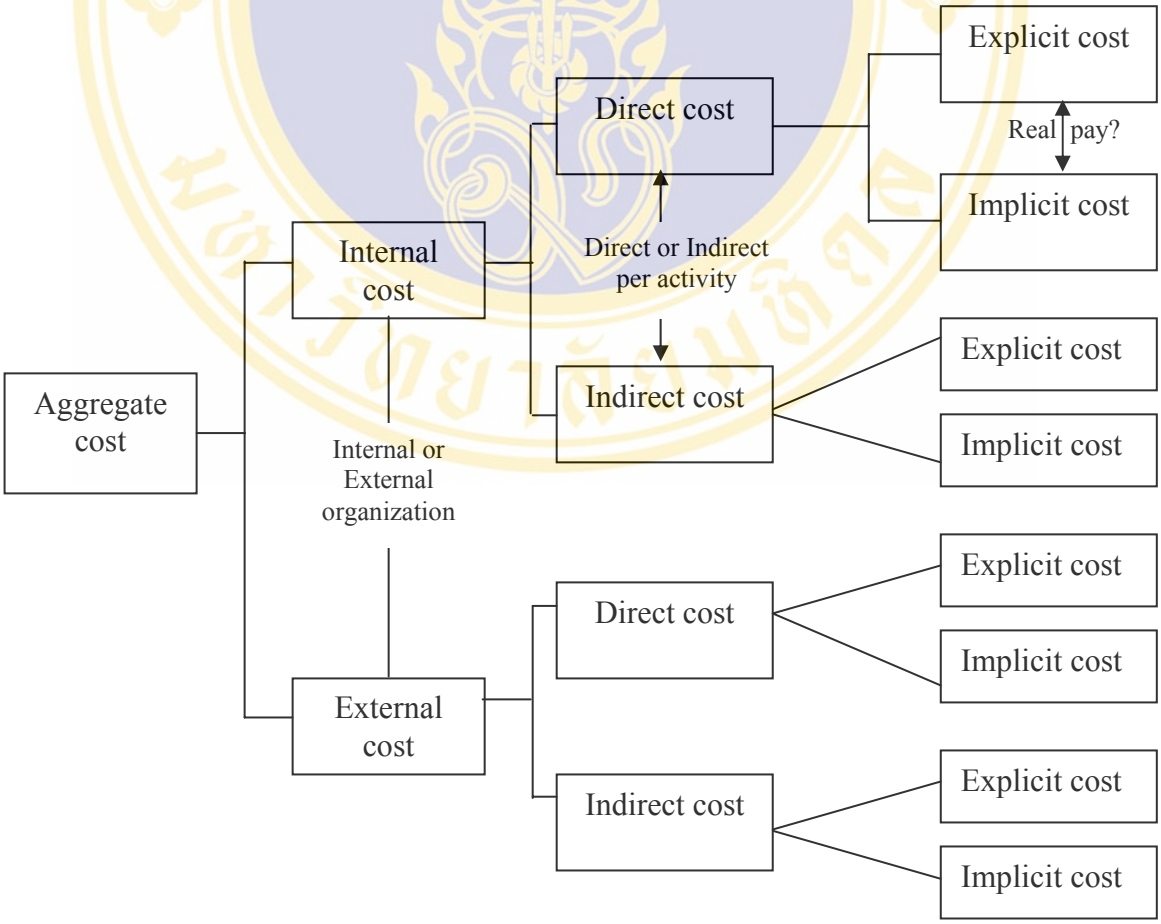


Diagram 1 Cost classification

Source: Kaewsonthi, S. & Kamlratanakul, P., 1993

Jacobs, P. & Rapoport, J. (2002: 103) and Amos, O.M. Jr. (1987: 394) mentioned that cost can be classified into two groups:

1. Fixed costs are defined as those that do not change with output within the relevant time frame. Variable costs, on the other hand, increase as output increases.

2. Variable costs are costs of variable inputs that the relation between the cost to the provider and the level of output. This relation depends on the quantities of resources used (determined by the production relationship) and the money paid for, or the opportunity cost imputed to, these resource services.

Cost classification in this study is classified by inputs are considered as a capital cost and recurrent cost.

2.3.1 Components of cost

2.3.1.1 Capital costs

Cresse, A. & Parker, D. (1994: 59-60) and Drummond, M.F., et al. (1997: 59) mentioned about capital costs that was the cost of resources used over a specific period, rather than at the time they are purchased. That is, the resources bought in one year and used for several years. A way of spreading out the cost over the study period is to divide the total capital cost by the number of years of the item's expected life, to give a kind of depreciation referred to as straight line depreciation. Cost of building space is probably better achieved by estimates based on the rental value. A module also suggested a cut-off value of $100 to distinguish equipment from supplies.

Cresse, A. & Parker, D. (1994: 31) summarised about buildings pose problems, because of the difference between original and replacement costs and the significance of inflation; their costs are often better estimated by their rental value.

Drummond, M.F., et al. (1997: 59) mentioned about capital costs that are representative and investment in an asset which is used over time. Most assets, such as equipment and buildings, wear out, or depreciate, with time various accounting procedures such as straight line, are available for use in the accounts of the organization.

Rayburn, L.G. (1993: 627) mentioned cost of capital that is a composite of the cost of various sources of funds from debt and equity that make up a firm's capital structure. It is a weighted average found by determining the costs of the individual types of capital and multiplying the cost of each by its proportion in the firm's total capital structure.

Some common useful life estimations for capital costs are as follows: (Tridech, P., 1994: 33) Buildings are 20 years, equipment 10 years, vehicles 5 years.

Creese, A. & Parker, D. (1994: 6) summarised capital costs as below:

- Vehicles: Bicycles, motorcycles, four-wheel drive vehicles, trucks;

- Equipment: Refrigerators, sterilizers, manufacturing machinery, scales, other equipment with unit cost (price) of $100 or more;

- Buildings, space: Health centres, hospital, training schools, administrative offices, storage facilities;

- Training, non-recurrent: Training activities for health personnel that occur only once or rarely.

Depreciation cost

Riwpiboon, A. (2001: 5); Kongsawat, S. (1995: 8); Pacharanamol, W., et al. (2001: 15) and Laping, P. (2004: 18) described capital cost that is depreciation cost means the building, the structure and articles have limit of work life so condition and value of them will decrease every year. There are many calculated method for depreciation cost but Public Health Organization suggested using Straight line method or average annual cost. The formula is as follows:

$$\text{Average annual cost} = \frac{\text{Cost of purchase}}{\text{Working life (years)}}$$

Hanson, K. & Gilson, L. (1993: 64-67) summarised that calculating the total cost of an activity will allow you to compare average total costs between facilities, and to further explore the ways in which costs are affected by the level of output in a facility. There are a number of methods commonly used to spread the cost of capital investment over its years of use (that is, to determine its annual cost). The most commonly used method (and the one we will use here) is "straight line

depreciation", in which the total cost is spread evenly over the life of the equipment by simply dividing the cost by the expected years of life and allocating this cost to the annual cost of the activities.

Annual cost = Total cost / Useful life.

The useful life of different types of inputs should be determinant on the basis of discussions with Ministry of Works, equipment and vehicle technicians, etc. There may be differences depending on where the input is used: for example, vehicles used in rural areas may last only 3 years, while in urban areas their useful life may be 5 years or more. Some common useful life estimations are as follows:

Buildings: 20-30 years
Furniture: 10 years
Equipment: 5-10 years
Vehicles: 3-5 years
Linen: 2 years
Calculate the area of each room: Area = length x width

Area should be multiplied by the construction cost per square meter (from the Ministry of Works or recent tenders). Total cost = area x cost/m^2

In this study capital cost is depreciation cost of buildings renovation, durable articles and consultancies:

1. All durable articles have 5 years and 8 years in dental durable articles useful life.
2. Buildings have 20 years useful life, that this study is taken construction include the capital cost because the Faculty of Dentistry includes construction into account of the capital cost.
3. Land is not taken into account of the capital cost because land had useful life more than 20 years. The formula is as follows:

$$\text{Average annual cost} = \frac{\text{Cost of purchase}}{\text{Useful life (years)}}$$

2.3.1.2 Recurrent costs

Creese, A. & Parker, D. (1994: 6) mentioned recurrent costs that are used up in the course of a year and are usually purchased regularly.

- Personnel (all types): Supervisors, health workers, administrators, technicians, consultants, casual labour;
- Supplies: Drugs, vaccines, syringes, small equipment (unit cost of under $100);
- Vehicles, operation & maintenance: Petrol, diesel, lubricants, tyres, spare parts, registration, insurance;
- Building, operation & maintenance: Electricity, water, heating, fuel, telephone, telex, insurance, cleaning, painting, repairs of electricity, plumbing, roofing, and heating;
- Training, recurrent (e.g. short, in-service courses);
- Social Mobilization, operation costs;
- Other operating costs not included in above.

In summary, recurrent cost is occurred cost to follow quantity of treatment activity which consists of labour cost and material cost.

2.3.1.2.1 Labour cost

Riwpiboon, A. (2001: 16); Kongsawat, S. (1995); Pacharanamol, W., et al. (2001: 8); Supachutikul, A. (1996: 30) and Laping, P. (2004: 18) explained that labour cost meant all benefits which the workers gained from their working place such as salaries, wages, overtime payment, training expenses, medical care cost of officer, rental house expense, child assistance payment, children education fee etc. After summarizing all labour costs, then one must consider about cost centre of each worker. If finding someone works more than one department so searching allocation method for allocate labour cost to those cost center and conclude each cost centre's labour cost.

Creese, A. & Parker, D. (1994: 33) summarised recurrent inputs, personnel that the component salaries and wages, along with other expenses for personnel, are frequently the single large costs item in health programmes. Care

should therefore be taken in estimating their value. In most cases you will be interested in both the staff directly involved in the activity you are concerned with (e.g., nurses, health aides, trainers, supervisors) and other supporting staff (e.g., management staff, cleaners, guards, drivers). Naturally, you will want to cover the costs only of the persons whose time in whole or in part is properly assigned for your programme.

Kongsawat, S. (1995: 10) described about the working record of the officials is not enough and there should be the analysis as below.

1. Time keeping: This kind of record is to keep the working record of the officials weekly or monthly.

2. The calculation and working hour analysis of the officials directly and indirectly should be done.

3. The wages for calculation should be the wages before tax calculation.

In this study, the labour cost means expenses paid for officers of orthodontic treatment activities with fixed appliance in form of hard cash such as salaries, wages, remuneration of high position, child education fee, treatment expense and training expenses.

2.3.1.2.2 Material cost

Pacharanamol, W., et al. (2001: 13); Supachutikul, A. (1996: 5); Budget office (2002: 6) and Laping, P. (2004: 7) described material cost that meant all kinds of consumed material that each cost unit drew from discharging section during the term of study (Major discharging section of hospital such as pharmacy and materials), including maintenance, repair and utilities expense. In accounting concept implies some durable articles having low cost (such as under 5,000 Baht) as material cost. Therefore, the analysis of cost shall be based on the principle used by hospital for accounting. Any how it should be careful not to be repeatable between material cost and capital cost; any costs considered as material cost will not be counted as depreciation cost although such materials have used for more than one year.

Riwpiboon, A. (2001: 16) divided material cost into two kinds as follows: the material which each cost centre purchased by themselves and the material defrayed from the releasing centre. Including maintenance expenses and out-sourcing for clean building etc.

Rayburn, L.G. (1993: 30) and Kongsawat, S. (1995: 8) defines direct materials cost as an appropriate base if there is a logical relationship between direct material usage and overhead cost. This occurs if each product involves the same material costs or if the same amount of material is applied per hour. Also, if many of the overhead costs result from material handling, direct material cost is a valid basis.

For this study, material cost means all kinds of material accessories used in orthodontic treatment activities with fixed appliance and used during treatment such as dental materials, office materials, public utility expense and maintenance expenses etc.

2.4 Type of cost measurement

Creese, A. & Parker, D. (1994: 53) explicates about unit cost that is sometimes called average cost, i.e. the calculation for average is by dividing total cost with quantity of products or services.

Summarily, unit cost or average cost means the average cost per product. The calculation formula is as follows.

$$\text{Unit cost} = \frac{\text{Full cost}}{\text{The number of service per activity}}$$

Hanson, K. & Gilson, L. (1993: 16) and Amos, O.M. Jr. (1987: 406) explained about average or “unit” costs of service is the total cost per unit of output. It is specified as:

$$\text{Average (or unit) cost} = \frac{\text{Total cost}}{\text{Quantity}}$$

This study assumes unit cost as the comparison of the quantity of resources that used for the output. When we get full cost of fixed orthodontic treatment, and then divide it by treated method of postgraduate, a cost per complete case will be obtained:

$$\text{Unit cost} = \frac{\text{Total cost}}{\text{Number of patients}}$$

Drummond, M.F., et al. (1997: 61) summarised definitions of cost as follows:

Total cost (TC) = cost of producing a particular quantity of output

Fixed cost (FC) = cost which does not vary with the quantity of output in the short run (about one year), e.g. rent, equipment lease payments, some wages and salaries. That is costs, which vary with time, rather than quantity

Variable cost (VC) = cost, which varies with the level or output, e.g. supplies, food, fees for service

Cost function (TC) = f(Q), total cost as a function of quantity

Average cost (AC) = TC/Q, the average cost per unit of output

Marginal cost (MC) = (TC of (x + 1) units) – (TC of x units)

= d(TC)/dQ evaluated at x

= The extra cost of producing one extra unit of output.

Deakin, E.B., et al. (1991: 471) and Hanson, K. & Gilson, L. (1993: 16) mentioned that the terms "full cost" or "full product cost" are used to describe a product's cost that includes both (1) the variable costs of producing and selling the product, and (2) a share of the organization's fixed cost. Sometimes decision makers use these full costs, mistakenly thinking they are variable costs.

Jacobs, P. & Rapoport, J. (2002: 104-106) and Amos, O.M. Jr. (1987: 404) mentioned about the total cost (TC) that is the sum of all costs incurred in producing a given level of output; total variable cost (TVC) is the total cost of variable inputs for any level of output; total fixed cost (TFC) is the total cost of all fixed factors. Total cost is the sum of the total variable cost and the total fixed cost.

The behaviour of the total variable cost depends on two factors: (1) the relation between output and (2) variable inputs.

Marginal cost is simply the addition to total variable cost needed to produce one extra unit of output. It is thus defined as $\Delta TC/\Delta Q$.

The average cost is the third way of looking at costs to average the costs required to obtain a given level of output. The average total cost (ATC) is the total cost per unit of output and is defined for any level of output. It equals TC/Q. It measures the value of the average resource commitment required to sustain a given scale of output. The behaviour of the average total cost depends on the behaviour of the average fixed cost (TFC/Q) and the average variable cost (TVC/Q).

Amos, O.M. Jr. (1987: 407) defines the marginal cost as the change in total cost resulting from a change in the quantity of output.

In summary, total cost is the sum of the total capital cost and the total recurrent cost for treatment with closing loop mechanics and sliding mechanics.

2.5 Step of cost analysis

Hanson, K. & Gilson, L. (1993: 16) summarised about general costing principles that there are five main steps to be followed in costing:

2.5.1 Identify the resources used to produce the services being costs;

2.5.2 Estimate the quantity of each input used;

2.5.3 Assign monetary values to each unit of input and calculate the total cost of the input;

2.5.4 Allocate the costs to activities in which they are used;

2.5.5 Use measures of service output to calculate average costs.

2.6 Adjust the value of money in different times in the value of year to analyse (Riwpiboon, A., 2001: 6). Steps to adjust value of money are as follows:

2.6.1 Adjust the value of money in the future is present in economic analysis that have adjusted the value of a money in the same time. By setting is the only one year such as to do study year. The formula is as follows:

$$PV = FC \times [1/(1+r)^n]$$

Where PV = Present value

FC = Future cost

r = discount rate or interest rate

n = the number of years into the future

Table of discount factor used formula is as follows:

PV = FC x DF(n,r).

Where DF(n,r) = Discount factor at discount rate of r % and n years

2.6.2 Adjust the value of money in the future is present that the cost analysis could not be found price or present value or to require year but have data of year into the future. By used price index or inflation rate is self to adjust that used formula as follow:

$P_i = P_{t-n}(1+i)^n$

Where P_t = price of place year t to require

P_{t-n} = price of place year t-n that have data

n = the number of years into the future

i = inflation rate

Amos, O.M. Jr. (1987: 288) explained about discount rate that is the interest rate charged by the Federal Reserve System to banks for borrowed funds. However, the discount rate is used as a signal of the Fed's intentions. If the Fed wants to send out word that it is going to decrease the money supply with the other tools, it will raise the discount rate. In principle, this is how the discount rate can be used to control the money supply.

2.7 Cost allocation

Amos, O.M. Jr. (1987: 5) defines that the allocation is the process of distributing resources for the production of the goods and services, and of distributing goods and services for consumer use.

Rayburn, L.G. (1993: 105); Laping, P. (2004: 21) and Pacharanamol, W., et al. (2001: 22) mentioned about cost allocation basis that the basis used to allocate indirect costs must bear a relationship to the kind of services a department gives.

Deakin, E.B., et al. (1991: 99-102) defines about a cost allocation that is proportional assignment of a cost to cost objects. Cost allocation is an important topic in both financial and managerial accounting. Few accounting topics have evoked as much literature and debate. No matter what career you choose, you will encounter the use of allocations. They maybe used to compute the performance measures by which you and your division are evaluated. The primary managerial reason for cost allocation was to remind responsibility centre managers that common costs exist and had to be recovered by division profits.

Hanson, K. & Gilson, L. (1993: 87) mentioned about allocated efficiency: concerns the allocation of resources. This can refer to the allocation of resources to health care as compared with investments in other economic sectors, or to different types of health service outputs.

McLean, R.A. (2003: 130-131) explained about cost allocation that is based on (1) an allocation method and (2) a set of allocation criteria. There are four cost allocation methods: direct, step-down, double distribution, and reciprocal.

1. The direct allocation method is the easiest to implement, but it ignores intermediate cost flows.

2. The step-down allocation method, although some what more difficult to implement, is an improved version of the direct allocation method by recognizing intermediate cost flows.

3. The double (or multiple) distribution method of cost allocation improves the step-down method by recognizing that resources flow in more than one direction.

4. The recognition that resources flow in many directions among responsibility centres is pushed to the limit in the application of the reciprocal cost allocation method.

Deakin, E.B., et al. (1991: 158) summarised service department costs that are allocated to production department to measure the cost of goods or services for decision making.

In the first stage of cost allocation, service department costs are allocated to user departments as follows:

One of three methods of allocating service department costs is selected:

1.1 Direct method

1.2 Step method

1.3 Simultaneous solution method

In the second stage of cost allocation, costs are allocated from production departments to units or jobs.

Drummond, M.F., et al. (1997: 64-65) summarised about the detailed consideration of costs is required, various methods for allocating shared (or overhead) costs are available, namely:

1. Direct allocation (ignores interaction of overhead departments). Each overhead cost (e.g. central administration, housekeeping) is allocated directly to final cost centres (e.g. programmes like day surgery; departments like wards or radiology). Therefore, a given ward's share of central administration would be equal to the total

cost of central administration, multiplied by the ward's share (or proportion) of the allocation basis (say, paid hours for staff). Note that the ward's share is its paid hours divided by total paid hours of all final cost centres, not total paid hours for the whole organization. The latter method would underestimate the costs in all final cost centres;

2. Step down allocation (partial adjustments for interaction of overhead departments). The overhead departments are allocated in a stepwise fashion to all of the remaining overhead departments and to the final cost centres;

3. Step down with iterations (full adjustment for interaction of overhead departments). The overhead departments are allocated in a stepwise fashion to all of the other overhead departments and to the final cost centres. The procedure is repeated number of times (about three) to eliminate residual unallocated amounts;

4. Simultaneous allocation (full adjustment of interaction of overhead departments). This method uses the same data as (2) or (3) but it solves a set of simultaneous linear equations to give the allocations. It gives the same answer as method (3) but involves less work. (The method is shown diagrammatically in Diagram 2.)

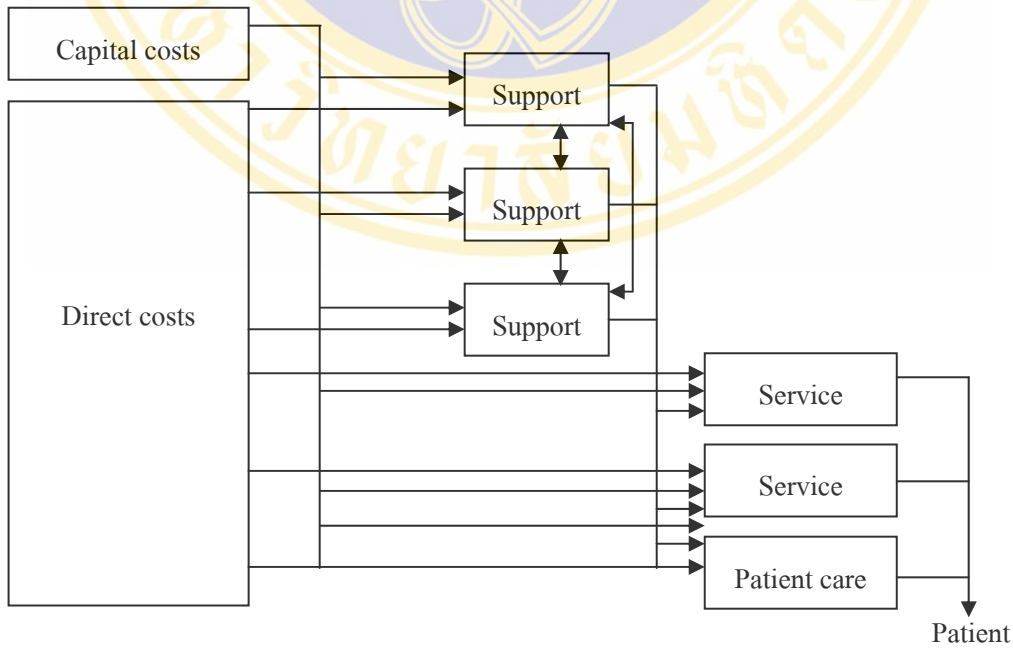


Diagram 2 Schematic illustrations of cost allocations

Source: Drummond, M. F., et al., 1997

In summary, this study will analyse cost of the Orthodontic Clinic. For cost allocation method direct distribution method will be performed and use proportion of time in cost allocation to each treatment method.

3. Effectiveness evaluation

Creese, A. & Parker, D. (2000: 41); Kaesonthi, S. (1991: 173) and Tridech, P. (1998: 38) define the effectiveness as a measure of the extent to which objectives are achieved. There are other kinds of effectiveness indicators, which measure intermediate changes instead of final outcomes.

Gold, M.R. (1996: 137) defines effectiveness as the simple definition that health services are considered to be effective to the extent that they achieve health improvements in real practice settings. Thus, effectiveness must be distinguished from two closely related concepts: efficacy, which denotes how well the intended objectives are realized in ideal settings often academic or research environments in which services or treatments are developed and initially tested, and appropriateness, which reflects a broader range of issues considered in deciding whether an intervention should or should not be done, including assessments of the extent to which the expected health benefit exceeds to expected negative consequences of the intervention, as well as considerations of acceptability, feasibility, and cost. One role of CEA is to provide guidance in the determination of the appropriateness of an intervention given what is known about its effectiveness and cost.

Jacobs, P. & Rapoport, J. (2002: 381) mentioned about concept of effectiveness is related to differences in outcomes between interventions under non-experimental conditions. Effectiveness must be determined from data collected from routine operations. Billing data, collected by insurers, provides information that can be used to determine effectiveness. Despite these problems in determining effectiveness, it is this measure of difference, not that of efficacy, that we seek in our cost-effectiveness model. This is because the cost-effectiveness model is used to inform policy or management decisions, both of which are carried out under actual conditions.

Graber, T.M. (1994: 18-19) explained about effectiveness of orthodontic treatment has received remarkably little study. This area now is becoming the subject

of investigation, stimulated by two factors from opposite points on the professional compass. Those who support orthodontic treatment financially through the various third party plans want proof that their funding is producing results. At the same time the professionals are bombarded by an increasing number of new technical approaches, and they are inclined to compare the effectiveness of radically different treatment approaches. Recently, the National Institute of Dental Research has funded studies on the effectiveness of orthodontic treatment with a special focus on the alternative approaches. Although the data for treatment effectiveness still are quite limited, it is comforting to orthodontists to know that when patients who have undergone orthodontic treatment are surveyed, the majority believe that they benefited from the treatment and are pleased with the results.

Mitchell, L. (1996: 5-6) summarised the effectiveness of treatment was decision to embark upon orthodontic treatment. Orthodontist must also consider the effectiveness of appliance therapy in correcting the malocclusion of the individual concerned. This has several aspects:

1. Are the tooth movements planned attainable? Tooth movement is only feasible within the constraints of the skeletal and growth patterns of the individual patient.

2. There is a wealth of evidence to show that orthodontic treatment is more likely to achieve a pleasing and successful result if fixed rather than removable appliances are used, and if the operator has had some postgraduate training in orthodontics.

3. Patient co-operation.

In summary, effectiveness is the evaluation of outcomes of orthodontic treatment comparing with goals of orthodontic treatment.

3.1 Measurement of effectiveness

Gold, M.R. (1996: 163) mentioned about the process of calculating the denominator for the C/E requires computation of the net effectiveness of the intervention where net effect is defined as the magnitude of the difference in outcome

between persons who are subjected to the intervention and persons experiencing the alternative(s) to which the intervention is being compared.

Finding valid measures of treatment success is important for both health care providers and health care consumers. Dental consumers are interested in value obtaining the best quality service at the lowest cost. Likewise, providers would like to know which treatments are most effective, i.e., have the best chance of success.

Although many aspects of orthodontics are not easily measured, several valid and reliable indexes have been developed to evaluate the alignment of the teeth before and after orthodontic treatment.

The American Board of Orthodontics has its goal to establish and maintain the highest standards of clinical excellence in orthodontics. Procedures to accomplish the goal consisted of:

1. Evaluates the knowledge and clinical competency of graduates of accredited orthodontic programs,

2. Re-evaluates clinical competency throughout a Diplomate's career through recertification,

3. Contributes to the development of quality graduate, postgraduate, and continuing education programs in orthodontics, and

4. Contributes to certification expertise throughout the world.

3.2 What will be the chosen measure of effectiveness?

Drummond, M.F., et al. (1997: 97-98) have suggested that in order to carry out a C/E analysis, there are some rules of thumb, as follows:

1. Always take time to clarify the objectives of the programme or treatment;

2. If one major dimension for the measurement of "success" is apparent, perform a C/E analysis based on this dimension; and

3. Be on to lookout for other attributes of the alternatives being assessed, even if the medical research design does not consider these formally. Where possible, record the effectiveness of the alternatives as judged on these extra dimensions and be prepared to mount ad hoc surveys to obtain more information.

4. Keep open the possibility of employing more sophisticated forms of analysis if it turns out that there is more than one appropriate dimension for judging effectiveness. Alternatively it might be necessary only to present an array of the differential achievement, of alternative programmes. These can then be given to the decision maker, at the programmatic or clinical level, so that he can make his own trade-off between effects.

Creese, A. & Parker, D. (1994: 64) says about effectiveness in general though, one should choose an effectiveness measure relating to a final output.

C/E analysis included a comparison of costs and outcomes. Using this form of analysis the outcomes of alternatives are measured in units such as cases successfully treated. These outcomes are then related to the direct costs of the procedure by calculating C/E ratios, or cost per unit of effectiveness, such as cost per life year gained.

3.3 Tools of effectiveness measurement

The ABO Objective Grading System (ABO index) scores was designed to evaluate finished dental casts and panoramic radiographs to determine whether the finished case met the ABO's standards for alignment of teeth.

Casko, J.S., et al. (1998: 599) summarised that to evaluate treatment results, the American Board of Orthodontics spent countless hours to develop this system for assessing the occlusal and radiographic results of orthodontic treatment. The usefulness of this system depends not only on its objectivity, but more importantly on the validity and reliability of the measurements. After repeated comparison of both objective and subjective systems, the Directors are confident that the "cut-off" score to pass this portion of the phase III examination is valid. Reliability will be insured through the use of a precise measuring instrument (shown in Fig. 3).

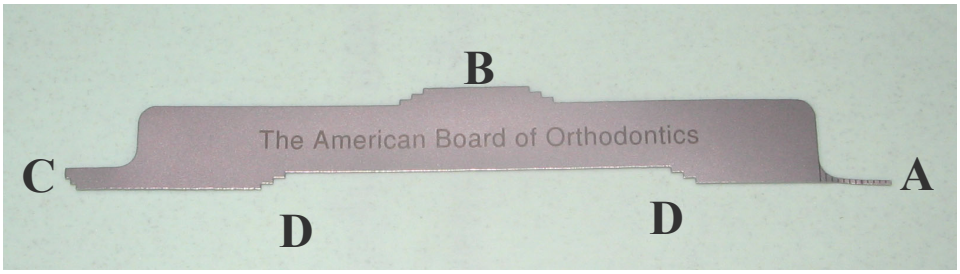


Figure 3 ABO measuring gauge. A, 1 mm in width and measures discrepancies in alignment, overjet, occlusal contact, interproximal contact, and occlusal relationships; B, steps measure 1 mm. in height and are used to determine discrepancies in mandibular posterior buccolingual inclination; C, steps measure 1 mm. in height and are used to determine discrepancies in marginal ridges; D, steps measure 1 mm. in height and are used to determine discrepancies in maxillary posterior buccolingual inclination.

This study used the criteria of ABO to measure treatment result. ABO index is a tool to assess the adequacy of their finished orthodontic results, the Board has established an Objective Grading System to evaluate the final dental casts and panoramic radiographs (Detail in Appendix).

3.4 Criteria of effectiveness measurements

The ABO Objective Grading System (ABO index) for scoring dental casts and panoramic radiographs contains eight criteria: alignment, marginal ridges, buccolingual inclination, occlusal relationships, occlusal contacts, overjet, interproximal contacts, and root angulation. For scoring the dental casts and panoramic radiographs based on of ABO (2004) was established. In general, a case report that loses more than 30 points will fail and a case loses less than 20 points will pass.

3.5 General data

General data of effective treatment is consisted of gender, age, malocclusion before treatment, timing of treatment and co-operation that the researcher taken to analyse for consideration with effectiveness.

Isaacson K.G., et al. (1984: 13-16) and Williams J.K., et al. (1995: 135) set co-operation level of patient into 3 levels which are excellent, good and poor.

For this study co-operation is set into 3 levels, namely good, fair and poor that would be ideal of orthodontists.

Since malocclusion has differences in severity, discrepancy index, (DI) was introduced to measure the severity level for malocclusion evaluated before treatment.

The DI included cephalometric values, such as ANB and mandibular plane angles. The DI was used to evaluate the difficulty of the malocclusion relative to treatment outcomes. By using ABO measuring gauge (Fig. 1), the DI can be calculated.

There are 10 variables for DI measurement which are overjet, overbite, anterior openbite, lateral openbite, crowding, occlusion, lingual posterior x-bite, buccal posterior x-bite, cephalometrics: ANB, SN-MP, IMPA and, other: missing or supernumerary teeth, ectopic eruption, etc. (Detail in Appendix)

Below are score of severity level. (Cangialosi, T. J., et al., 2004)

	DI scores
Easy	< 10
Mild	11-15
Moderate	16-20
Difficult	21-25
Very difficult	> 26

This study assessed orthodontic treatment outcomes by using criteria and tool of ABO which are DI and ABOI to dental casts and paronamic radiographs before and after treatment.

4. Orthodontic theory

Mitchell L. (1996: 1); Houston, W.J.B. (1992: 1) and Moyers R.E. (1988: 3) defines orthodontics as the branch of dentistry concerned with facial growth, with development of the dentition and occlusion, and with the diagnosis, interception, and treatment of occlusal anomalies.

4.1 Goals of orthodontic treatment

Isaacson, K.G., et al. (1984: 4) and Williams, J.K. (1995: 2) summarised the aims of orthodontic treatment as follows:

- Relief of crowding;
- Correction of the rotational and apical displacement of teeth;
- Correction of the interincisal relationship;

- Establishment of a satisfactory buccal intercuspation;
- A pleasing facial appearance;
- A stable end result.

Houston, W.J.B., et al. (1992: 141) and Davies S.J., et al. (2001: 539) stated that the aim of treatment is to produce an occlusion that is stable, functionally adequate and aesthetically satisfactory.

Proffit, W.R., et al. (1993: 3) and Petchkup V. (1990: 81) stated that an important goal of orthodontic treatment is to enhance facial aesthetics and achieve better stability of the occlusion relationships.

Graber T.M., et al. (1994: 345) suggested that the primary objective of the Charles H. Tweed International Foundation for Orthodontic Research today is the spatial positioning of the dentition within the oral environment to obtain maximum health, aesthetics, function and stability. Specifically it is excellent in tooth alignment, arch form, and axial inclination of the teeth, with optimal occlusal intercuspation of the maxillary and mandibular dentitions through the use of one of the most precise instruments for the correction of malocclusions that exist in the world today.

For this study, the researcher defines goals of orthodontic treatment as good occlusion and efficient function.

4.2 Malocclusion

Millett, D., et al. (2000: 5) and Houston, W.J.B., et al. (1992: 5) defines malocclusion as an unacceptable deviation aesthetically and/or functionally from the ‘ideal’ occlusion. (Klineberg, I. & Jagger, R., 2004: 93) Malocclusion may be of dental or skeletal origin, or both. Deviations could occur in all the dimensions, that is, anteroposterior, vertical or transverse, in isolation or in combinations of varying severity. (Millett, D., et al., 2000: 5 and Proffit, W.R., et al., 1993: 8).

4.2.1 Classification of malocclusion

Ireland, A.J. & McDonald, F. (2003: 32-34) Millett, D. and Welbury R. (2000: 5); Shaw, W.C. (1993: 156-159); Thurow, R.C. (1982: 113); Proffit, W.R., et al. (1993: 3); Salzmann, J.A. (1974: 53-65) and Ireland, A.J. & McDonald, F. (2003:

35) and Darendeliler, A. & Kharbanda, O. (2004: 93-94) classified malocclusion based on molar relationships into three classes, using Roman numerals (I, II, III) to denote the classes and Arabic numerals (1,2) to denote divisions. A malocclusion that exists unilaterally is termed a subdivision. Using the maxillary first molar as a reference, the classification is: normal, distal lower arch (class II), or mesial lower arch (class III) relationship. Figure 4 illustrates dental classes I, II and III.

1. Class I malocclusion exists when maxillary and mandibular first molar teeth have a normal cusp to fossa relationship, but there may be deviations in the arrangement of teeth, inta-arch, interarch or both. The common features of class I malocclusions include:

- maxillary protrusion
- crowding/spacing
- anterior/posterior crossbites
- deep/open bite
- midline shift
- combinations of the above.

2. Class II malocclusion the lower first molar is distal to its normal relationship with the maxillary first molar; the mesiobuccal cusp of the maxillary first molar falls mesial to the buccal groove of the mandibular first molar. The usual features of such malocclusions are:

- distal positioning of lower canines (class II canine)
- maxillary protrusion
- deep bite
- inter and/or intra-arch deviations in teeth.

Class II malocclusions associated with proclined maxillary incisors are called division 1 or with retroclined maxillary incisors division 2.

3. Class III malocclusion exists when the lower arch (mandibular first molar) is mesial to its normal relationship with the maxillary first molar, that is, the mesiobuccal cusp of the maxillary first molar falls distal to the buccal groove of the lower first molar.

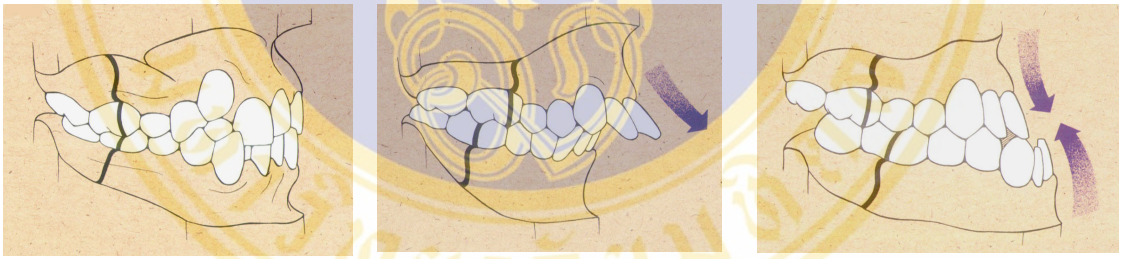
The advent of cephalometrics allowed study of the morphology of the cranium, face and jaws, which provided a better understanding of the skeletal and

dental components of malocclusion. The allowed classification of skeletal jaw relationships include:

1. Skeletal class I: Orthognathic or normal; maxillary and mandibular skeletal bases are in a normal anteroposterior relationship. Skeletal class I jaw relationship does not necessitate a dental class I relationship.

2. Skeletal class II: Distal jaw relationship exhibits an anteroposterior discrepancy between the maxillary and mandibular bases. A skeletal class II relationship could arise from a smaller mandible or an anteriorly placed (or larger) maxilla, or a combination of both.

3. Skeletal class III: Mesial jaw relationship exists when the mandibular skeletal base is mesial to the maxillary base in an anteroposterior relationship. Such a relationship could arise when there is a normal maxilla and a large mandible or as a pseudo-class III with a small maxilla and a normal-sized mandible. A varying combination of maxillary deficiency and mandibular prognathism also occurs.



Class I Class II Class III

Figure 4 Molar classification
Source: Moyers, R.E., 1988

Silva, R.G., et al. (2001) studies the prevalence of malocclusion among Latino adolescents in the United States between the ages of 12 and 18 years. They found more than 93% have malocclusion from 507 populations.

In summary, malocclusion is considered based on the molar relationships, which are divided into three classes - class I, II and III. This study will investigate only class I malocclusion, the maxillary and mandibular first molar teeth have a normal

cusp to fossa relationship, but there may be deviations in the arrangement of teeth intra arch, inter arch or both.

4.2.2 Good occlusion

Carlsson, M.Z. & Rugh (1988: 15) defines good occlusion as the act of closure or state of being closed and relative to dentistry, the relation of the maxillary and mandibular teeth when in functional contact during activity of the mandible.

Moyers, R.E. (1988: 13) opined that functional is normal for most biologic forms to establish effective homeostasis with the environment in order to adapt and survive.

Houston, W.J.B., et al. (1992: 7) mentioned about functional criteria that orthodontic treatment has often been recommended on the grounds that malocclusion may be detrimental to dental health. Three aspects of oral disease have to be considered: caries and periodontal disease; traumatic occlusion; and craniomandibular disorders.

ABO (2004: 14) described about evaluation of the orthodontic treatment results presented on the attainment of the following orthodontic treatment objectives:

1. Treatment complementing facial growth,
2. Facial harmony balance and harmony of the soft tissue and proper proportion of facial structures,
3. Maximum aesthetics of the teeth and face,
4. Dental health maximum health of the teeth, the supporting tissues and the adjacent structures,
5. Optimal function, free of interference's and trauma,
6. Excellent occlusion,
7. Favourable intercuspation of the teeth,
8. Alignment of permanent second molars,
9. Favourable overjet and overbite relationship,
10. Favourable correction of rotations of all teeth,
11. Favourable axial inclination of all teeth,
12. Complete space closure,

13.Coordinated ideal arch form with all the teeth aligned within their supporting structures,

14.Good vertical control,

15.Good stability.

Andrews, L.F. (1972: 296-309) pointed out that it is the inclination of the crown not of the long axis that is important, and summarised the requirements of an ideal occlusion as 'six keys' which should also be treatment objectives:

Key I. Molar relationship: The distal surface of the disto-buccal cusp of the upper first permanent molar occludes with the mesial surface of the mesio-buccal cusp of the lower second permanent molar.

Key II. Crown angulation (mesio-distal tip): The gingival portion of each crown is distal to the incisal portion and varied with each tooth type.

Key III. Crown inclination (labio-lingual, bucco-lingual): Anterior teeth (incisors) are at a sufficient angulation to constant and similar from 3-5 and increased in the molars. Lower posterior teeth, lingual tip increases progressively from the canines to the molar.

Key IV. No rotations.

Key V. No spaces.

Key VI. Flat occlusal planes.

4.3 Orthodontic treatment

Salzmann, J.A. (1974: 145) and Renfroe, E.W. (1975: 229) divides type of orthodontic treatment as follows:

1. Preventive orthodontics.
2. Interceptive orthodontics.
3. Corrective early and late.
4. Posttreatment maintenance or retention.
5. Dentofacial orthopedics.

Houston, W.J.B., et al. (1992: 160) and Isaacson, K.G., et al. (1984: 1) cited factors which determine the nature of achieved tooth movement. One of these factors is the type of appliance used.

Removable appliances produce tooth movement essentially by tipping the teeth. In order to produce rotational, bodily and apical movement efficiently, fixed appliances are required. A basic difference between the possibilities of tooth movement offered by removable and fixed appliances is thus immediately obvious.

A large number of fixed appliance techniques are available, and the type of mechanism used will in part determine the nature of the tooth movement achieved.

4.4 Orthodontic appliances

Foster, T.D. (1990: 231) categorized orthodontic appliances into two broad categories.

1. Passive appliances, which maintain the position of the teeth. These are commonly used for space maintenance after extractions or for the maintenance of tooth position after active tooth movement.

2. Active appliances, which bring about movement of the teeth. These may either incorporate active forces within the appliance, or transmit forces from another source, usually the muscles of mastication or the circumoral musculature.

Appliances may be fixed to teeth or may be removable by the patient, or may contain a combination of fixed and removable components.

All appliances should be comfortable to wear and readily acceptable by the patient. They should be well tolerated by the oral tissues, and should be sufficiently robust to stand up to the stresses of oral function. They should also be readily cleanable by the patient so that they do not constitute a hazard to oral health. They should be capable of being firmly positioned in the mouth, with no tendency to be inadvertently dislodged, a quality usually known as retention or fixation.

4.4.1 Fixed appliances

Houston, W.J.B. (1992: 302); Millett, D. & Welbury, R. (2000: 63); Mitchell L. (1996: 174) and Renfroe, E.W. (1975: 3) mentioned that the orthodontic appliance is an instrument used to move teeth as necessity demands. However, it is

only by complete mastery over its potentialities by the operator that the appliance can attain the desired result. To control these taxes the ability of the specialist to the utmost.

Isaacson, K.G. & Williams, J.K. (1986: 5) explained about fixed appliances that are commonly used to provide tipping movements, but their advantage over removable appliances is that by applying a force couple to the crown of the tooth, controlled apical movement is possible.

4.4.2 Appliance components

Salzmann, J.A. (1974: 410); Mitchell, L. (1996: 176); Foster, T.D. (1990: 261) and Isaacson, K.G. & Williams, J.K. (1984: 17) described about component of fixed orthodontic appliances that consisted of three basic components: bands, brackets and archwires. Bands serve the primary function, providing the means of attachment of brackets to the crowns. Brackets are designed for attachment of archwires and for the transmission of forces from archwires through bands to the teeth and their supporting structures. Bands and brackets can be considered passive in the sense that no tooth moving forces are stored in them or generated by them. Archwires, on the other hand, are the active components of the fixed appliance system.

4.4.3 Types of fixed appliances

Foster, T.D. (1990: 261) explained about any orthodontic appliance which is fixed to the teeth comes under the general description of ‘fixed appliance’. There are, however, many different fixed appliance systems in use, which vary considerably in their methods of achieving tooth movement and in the details of their component parts. Certain principles of treatment run through these various systems, and these a review of few of the types of appliance available.

Isaacson, K.G., et al. (1984: 158-163) explained about types of specific fixed appliance techniques. A brief description of the main techniques, covering their principal features, is included here so that the reader can be aware of complex techniques in use at the present time divided as follows:

- Edgewise techniques.
- Tweed technique.

- Light-wire techniques.
- Begg. technique.
- Combination techniques.

4.4.4 Edgewise techniques

Moyers, R.E. (1988: 521); Thurow, R.C. (1982: 146) and Renfroe, E.W. (1975: 138) explained about the edgewise mechanism which was the last and most advanced of the several appliances invented by Dr. Edward H. Angle. It is a multibanded precision appliance consisting of a rectangular labial archwire fitted and ligated into horizontal slots in brackets and terminating in rectangular tubes on the second molar bands. The archwire originally was 0.022x0.028 inch, with the narrow (0.022 inch) dimension laying against the facial surfaces of the teeth hence its name. Control in all directions is possible, and all individual teeth may be moved simultaneously in three directions.

Millett, D. & Welbury, R. (2000: 67) used an individual bracket with a rectangular slot for each tooth to give it 'average' inclination and angulation and to allow placement of flat archwires. Bracket prescriptions described by Andrews and Roth are available. Orthodontic treatment with fixed appliances has two techniques: Sliding mechanics and Closing loops.

Proffit, R.W., et al. (1993: 344) mentioned about the contemporary edgewise, the modern appliance. The contemporary edgewise appliance has evolved for beyond the original design while retaining the basic principle of a rectangular wire in a rectangular slot.

4.4.4.1 Closing loop mechanics

Renfroe, E.W. (1975: 146-147) defined the closed loop is one in which the sides of the loop are close together. Obviously, it can only be activated by pulling them apart. It is a very efficient tension force when used in arch shortening mechanics. Closed loops are used singly and in multiples. The closed loop is constructed in the same manner as the open loop except that its sides nearly approximate. As before, the arch wire between the sides of the loop is severed, and its length is limited the same as the open loop's.

Bennett, J.C. & McLaughlin, R.P. (1993: 74) agreed that about orthodontist normally used ‘closing loops arches’ which were activated in the office by opening the closing loops and moving the archwire through the posterior bracket slots (Fig. 5). For the first time in orthodontics, because of the level bracket slot alignment provided by the new appliances, archwires could be more effectively moved through the posterior bracket slots when the patient was out of the office.

Isaacson, K.G. & Williams, J.K. (1984: 127) mentioned that a rectangular archwire with closing loops distal to the lateral incisors can be used to reduce an overjet and will control the incisor apical position. The mechanics of a closing loops archwire are such that the amount of palatal root torque that is applied to the incisors is at its maximum when the loops have just been activated, but as the loops close the torque is reduced. This, unfortunately, limits the amount of torque that can be applied.

Figure 5 Closing loops arches

Bennett, J.C., et al. (1993: 75) summarised the advantages and disadvantage of closing loops arches with the standard edgewise appliance as follows:

Advantages:

- Precise control of the amount of loop activation (frequently closing loops were activated minimally [1 mm] which limited the amount of tipping that initially occurred).

- Adequate ‘rebound time’ for tooth uprighting (since activation was minimal and the closing loops closed rather quickly with minimal tooth tipping, there was ample time between visits for tooth uprighting and maintenance of arch levelling).

Disadvantage:

- Extra wire bending time.

- Poor sliding mechanics (the closing loops required activation in the office by the orthodontist).

- Tendency to run out of space for activation (after two or three activations the omega loop made contact with the molar bracket and the archwire needed to be adjusted or remade).

- High initial force levels.

4.4.4.2 Sliding mechanics

Bennett, J.C. & McLaughlin, R.P. (1993: 74) suggested that a rectangular archwire which is not engaged in brackets in the buccal segments and is free to slide through buccal tubes on the molars can be used to reduce an overjet bodily. A combination of extra-oral anchorage applied by J hooks to the anterior part of the archwire, and intramaxillary elastic traction would provide the retraction force. If necessary, the amount of torque could be increased as the overjet is reduced.

Isaacson, K.G. & Williams, J.K. (1984: 127) stated that many orthodontists began using various forms of 'sliding mechanics' to close spaces. For example, hooks were frequently placed in the anterior section of 'straight' archwires and elastic or spring forces were tied to these hooks from on the molar brackets (Fig. 6).

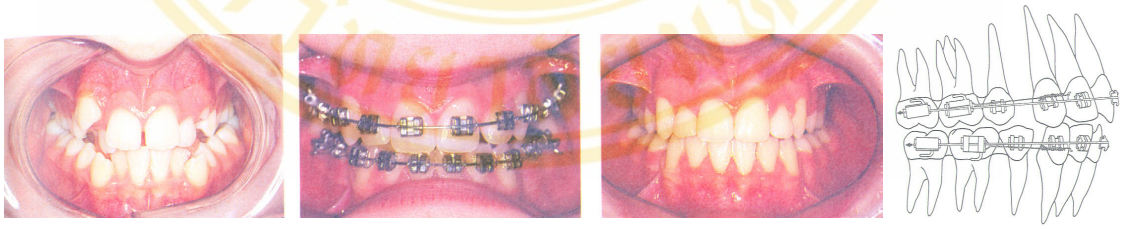


Figure 6 Sliding mechanics

Bennett, J.C., et al. (1993: 75) summarised the advantages and disadvantage of sliding mechanics with 'straight' archwires and preadjusted appliances as follows:

Advantages:

- Minimal wire bending time.

- More efficient sliding of archwires through posterior bracket slots.

- No running out of space for activation.

Disadvantages:

- Confusion concerning ideal force levels (since this was a new and untested system, there were no established guidelines concerning the amount of force to be used during space closure).

- Tendency to over activate elastic and spring forces, which caused initial tipping and then inadequate rebound time for tooth uprighting (elastic and spring forces, while dissipating after initial activation, continued to create a tipping effect and did not allow for needed tooth uprighting).

4.5 Background information

Foster, T.D. (1990: 202) mentioned about background information that it is necessary to have a certain amount of information about the patient. Orthodontic treatment cannot be considered in isolation, but must be part of the overall dental care programme. It is necessary to have information on the patient's age and awareness of the problem, any previous dental treatment and attitudes to treatment, and the medical history and state of health. Details of the oral health condition, dietary and oral hygiene habits are also important. If the patient is a child, it is also necessary to ascertain the parents' awareness and attitude to treatment.

All this information has its value. The age of the patient is important in relating general and dental development to chronological age, and in determining growth rate and stage of maturity. It may be important in choosing the best time for treatment. Previous treatment, oral health, attitudes and awareness are all important, though adverse findings in these respects need not contra-indicate orthodontic treatment. Oral health can be improved and attitudes changed, if it is felt necessary. The practicability of doing so must be considered when deciding on orthodontic treatment.

4.5.1 Gender

Shaw, W.C. (1993: 147) mentioned about gender that it has consistently been found that more girls than boys receive orthodontic treatment, though the prevalence of malocclusion within the sexes is the same. This is undoubtedly a

reflection of so-called sex role stereotyping wherein society places greater emphasis on maximizing attractiveness in the female. Parents will commonly indicate that their daughter's malocclusion would not have concerned them had it occurred in their son. (Moyers, R.E., 1988: 117) Sex differences are excepted for third molars, girls erupt their permanent teeth an average of approximately 5 months earlier than boys. The true sex difference in timing of intra-oral emergence is much less than the sex difference in the timing of appearance of most postnatal ossification centres, and the variability of normal eruption timing is small when compared with the normal variability in skeletal development.

4.5.2 Age

Bennett, J.C., et al. (1997: 354) mentioned about age that the development may begin as early as 5 years or as late as 16 years, with the peak formation period at 8 to 9 years. Calcification can start at age 7 years in some children and as late as age 16 years in others. Enamel formation is normally complete between 12 and 18 years, and root formation if normally completed between 18 and 25 years.

4.5.2.1 Age and tooth movement

Shaw, W.C., (1993: 129-130) mentioned the periodontal membrane of the child is richer in cells and generally more quickly responsive to new demands, such as the application of orthodontic force, than that of the adult. It has been shown that the natural closure of spaces after extractions occurs most readily in the younger patient, with a diminishing rate after 12 years of age (or a little later in boys). There is also no doubt that orthodontic tooth movement is more effectively and rapidly carried out at the time of tooth eruption and alveolar bone growth.

4.5.2.2 Age and facial growth

Shaw, W.C., (1993: 129-130) mentioned skeletal class I malocclusions may be treated at almost any age, though all will respond to treatment most rapidly and effectively at the time of the pubertal growth spurt. The pubertal growth spurt for girls has a mean peak velocity at 12 years of age with an average onset at 10 and completion at 14 years of age, though it may begin as early as 9 and

end as late as 15 years of age. Peak growth velocity occurs at 14 years in boys, beginning as early as 10 or even as late as 16 years of age and finishing anywhere from 13 to 17 years of age.

4.5.3 The timing of orthodontic treatment

Williams, J.K. (1995: 130) and Nanda, R. (1997: 1) summarised about treatment duration that the orthodontic treatment usually takes two years to complete.

Moyers, R.E. (1988: 16) mentioned about treatment duration that there are sex-related differences in the timing of many growth phenomena. Usually, girls precede boys.

4.5.4 Co-operation

Williams, J.K., et al. (1995: 37) summarised about co-operation that a high standard of oral hygiene must be demonstrated before commencing any form of orthodontic treatment particularly when fixed appliances are to be used. However, there are situations where, because of the malocclusion, a young patient may find it difficult to clean crowded teeth. Patients should be warned of the dangers and problems that may arise if fixed appliances are fitted and a high standard of oral hygiene is not sustained.

Isaacson, K.G., et al. (1984: 14) and Foster, T.D. (1990: 205) mentioned that the full co-operation of the patient is essential for successful orthodontic treatment, and the degree of co-operation likely to be achieved must be taken into account in deciding on treatment objectives throughout treatment.

Cadman, K.C., et al. (2002) studied on orthodontic treatment outcome in a First Nations population in Alberta, Canada: A comparative study. The group of patients between the 11 and 18 years of age which tests indicated statistically significant differences in the number of missed appointments ($P < 0.01$) and the number of comments on poor oral hygiene ($P < 0.02$) between two groups. Patient co-operation is likely to be more critical to successful treatment outcome in extraction.

Welbury, R.R. (2001: 305) and Isaacson, K.G., et al. (1984: 13) mentioned that an excellent standard of oral hygiene must be maintained throughout treatment. If oral hygiene is poor during the period of appliance wear, the possibility of

decalcification and caries is greatly increased and periodontal problems made more severe.

4.6 Orthodontic treatment stages

Bennett, J.C. & McLaughlin, R.P. (1993: 65) summarised about orthodontic treatment stages that the mechanical treatment of most orthodontic cases can be divided into the following six stages:

1. Anchorage control
2. Leveling and aligning
3. Overbite control
4. Overjet reduction
5. Space closure
6. Finishing

Steps of fixed orthodontic treatment are shown in diagram 3.

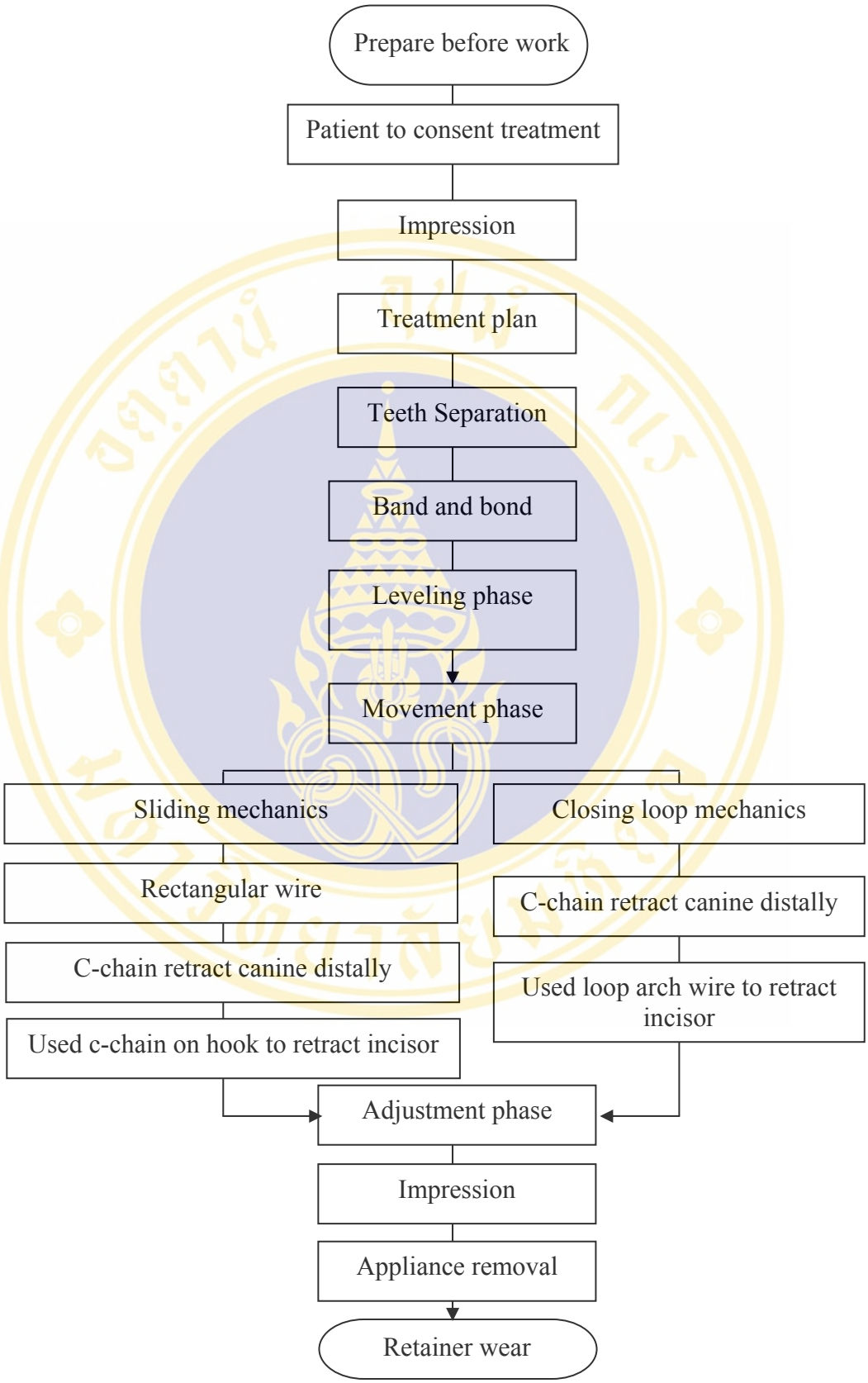


Diagram 3 Steps of fixed orthodontic treatment

Source: Orthodontic Clinic, 2005

5. Relevant researches

Studies about cost-effectiveness of orthodontic treatment popular are as follows:

Table 1 Relevant researches

No.	Years	Details of relevant researches
		Foreign Researches
1	1990	**Researcher:** Tang, E.L.K. & Wei, S.H.Y. **Topic:** Assessing treatment effectiveness of removable and fixed orthodontic appliances with the occlusal index. **Methodology:** This study randomly chosen and studied from patients who had completed orthodontic treatment by studying the study models. The sample included cases of patients who had been treated with removable and fixed appliances. Patients in the removable-appliance group were treated by undergraduate dental students and fixed-appliance group were consecutive patients of two postgraduate students in orthodontics that both appliances lived under staff supervision. The pre- and post-treatment study casts were scored by one examiner according to the Occlusal Index. The distribution of the sample, by sex and by appliance. **Results:** The average pre- and post-treatment OI scores, and the average reduction in OI scores for patients treated with Begg and Edgewise appliances are 1.79 and 1.55 consecutively in post-treatment. The average duration of treatment for patients in the removable-appliance group was 13.4 $\pm$ 10.3 months; for patients in the fixed-appliance group it was 20.2 $\pm$ 4.5 months.

Table 1 Relevant researches (cont.)

No.	Years	Details of relevant researches
2	1994	**Researcher:** Follin, M.E. & Milleding, A. **Topic:** Quad-helix treatment in general practice: A retrospective study of failures of appliance and estimation of costs. **Methodology:** Studied the treatment effects with the quad-helix appliance seldom remark upon problems and/or failures of the appliances or gave account for treatment costs. The present retrospective study was to estimate the costs of quad-helix treatments performed by General Practitioners, within the Public Dental Service, and to assess possible complications with the quad-helix appliance. **Results:** The mean quad-helix treatment cost was 2900 SEK (range 1298-6534). At the time of the study (1991) 10 SEK was equivalent to approximately £1 sterling. Fifty-nine per cent of the patients had at least one failure of the appliance, on average 2.5 numbers of times (range 1-11). Forty-six per cent of the patients had a minimum of on loose band.
3	1998	**Researcher:** Pietilä, T., et al. **Topic:** Cost and productivity analysis of orthodontic care in Finland. **Methodology:** Cross-sectional study that a retrospective questionnaire was considered feasible, although it led to partial estimation of the data. This study was to evaluate the costs of orthodontic services in Finnish municipal health centres in 1992, to describe and explain the variation in the costs among health centres by the main features of care, and to estimate the optimal size of an orthodontic unit. The data were gathered by a questionnaire sent to all health centers. They were asked to fill in the questionnaire together with the orthodontist or dentist chiefly responsible for orthodontic treatment which asked to estimate the share of the costs

Table 1 Relevant researches (cont.)

No.	Years	Details of relevant researches
3	1998	of dental care and to report on the personnel providing orthodontic treatment. **Results:** The cost of orthodontic treatment per complete case was, on average, FIM 7358, ranging from FIM 5556 to FIM 10,230 by province, and from FIM 1299 to FIM 24,751 by health centre.
4	2000	**Researcher:** Teh, L.H. & Kerr, W.J.S. **Topic:** Orthodontic treatment with fixed appliances in the General Dental Service in Scotland. **Methodology:** This study was undertaken in order to the quality and duration of orthodontic treatment results of cases treated with fixed appliances were randomly selected from the Scottish Dental Practice Board, that were collected from pre- and post-treatment study casts and to investigate the treatment outcome in terms of the quality of result, as measured by the PAR index. PAR scores and IOTN assessment were performed by one examiner and re-assessment by the same examiner. **Results:** The results of this study revealed that: (1) Mean post-treatment PAR was 7.8 $\pm$ 4.6 PAR points. (2) Median duration of treatment was 15 months, with a range of 2-41 months.
5	2002	**Researcher:** Järvinen, S. & Widström, E. **Topic:** Determinants of costs of orthodontic treatment in the Finnish public health service. **Methodology:** This retrospective study was to assess costs of orthodontic treatment in the public dental service of medium sized Finnish cities and to study factors affecting these costs, with special reference to the timing of the treatment. The data used in the study were based on randomly selected clinical records and dental plaster

Table 1 Relevant researches (cont.)

No.	Years	Details of relevant researches
5	2002	casts of 193 successfully treated orthodontic patients, aged 7-14 years at the start of the treatment and treated during the years 1988-1998 in Joensuu, 1983-1995 in Oulu, and 1988-1999 in Vaasa. The treatment was provided by qualified orthodontic specialists in local health centres. **Results:** The costs of treatment were lowest in one-stage treatments started in the permanent dentition, and were highest in two-stage treatments started in the mixed dentition. The mean cost of treatment was 1565 Euros per successfully treated patient, 1376 Euros (87.9%) for the time spent for treatment and 189 Euros (12.1%) for the appliances used.
6	2003	**Researcher:** Petrone, J., et al. **Topic:** Relationship of malocclusion severity and treatment fee to consumer's expectation of treatment outcome. **Methodology:** This study was to examine the relationship between consumer outcome expectations and treatment variables, including cost of treatment and malocclusion severity. The subjects were parents of patients recruited from 9 private orthodontic practices in Southwestern Pennsylvania, who was entering a single phase of orthodontic treatment, characterized by a full fee and complete fixed appliances. The parents completed a questionnaire regarding outcome expectations for their child's orthodontic treatment. Pre-treatment orthodontic study models of each child were evaluated with the peer assessment rating. **Results:** This study is suggested that orthodontic consumers have very high outcome expectations. Treatment fees ranged from \$1,500 to \$4,125, with a mean of \$3,248 (SD=\$689). Although significant variation of fees existed between practices (P = 0.0001). Also, the parents of patients with severe overall malocclusions,

Table 1 Relevant researches (cont.)

No.	Years	Details of relevant researches
6	2003	overjet, or midline deviations have expectations that exceed probable treatment outcomes. This study was found to be a primary motivating factor for parents seeking orthodontic treatment for their children that except for the ability to brush teeth better after treatment.
7	2004	**Researcher:** Richmond, S., et al. **Topic:** Evaluating the cost-effectiveness of orthodontic provision. **Methodology:** This study was valuated cost-effectiveness of orthodontic treatment with Index of Severity, Outcome and Need (ICON) that was useful tool to assess effectiveness. To estimate the cost in the hospital and community Dental service, one of two approaches that to detailed analysis of changes in resource used in the particular orthodontic setting, allocated a total budget to orthodontics and then divided by the number of treatments to arrive at the cost per treatment by three practitioners. Cost-effectiveness evaluation was to estimate the expected cost per successful outcome, that was, to adjust the cost per practitioner according to the probability that they would achieve a successful outcome. **Results:** In this study, The development of cost-effectiveness models would enable the development of new methods of remuneration based on the type and quality of service provided to practitioners. So, practitioner B was dominant that was, the practitioner was less expensive and more effective than practitioner A. Cost-effectiveness ratios were £667, £1,042 and £778 of practitioners C, A and B respectively.

Table 1 Relevant researches (cont.)

No.	Years	Details of relevant researches
8	2004	**Researcher:** Pinskya, Y.B., et al. **Topic:** Comprehensive clinical evaluation as an outcome assessment for a graduate orthodontic program. **Methodology:** The study was obtained from post-treatment records of 521 patients treated at the IUSD Graduate Orthodontic Clinic. At the beginning of the study, 542 patients were registered in the Clinic files as having their orthodontic treatments completed or prematurely terminated by the graduating classes of 1998, 1999 and 2000. This study was designed to serve as a baseline for comparing Subsequent treatment results on an annual basis. All records were scored 3 times. Treatment outcomes were assessed with the ABO OGS for scoring dental casts and root alignment on panoramic radiographs. **Results:** The average cost in the Hospital Dental Service could be estimated as £903 and the Community Dental Service as £505, with cost differences reflecting differences in remuneration and the types of facilities in which orthodontic care was delivered. Costing orthodontic clinics involved estimation of salaries, services and overheads, with treatment costs based on the treatment times and overall duration of treatment. The mean ABO OGS score for the entire sample was 34.4 points: 32.4, 33.1, and 37.8 points for 1998, 1999 and 2000, respectively. The mean treatment time of 33.94 $\pm$ 14.05 months. The quality of finished cases that was associated with a treatment time increase from 28.9 to 39.3 months. Scoring of all finished cases was an effective means for determining clinical outcomes.

Table 1 Relevant researches (cont.)

No.	Years	Details of relevant researches
9	2004	**Researcher:** Abei, Y., et al. **Topic:** Comparing orthodontic treatment outcome between orthodontists and general dentists with the ABO index. **Methodology:** This study used the ABOI to evaluate to compare treatment outcomes between patients treated by orthodontics specialists (OS) and patients treated by general dentists (GP). All casts were collected in 1997 and 1998 and were scored by 1 operator calibrated in the use of the ABOI. **Results:** The mean ABOI score for the OS group was 26.0 $\pm$ 11.4 compared with 29.6 $\pm$ 12.8 for the GP group. However, there was no statistical difference between the 2 provider groups.
10	2005	**Researcher:** Deguchi, T., et al. **Topic:** Clinical assessment of orthodontic outcomes with the peer assessment rating, discrepancy index, objective grading system, and comprehensive clinical assessment. **Methodology:** This study was to quantitatively assess orthodontic treatment outcomes in postgraduate orthodontic clinics at Okayama University (OU) and Indiana University (IU) were randomly selected from patients completed in 2002. Using the PAR index and DI index were used to evaluate the pretreatment records. PAR, ABOI and CCA were used to evaluate the post-treatment records. **Results:** The mean DI scores were 19 for OU and 17 for IU. The mean ABOI scores were 34 for OU and 33 for IU. Buccolingual inclination and overjet scores were significantly higher in OU patients compared with IU ($p < 0.05$).

CHAPTER III
MATERIALS AND METHODS

This chapter describes the methods used to conduct the study. It presents research study, population and sample, inclusion and exclusion criteria for selection sampling, the sampling procedures, instruments, data collection and data analysis.

Research design

With limited time and resources for this study, a cross sectional design to analyse cost and effectiveness of fixed orthodontic treatment in Orthodontic Clinic, Faculty of Dentistry, Mahidol University was decided.

The costs were retrospectively collected from all complete cases from 1988 to 2005 and financial information was collected in fiscal year 2005 (October 1, 2004 – September 30, 2005). Based upon existing information, if some data were incompletes, the prospective study would be used by observed and recorded with monthly.

The effectiveness was retrospectively collected from all complete cases of orthodontic records from the same period of cost data.

Population and sample

The populations were selected from dental records of patients who had completed orthodontic treatment in the Orthodontic Clinic. There were 1,025 cases of patients treated with fixed appliances by postgraduate students in orthodontics and under orthodontist supervision of the Orthodontic Department.

Inclusion and exclusion criteria for selected patient

For the purpose of the study, a set of criteria were developed to identify eligible for inclusion in the study. They were developed and used in consultation with experienced orthodontist in selecting the cases for this study, the following criteria were used:

Inclusion criteria

1. The patient received treatment with fixed appliances using closing loop mechanics or sliding mechanics.
2. Age at start of treatment ranging from 12 to18 years.
3. The patients were class I malocclusion.
4. The patient received treatment with fixed appliances and extraction 4 premolar teeth.
5. All cases had complete dental records including treatment record, panoramic radiographs and dental casts both pre-treatment and post-treatment.
6. The patients treated by postgraduate students and under orthodontist supervision who had more than 5 years experience.
7. The patient gave good co-operation and missed appointment less than or equal 7 times.
8. The severity of malocclusion levels ranging from 10 to 30 points according to DI for both treatment methods.

Exclusion criteria

1. Non-extraction or extraction less than 4 teeth.
2. The patient treated with removable appliance, orthognathic surgery.
3. The patient had cleft lip and palate.
4. The patient treated with combinations of fixed and removable appliances.
5. Cases had incomplete dental records.
6. Poor co-operation and missed appointment more than 7 times.
7. The severity of malocclusion level less than 10 and more than 30 points according to DI.

Using the inclusion and exclusion criteria, a number of cases were purposely selected. Detail was shown in diagram 4.

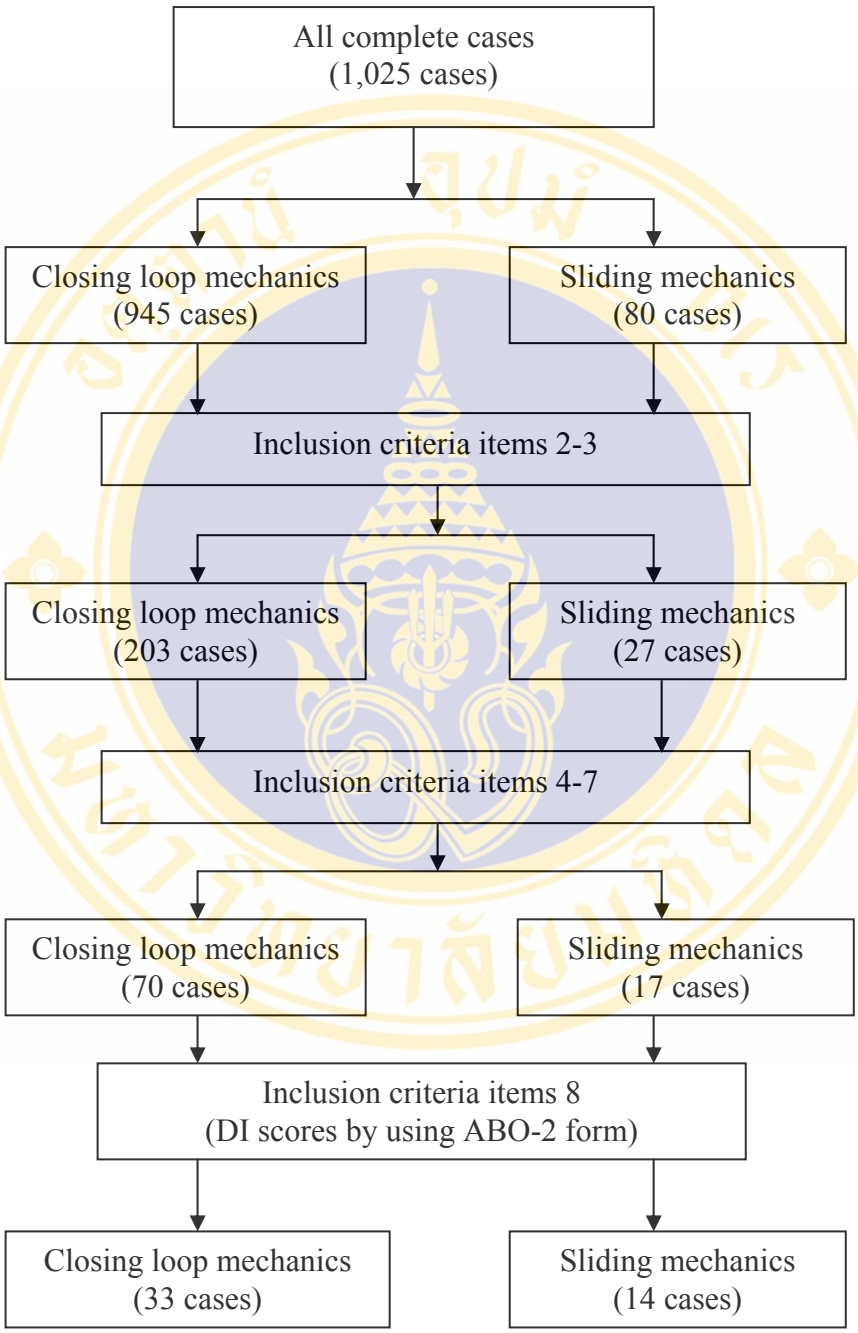


Diagram 4 Selection of samples

General data were also collected from complete cases, they were data of patients before treatment and using record form code ABO-2 for record gender, age,

malocclusion before treatment and treatment durations. That was made after selection sampling by using inclusion criteria items 1-7, they were 70 cases for closing loop mechanics and 17 cases for sliding mechanics. That was searching patients at the severity of malocclusion levels between 10 and 30 points of both treatment methods. DI was used to assess the difficulties of the presented cases according to the ABO by using record form code ABO-2, that was collected from dental records, panoramic radiographs and summary report of treatment results. It includes 8 categories: overjet, overbite, anterior openbite, lateral openbite, crowding, occlusion, lingual posterior x-bite, buccal posterior x-bite, cephalometrics measurements, and other, such as missing teeth, ectopic eruption, etc.

Below were scores of severity of malocclusion levels. (Cangialosi, T.J., et al., 2004).

	DI scores
Easy	≤ 10
Mild	11-15
Moderate	16-20
Difficult	21-25
Very difficult	≥ 26

Research tools

The data comprised of a number of variables that can be broken down into: 1) Costing data (capital cost, labour cost and material cost), 2) Effectiveness data (treatment results and general data). The tool of this study was developed to collect data backward and forward, based on literature review, effectiveness evaluation's concept of ABOI score and there were adjusted to be suitable within studied area. Record forms are comprised of 2 parts as follows:

Part I Costing record form is composed of:

Record form code CC-1: Capital cost (Clinic renovation cost)

Record form code CC-2: Capital cost (Durable articles and consultancies cost)

Record form code LC-1: Labour cost record

Record form code LC-2: Labour cost (Using time record for activity of staff who works more than 1 department)

Record form code MC-1: Material cost record (Orthodontic material, waste orthodontic material and orthodontic instruments)

Record form code MC-2: Material cost (Public utility for electrical supply)

Record form code MC-3: Material cost (Public utility cost for water supply and maintenance)

Part II Effectiveness record form using of ABO-1 in record treatment results.

Table 2 The type of data allocated according to the source of information

Topic	Source	Technical remark
Cost	**Inventory list**	**Capital cost** The durability for durable articles as 5 years and 8 years for dental durable articles of which the price is equal or more than 5,000 baht (US$100). **Recurrent cost** Dental equipment of which the price is less than 5,000 baht (US$100).
	Salary account	**Recurrent cost in the line of labour cost** Salary and welfare of personnel
	Dental records	**Recurrent cost in the line of material cost** 1. Orthodontic material cost 2. Number of complete cases of each treatment method

Table 2 The type of data allocated according to the source of information (cont.)

Topic	Source	Technical remark
	Expenditure financial record	**Recurrent cost in the line of material cost** Utilities, electricity fee, water supply fee and maintenance **Capital cost** Clinic renovation and consultancies
	Blueprint	**Recurrent cost in the line of material cost** Utilities, water supply fee **Capital cost** Using to divide the area of each unit cost
Effectiveness	**Dental casts and panoramic radiographs**	**Effective levels** ABOI score has 8 criteria by using gauge of ABO in measurement final dental casts.
General data	**Dental records and summary report of treatment results**	**Characteristic of patient** 1. Gender 2. Age 3. Treatment duration 4. Co-operation of patient
	Dental records, dental casts, panoramic radiographs and summary report of treatment results	**Severity of malocclusion level** Using DI score of ABO in measurement severity of malocclusion level that was measured before treatment.

The ABOI score has 8 criteria: alignment, marginal ridges, buccolingual inclination, occlusal relationships, occlusal contacts, overjet, interproximal contacts, and root angulation. The ABO measuring gauge was used to score casts (Fig 3).

An interpretation on the scores was divided into 3 levels based on ABO (2004) as follows:

	ABOI scores
Good	≤ 20
Acceptable	21-30
Unacceptable	> 30

Pre-treatment and post-treatment ABO index, weighted according to the method given by orthodontist, were measured on dental casts and panoramic radiographs. Effectiveness measurement was consisted of ABO measuring gauge.

Microcomputer

Software package was used for data entry. Most questions required usage of numeric code where appropriate. Standard package program for data analysis and presentation was used. All quantitative data were double entered by two data entry checks. Double entry and cleaning were done with Micro-computer using Software packages for collecting and calculating data including research presentation.

Standardization of the tools

Research tool was standardized as follows.

1. Cost record form

Validity test, based on reviewing the relevant theories and researches, and the conceptual framework of the study, the first draft record form was conducted. Thesis advisors and 3 experts were consulted to assess its content validity and construct validity. Then the record form was revised and tries out to collect data. After that, then the record form was revised before using.

2. Effectiveness record form

2.1 Validity test

Approved record form of ABO by orthodontist expert based on Thai people (shown in appendix) was consulted to assess for content validity and construct validity. Then the record form was revised and tries out to collect data. After that, then the record form was revised before using.

2.2 Reliability test

Calibrating examination was double measured by the same examiner a week after the initial scoring of subsample 10 cases with ABOI score. The Cronbach's alpha coefficient method was used to assess the reliability of examiner. The result of the reliability test was 0.88.

Ethical considerations

The study was performed in accordance with international ethical guidelines, which include the following:

1. This study got permission from the Dean of Faculty of Dentistry, Mahidol University. The cost and effectiveness were evaluated by using data from complete cases and personal information of staff in the Orthodontic Department.

2. This study got permission from the ethical committee on human rights related to human experimentation Mahidol University.

3. Co-operation request for data collection was made by asking question and explaining benefit and the impact of studies.

4. Personal information in this study such as names and addresses were not recorded and remained confidentially and present as overall information. Those data were using codes in the record form.

Data collection

To collect the cost and effectiveness of fixed orthodontic treatment in the Orthodontic Clinic, the office software packages were used as divided into two parts as follows:

Part I: Cost collection

The study procedure consisted of 3 steps as the following approach:

Step 1 Study organization structure and treatment process

This study was used concept of accounting cost as well as economic cost to apply in cost analysis of each activity that consisted of retrospective study and prospective study.

Retrospective study: Data from secondary sources such as personnel files, report of the account of the Faculty of Dentistry, Mahidol University in fiscal year 2005 were collected from financial information including labour cost and capital cost. For dental records, dental casts and panoramic radiographs of complete cases were collected from 1988 to 2005 to analyse material cost. These costs were considered as direct costs of each treatment method.

Prospective study: Data of the Orthodontic Clinic in the fiscal year 2005 which could not be found due to incomplete reports elaborating of all activities prior to the primary data collection period, such as how much time to work for either treatment methods - closing loop mechanics and sliding mechanics for each activity. This period for primary data collection was done during November 1-30, 2005.

Step 2 Define activities

The researcher defined the activities. Therefore, the whole activities of the Orthodontic Clinic were divided in to three main sections: 1) orthodontic care section, 2) laboratory section and 3) supporting section.

Step 3 Identify resources into cost type

After having defined activities, the next step was data collection of cost. In this step costs were gathered for the activity producing the products or services provided as the output costing.

The capital cost and recurrent cost by activities were calculated first and then the total cost was calculated by activities.

3.1 Capital cost

Capital cost includes depreciation cost of durable articles and clinic renovation. These costs were separately collected, particularly durable articles and clinic renovation that the useful life did not expire. The useful life determination includes:

3.1.1 All kind of durable articles was determined to have the useful life of 5 years and all kind of dental durable articles was determined under frame of Comptroller General's Department (2001) to have the useful life of 8 years.

3.1.2 Clinic renovation was determined to have the useful life of 20 years.

For data collection of clinic renovation and durable articles that would be collected on record from code CC-1 and CC-2 setting from inventory. If the data was incomplete, researcher would measure the real building area of cost for each activity.

Data collection of depreciation cost of building as follows:

1. Survey all clinic renovation of the Orthodontic Clinic and record total number of clinic renovation that were constructed less than 20 years. The record included names of the room or activity, construction price, established year, then calculate the depreciation cost of each treatment method.

2. Calculate the used area of each unit cost from the blueprint.

3. Calculate the proportional area of each activity in order to allocate the depreciation cost of that building to each treatment method appropriately. The method was to multiply the proportion of each area overall to the depreciation cost of each treatment method.

4. The researcher collected all expenses of the consultants from expenditure financial record of fiscal year 2005 that were recorded from work hours per visit when supervising postgraduate students during treated patient.

3.2 Recurrent cost

Recurrent cost is the cost for running the orthodontic treatment activities of complete cases. The line items under recurrent cost of this study are labour cost and material cost.

3.2.1 Labour cost

Labour cost was the most significant expense of the Orthodontic Clinic. The collected steps were as follows:

3.2.1.1 The researcher collected all expenses of the labour cost that was included salary, wage, remuneration of high position and welfare etc. The data from salary account, welfare expense account and cash account were collected. The labour cost was directly allocated to the cost of activity needed to the steps to calculate the labour cost as follow:

3.2.1.1.1 To calculate the time of working hours per visit of each staff to work in each activity needed to be identified by taking note of time and the total work hours in minutes per visit of each treatment method.

3.2.1.1.2 To allocate the labour cost into each treatment method, the total numbers of staff in each cost activity were verified, and then distributed total cost of that group such as orthodontist, dental technician, dental assistance, etc. The labour cost data of the orthodontist group were recorded from work hours per visit when supervising postgraduate students during treated patient.

The labour cost per activity was calculated from real time spent within 249 days of fiscal year 2005. Data were collected from payroll records of the Faculty of Dentistry (record from code LC-1 and LC-2).

3.2.2 Material cost

Material cost included orthodontic material, waste orthodontic material, orthodontic instruments, utility and maintenance. All expenses were based on the price of those materials and the amount used, as well as the real reimbursement. Sources of data were collected from dental records of complete cases and inventory list and expenditure financial record (record form code MC-1).

In case of public utilities about electrical supply, researcher would estimate cost from used volume in each activity group by electric equipment record and time used interval (record form code MC-2) at least one month.

For water supply, researcher would allocate from water value of the Faculty of Dentistry in fiscal year 2005 by identifying cost per square metre and proportion of spending time in treated of both treatment methods per visit at all steps

since the beginning to the completed treatment (appliance removal), that distribute to each treatment method (record form code MC-3).

Part II: Data collection of effectiveness in fixed orthodontic treatment

Effectiveness data was collected from dental records, dental casts and panoramic radiographs of complete cases by measuring the effectiveness of fixed orthodontic treatment results. Tool and criteria of ABOI score in measurement and record on ABO-1 were used. Because the postgraduate students did not use this tool and criteria of ABO to measure the dental casts, then in this study, new measurement was performed by orthodontist by using criteria of ABO form. The researcher classifies patient from all complete cases by using inclusion sampling in selection, that under control of orthodontist and experts in this field.

General data

General data were collected related to cost and effectiveness from dental records, dental casts and summary report of treatment results of postgraduate students provider includes gender, age, malocclusion before treatment and treatment duration by using record form code ABO-2.

Table 3 Sources of data collection

Descriptions	Researcher	Orthodontist	Faculty of Dentistry
Primary data			
Staff's working time spent at orthodontic clinic	X		
Secondary data			
Capital cost - Durable articles and consultancies	X		
Capital cost - Clinic renovation	X		
Labour cost - Salary and wage	X		X

Table 3 Sources of data collection (cont.)

Descriptions	Researcher	Orthodontist	Faculty of Dentistry
Material cost - Orthodontic material, waste orthodontic material and instruments	X	X	
Material cost - Public utility	X		X
Number of complete cases of each treatment method	X		
Characteristics of complete cases	X		
Severity of malocclusion level	X	X	
Effective level	X	X	

Source: Orthodontic Clinic, 2005

Data analysis

Validation of the data was done from the double entry (2 data sets) and checked against hard copy or original information from the dental records. All data were rechecked and entered in the computer by using office software packages in cost analysis and used statistical software packages for effectiveness analysis.

1. Cost analysis

Cost measurement was set by identifying the majority activity of fixed orthodontic treatment of both treatment methods by researcher and experts in this field (shown in diagram 3).

1.1 Capital cost

Capital cost was calculated from both clinic renovation and durable articles line items that had life span of more than one year and cost 5,000 baht (US$100) or more. In this study, life spans of those materials were determined as follows: Equipment and Furniture were categorized by observation depends on type and use. Durability period of each property was determined by the Bureau of the

Budget Office is 5 years and 20 years for clinic renovation. Land was excluded for this study. The construction was estimated value of the clinic renovation because the Faculty of Dentistry has included construction value in the investment account.

Calculated depreciation, in this study the life span of the durable articles determined as follows:

1. Durable articles were categorized by observation depends on type and use. Additional information was obtained from interviewing and observing the persons who used the durable articles. For some durable articles that the cost was shared, the cost was allocated by using service time in each activity and taken all working real time multiplying with depreciation cost by using 249 days per year in to calculate.

2. The depreciation costs of durable articles were calculated by straight-line method, taking equal amounts in each year of useful life.

$$\text{Depreciation cost in a year} = \frac{\text{Cost of purchase}}{\text{Useful life (years)}}$$

1.2 Recurrent cost

Recurrent cost is the cost for running activities. It includes labour, material, utility and maintenance costs. The formula was as follow:

Recurrent cost = Labour cost + Material cost (Material + Utility + Maintenance)

1.2.1 Labour cost

Labour cost was calculated per person and per activity of each treatment method, as well as an estimated cost of the consultant's time per visit. After that, the labour cost of the respective staff needs to be calculated by sharing the cost according to the proportion of work in the respective activity.

1.2.2 Material cost

Material cost was calculated from each treatment method that used real material in treated patient which recorded by clinician. The data of material cost of each activity were collected from the starting time till the end of treatment. The formula was as follow:

Total price of each material of complete cases = Number of material x Unit price

1.2.2.1 Public utility

Public utility costs included water supply and electrical supply. The public utilities become the expense per month of Faculty of Dentistry in fiscal year 2005. The steps of calculation data were as follow:

1.2.2.1.1 Water supply cost was calculated by taken water value of the Faculty of Dentistry in fiscal year 2005 divided by all area got water price per square metre.

1.2.2.1.2 Electrical supply cost was calculated from area spent and number of electric equipment that using time by prospective study unless one month in each activity.

The utility cost was allocated of water supply and electrical supply in each treatment method by using service time each activity and then taken all working real time multiplying with proportion of utility value.

1.3 Total cost analysis

The total cost = Capital cost + Recurrent cost

1.4 Average cost calculation

The purpose of this calculation was to find out the cost per complete case in each treatment method. The basic calculation of unit cost was presented as follow:

$$\text{Average cost} = \frac{\text{Total cost, or TC}}{\text{Quantity Q}}$$

TC = Total cost

Q = Quantity (The total number of complete cases in each treatment method)

2. Effectiveness analysis

Effectiveness analysis was measured from the result of treatment and compared treatment with goals of treatment. A goal of treatment was the key to

analyse the effectiveness of ABO. Those used the data from dental records, dental casts, panoramic radiographs and summary report of postgraduate students provider. To analyse it would be considered together with general data which step to analyse were as follow:

2.1 Preparation

2.1.1 The researcher prepared handbook and score criteria that were prepared to measure the effective was by orthodontist that would be performed in natural unit.

2.1.2. The researcher performed effectiveness record form code ABO-1 from dental casts and panoramic radiographs after treatment and calibrated with orthodontist for reliability measurement of ABOI score and effectiveness measurement, that received reliability was 0.88.

2.2 Implement

2.2.1 The researcher collected general data which consisted of gender, age, malocclusion before treatment and treatment duration to be considered with effectiveness by record on ABO-2 form. For malocclusion before treatment, the researcher collected data from dental records, that postgraduate students provider who recorded before treated each patient and measured dental casts for scoring and set severity level by using criteria of ABO under control of orthodontist.

2.2.2 Treatment results were measured from dental casts and panoramic radiographs after treatment and scored by orthodontist, which used ABOI score and record on ABO-1 form. For tool in measurement dental casts shown in figure 3.

The following were analysed of the treatment results. Details of ABOI score by component were assessed as follows:

Table 4 Detail of ABOI score by component

Variables	Technical remark
Alignment	In the maxillary posterior region, the mesiodistal central groove of the premolars and molars is used to assess adequacy of alignment.

Table 4 Detail of ABOI score by component (cont.)

Variables	Technical remark
Marginal ridges	They were used to assess proper vertical positioning of the posterior teeth.
Buccolingual inclination	It is used to assess the buccolingual angulation of the posterior teeth. It shall be assessed by using a flat surface that is extended between the occlusal surfaces of the right and left posterior teeth.
Occlusal relationship	It is used to assess the relative anteroposterior position of the maxillary and mandibular posterior teeth.
Occlusal contacts	They were measured to assess the adequacy of the posterior occlusion.
Overjet	It is used to assess the relative transverse relationship of the posterior teeth and the anteroposterior relationship of the anterior teeth.
Interproximal contacts	They were used to determine if all spaces within the dental arch have been closed. Persistent spaces between teeth after orthodontic therapy are not only unesthetic, but can lead to food impaction.
Root angulation	It is used to assess how well the roots of the teeth have been positioned relative to one another. The relative angulation of the roots of maxillary and mandibular teeth is assessed on the panoramic radiograph.

Source: ABO, 2004

After orthodontist gave score of effectiveness treatment of each treatment method, the researcher proceeded data collection for average and percentage of each treatment method to compare between closing loop mechanics and sliding mechanics. The results of all complete cases were analysed of the treatment results that as calculated by t-test analysis.

For general data, information analysed from complete cases was used in conjunction with effectiveness. The data analysis was performed by using statistical

descriptions including the arithmetic mean and the standard deviations were calculated for demographic, treatment duration and pre-treatment parameters. After that, t-test was used for comparing mean of general data of both treatment methods.

Statistical analysis

Statistical analysis of the data was performed with Software packages. This study used descriptive and inferential statistics as follow:

1. Descriptive statistics

Percentage, mean, ratio and standard deviation were performed to describe general characteristics of the samples, cost and effectiveness of fixed orthodontic treatment.

2. Inferential statistics

The effectiveness data was analysed by used t-test to compare the following parameters: pre-treatment and post-treatment ABO indexes; ABOI scores of individual teeth; and DI scores. Correlations between the DI scores and treatment methods or between ABOI scores and treatment methods were evaluated with the Fisher's exact test. The statistical significant level was an alpha value at 5% level.

3. Sensitivity analysis

The aim of a sensitivity analysis is to establish how the end result changes if the initial parameters vary. In this study, it was performed to estimate how much certain parameters (cost and effectiveness) would have to change in order to change the ranking of the two methods of treatment by adjusting number of patients and instructors.

CHAPTER IV
RESULTS

The purpose of this study was to analyze cost and effectiveness of fixed orthodontic treatment in the Orthodontic Clinic of the Orthodontic Department, Faculty of Dentistry, Mahidol University, which was done by using both primary and secondary sources of data in the fiscal year 2005 (October 1, 2004 – September 30, 2005). The research results are consisted of six parts as follows:

Part I: General information in cost analysis of fixed orthodontic treatment

Part II: Characteristics of complete cases

Part III: Full cost in orthodontic treatment, which included:

1. Total cost of fixed orthodontic treatment with closing loop mechanics and sliding mechanics which consisted of:

1.1 Recurrent cost

1.2 Capital cost

2. Unit cost of fixed orthodontic treatment

Part IV: Effectiveness level of fixed orthodontic treatment

Part V: The comparison of unit cost and effectiveness level of fixed orthodontic treatment between closing loop mechanics and sliding mechanics

Part VI: Sensitivity analysis of cost and effectiveness level of fixed orthodontic treatment

Part I: General information in cost analysis of fixed orthodontic treatment

The Orthodontic Clinic, Faculty of Dentistry, Mahidol University, had 20 dental units. Total operating area was approximated 420 square meters. The operation function was divided in to three main sections: 1) orthodontic care section, 2) laboratory section and 3) supporting section. There were 29 staff members in the

Orthodontic Clinic which were categorized as 1) civil service staff: 9 orthodontists, 2 dental technicians and 5 dental assistants, 2) university employee: 5 orthodontists and 4 dental assistants, 3) 2 permanent employees and 4) 2 temporary employees (Table 5). The orthodontic clinic was renovated during 2002-2003 with the estimated cost was 2,693,211 baht.

The sample used in this study comprised of 33 cases using closing loop mechanics and 14 cases using sliding mechanics treatment. There were 11 instructors (78.57%) who supervised postgraduate students to treat the patients with closing loop mechanics whereas only 3 instructors (21.43%) supervised postgraduate students to treat the patients with sliding mechanics. The mean work time of orthodontists, dental technician, dental assistants and the other staff for closing loop mechanics was 58,899.01 minutes per complete treatment and 26,894.08 minutes per complete treatment for sliding mechanics.

Table 5 Type of the Orthodontic Clinic staffs in the fiscal year 2005

Types of staff	Number (%)
Civil servant staff:	
Orthodontist (instructor)	9 (31.03)
Technician	2 (6.90)
Dental assistant	5 (17.24)
University employees:	
Orthodontist (instructor)	5 (17.24)
Dental assistant	4 (13.79)
Permanent employees	2 (6.90)
Temporary employees	2 (6.90)
Total	**29 (100)**

Part II: Characteristics of complete cases

The patients in this study were consecutively treated patients by postgraduate students in orthodontics. For the closing loop mechanics group, the average pre-treatment age was 14.38 ± 1.36 years. The average treatment duration was 32.61 ± 7.92 months. Females constituted 60.61% of the sample, and males 39.39%. For the sliding mechanics group, the average pre-treatment age was 14.03 ± 1.65 years. The average treatment duration was 34.36 ± 8.14 months. Females constituted 71.43% of the sample, and males 28.57%. When testing for statistically significant differences between closing loop mechanics and sliding mechanics treatments, no statistical difference was confirmed (Table 6).

Table 6 Characteristics of complete cases

	Type of treatment			
	Closing loop mechanics	**Sliding mechanics**	**t**	**p-value**
	Mean (sd) (n=33)	**Mean (sd) (n=14)**		
Age at the start of treatment (years)	14.38(1.36)	14.03(1.65)	.76	0.45
Duration of treatment (months)	32.61 (7.92)	34.36 (8.14)	-.69	0.46
Gender n(%)			-.70	0.49
Male	13 (39.39)	4 (28.57)		
Female	20 (60.61)	10 (71.43)		

The mean pre-treatment DI scores of fixed orthodontic treatment for 47 complete cases was 16.00 ± 5.08. The median DI scores were 16.00 for the 33 closing loop mechanics cases and 15.00 for the 14 sliding mechanics cases. When testing for statistically significant differences between closing loop mechanics and sliding mechanics treatments, no statistical difference was found. When testing for association of DI scores and type of treatment of both treatment methods by using Fisher's exact test, there was no association (Table 7).

Table 7 DI scores by treatment methods

Ranges of DI scores	Closing loop mechanics		Sliding mechanics	
	Number (n=33)	%	Number (n=14)	%
10 (Easy)	1	3.03	2	14.29
11-15 (Mild)	14	42.43	5	35.71
16-20 (Moderate)	12	36.36	3	21.43
21-25 (Difficult)	5	15.15	1	7.14
26-30 (Very difficult)	1	3.03	3	21.43
Median	16.00		15.00	
t-test			p = 0.83	
χ^2			p = 0.46	

Source: Cangialosi, T.J., et al., 2004

DI means severity of malocclusion levels before treatment

Part III: Full cost in orthodontic treatment

This part demonstrates full cost in orthodontic treatment which consists of total cost and unit cost of fixed orthodontic treatment with closing loop mechanics and sliding mechanics.

1. Total cost of fixed orthodontic treatment with closing loop mechanics and sliding mechanics

Table 8 shows that total cost of fixed orthodontic treatment with closing loop mechanics was 1,214,731.36 baht. The distribution of the total costs for closing loop mechanics was 83.97% for recurrent cost and 16.03% for capital cost (Table 8).

Total cost of fixed orthodontic treatment with sliding mechanics was 503,794.19 baht. The distribution of the total costs for sliding mechanics was 79.95% for recurrent cost and 20.05% for capital cost (Table 8).

Table 8 Total costs by component in orthodontic treatment with fixed appliances

Type of cost	**Type of treatment**			
	Closing loop mechanics		**Sliding mechanics**	
	Baht (%) (n=33)		**Baht (%) (n=14)**	
Recurrent cost				
Labour cost	694,734.26	(57.19)	254,243.35	(50.47)
Material cost	325,284.08	(26.78)	148,544.46	(29.48)
Capital cost	194,713.02	(16.03)	101,006.38	(20.05)
Total cost	**1,214,731.36**	**(100)**	**503,794.19**	**(100)**

1.1 Recurrent cost and the components of recurrent cost

The recurrent cost of fixed orthodontic treatment with closing loop mechanics was 1,020,018.34 baht. This included the labour cost and material cost. The labour cost, which included the salary and welfare, was 694,734.26 baht (68.11% of the recurrent cost). The material cost, which included the orthodontic materials, waste orthodontic materials, orthodontic instruments, utility and maintenance, was 325,284.08 baht (31.89% of the recurrent cost) (Table 9).

The recurrent cost of fixed orthodontic treatment with sliding mechanics was 402,787.81 baht. This included the labour cost and material cost. The labour cost, which included the salary and welfare, was 254,243.35 baht (63.12% of the recurrent cost). The material cost, which included the orthodontic materials, waste orthodontic

materials, orthodontic instruments, utility and maintenance, was 148,544.46 baht (36.88% of the recurrent cost) (Table 9).

Table 9 Recurrent costs by component in orthodontic treatment with fixed appliances

Type of recurrent cost	Type of treatment			
	Closing loop mechanics		Sliding Mechanics	
Labour cost, Baht (%)				
Salary				
Orthodontist	100,058.81	(14.40)	7,708.76	(3.03)
Dental technician	29,940.60	(4.31)	12,034.16	(4.73)
Dental assistant and other staff	370,808.00	(53.37)	185,931.91	(73.13)
Remuneration of high position	5,116.32	(0.74)	1,522.02	(0.60)
Medical care	166,012.36	(23.90)	45,354.37	(17.84)
Child education	7,929.80	(1.14)	149.15	(0.06)
Training and conference	14,868.37	(2.14)	1,542.98	(0.61)
Total labour cost	**694,734.26**	**(68.11)**	**254,243.35**	**(63.12)**
Material cost, Baht (%)				
Orthodontic material	189,699.96	(58.32)	71,259.27	(47.97)
Waste orthodontic material	20,594.37	(6.33)	11,688.49	(7.87)
Orthodontic instruments	4,636.69	(1.43)	3,059.23	(2.06)
Utility	44,432.14	(13.66)	24,612.53	(16.57)
Maintenance	65,920.92	(20.27)	37,924.95	(25.53)
Total material cost	**325,284.08**	**(31.89)**	**148,544.46**	**(36.88)**
Total cost (Labour and Material)	**1,020,018.34**	**(100)**	**402,787.81**	**(100)**

1.2 Capital cost and the component of capital cost

The capital cost of fixed orthodontic treatment with closing loop mechanics was 194,713.02 baht. The highest depreciation was dental and general durable article (76.54%). The lowest of the depreciation was the consultant 8.21% (Table 10).

The capital cost of fixed orthodontic treatment with sliding mechanics was 101,006.38 baht. The highest depreciation was dental and general durable article (83.69%). The lowest of the depreciation was the clinic renovation 16.31% (Table 10).

Table 10 Capital costs by component in orthodontic treatment with fixed appliances

Type of capital cost	Type of treatment	
	Closing loop mechanics	Sliding mechanics
	Baht (%)	Baht (%)
Durable articles	149,029.75 (76.54)	84,536.61 (83.69)
Clinic renovation	29,698.94 (15.25)	16,469.78 (16.31)
Consultant	15,984.33 (8.21)	0
Total capital cost	**194,713.02 (100)**	**101,006.38 (100)**

2. Unit cost of fixed orthodontic treatment

The 47 patients who had completed of fixed orthodontic treatment had a mean treatment duration of 33.13 months. The mean treatment cost of fixed orthodontic treatment for 47 patients was 36,564.37 baht per complete case.

The unit cost of closing loop mechanics and sliding mechanics are shown in Table 11.

Table 11 Unit cost of fixed orthodontic treatment using closing loop mechanics and sliding mechanics

Type of treatment	Number of patient (case)	Duration of treatment (months) mean(sd)	Cost per complete case (Baht/case)
Closing loop mechanics	33	32.61 (7.92)	36,810.04
Sliding mechanics	14	34.36 (8.14)	35,985.30
Total	**47**	**33.13 (7.94)**	**36,564.37**

Part IV: Effectiveness level of fixed orthodontic treatment

The mean effectiveness level of treatment results of fixed orthodontic treatment in the Orthodontic Clinic for 47 patients was 27.92 $\pm$ 5.02. This was scored by one examiner according to the American Board of Orthodontics (ABO) Objective Grading System (ABO index) for scoring dental casts and root alignment on panoramic radiographs. The mean scores were 28.52 $\pm$ 4.71 for the closing loop mechanics and 26.50 $\pm$ 5.60 for the sliding mechanics methods.

When considering the effectiveness levels of fixed orthodontic treatment in treated patient for closing loop mechanics, it was found that the majority (63.64%) had acceptable effectiveness. For sliding mechanics, it was found that 21.43% had good effectiveness and 57.14% had acceptable effectiveness. The treated cases that lost more than 30 points was 36.36% in closing loop mechanics and 21.43% in sliding mechanics group. However, the measured ABOI score in this study did include all criteria of ABO in measurements. There was no statistically significant difference in means of ABOI score between two methods of treatment. When testing for association of DI scores and type of treatment of both treatment methods, there was no association (Table 12).

Table 12 ABOI score distribution by treatment methods

ABOI score	Closing loop mechanics		Sliding mechanics	
	Number	%	Number	%
< 20 (Good)	-	-	3	21.43
21-30 (Acceptable)	21	63.64	8	57.14
> 30 (Unacceptable)	12	36.36	3	21.43
Mean(SD)	28.52(4.71)		26.50(5.60)	
t-test	p = 0.21			
χ^2	p = 0.50			

Source: ABO, 2004

ABOI means tool to assess the adequacy of finished orthodontic results

The mean values for the 8 ABOI components for closing loop mechanics and sliding mechanics treatment were shown in Table 13. When testing for statistically significant differences between both treatment methods, no statistical difference in all components of ABOI score (Table 13). It was noted that the most points lost of treatment outcomes for both treatment methods was the marginal ridge, and contact point was the second factors.

Table 13 ABOI score by component

Components	Closing loop mechanics	Sliding mechanics	t	p-value
	Mean (sd)	Mean (sd)		
Alignment	1.36 (1.03)	1.14 (0.53)	0.97	0.34
Marginal ridge	5.91 (1.40)	6.00 (1.57)	-.20	0.85
Buccolingual inclination	4.45 (2.21)	3.86 (2.21)	0.85	0.40
Overjet	2.03 (1.53)	2.00 (1.57)	0.62	0.95
Occlusal contact	4.58 (2.11)	4.00 (2.04)	0.87	0.39
Occlusal relationship	3.48 (2.02)	3.07 (1.82)	0.66	0.51
Interproximal contact	3.06 (1.60)	2.57 (1.65)	0.95	0.35
Root angulation	3.64 (1.37)	3.93 (1.21)	-.69	0.49

Part V: The comparison of unit cost and effectiveness level of fixed orthodontic treatment between closing loop mechanics and sliding mechanics

ABOI is a very useful tool to assess effectiveness because it has clear cut-off levels and acceptable criteria to be used in cost-effectiveness analysis. The measure of effectiveness is simply to look at the proportion of acceptable outcomes. According to the ABO standards, dental casts that lose less than or equal 30 points are acceptable. The cost-effectiveness analysis is done by estimating the cost per

successful outcome, that is, to adjust the cost per complete treatment according to the proportion that it would achieve a successful outcome (Table 14).

Of the 47 treated cases, 33 cases were treated by closing loop mechanics and 14 cases were treated by sliding mechanics. When considering the acceptable outcome (ABOI less or equal 30 scores), there were 21 acceptable cases (63.64%) in closing loop mechanics and 11 acceptable cases (78.57%) in sliding mechanics treatment. Effectiveness levels data showed that the mean ABOI score was 28.52 $\pm$ 4.71 for closing loop mechanics and was 26.50 $\pm$ 5.60 for sliding mechanics. There was no statistically significant difference in mean ABOI score between two methods of treatment (Table 14).

The average treatment costs by using closing loop mechanics were 36,810.04 baht which was composed of capital cost, labour cost and material cost 5,900.39, 21,052.55, 9,857.10 baht respectively and the average treatment costs were 35,985.30 baht which was composed of capital cost, labour cost and material cost 7,214.74, 18,160.24, 10,610.32 baht respectively for sliding mechanics. There was statistically significant difference in average treatment costs between two methods of treatment at the 5% level (Table 14).

Table 14 Comparing closing loop mechanics versus sliding mechanics

Type of comparing	Type of treatment		t	p-value
	Closing loop mechanics	Sliding mechanics		
	Mean (sd) (n=33)	Mean (sd) (n=14)		
Effective levels (ABOI)	28.52 (4.71)	26.50 (5.60)	1.27	0.21
Unit cost	36,810.04	35,985.30	2.25	0.03*
Capital cost	5,900.39	7,214.74	-	1.00
Labour cost	21,052.55	18,160.24	-	1.00
Material cost	9,857.10	10,610.32	-2.06	0.04*

* Statistically significant at 5%

Part VI: Sensitivity analysis of cost and effectiveness level of fixed orthodontic treatment

The sensitivity analysis was performed by equally adjusting the number of patients. Therefore, 33 treated cases by closing loop mechanics would be reduced to 14 cases and the 14 treated cases by sliding mechanics would be remained. There was no statistically significant difference in average treatment costs between the two methods, except the material cost at the 1% level (Table 5).

Table 15 Adjust the number of complete case

Type of comparing	Type of treatment		t	p-value
	Closing loop mechanics	Sliding mechanics		
	Mean (sd) (n=14)	Mean (sd) (n=14)		
Effective levels (ABOI)	27.71 (4.81)	26.50 (5.60)	0.62	0.54
Unit cost	37,784.95	35,985.30	1.21	0.24
Capital cost	6,218.33	7,214.74	-	1.00
Labour cost	21,030.07	18,160.24	-	1.00
Material cost	10,536.55	10,610.32	-3.04	0.005*

* Statistically significant at 1%

Another sensitivity analysis was performed by equally adjusting number of instructors and patients. Therefore, 33 treated cases by closing loop mechanics would be reduced to 14 cases and the 14 treated cases by sliding mechanics would be remained. The number of instructors was also adjusted from 11 persons to 3 persons which was equal to sliding mechanics. There was statistically significant difference in unit and material costs between two methods of treatment at the 1% level (Table 16).

Table 16 Adjust the number of complete case and instructors

Type of cost	Type of treatment		t	p-value
	Closing loop mechanics	Sliding mechanics		
	Mean (sd) (n=14)	Mean (sd) (n=14)		
Age at the start of treatment (years)	14.13(1.28)	14.03(1.65)	0.18	0.86
Duration of treatment (months)	29.57(8.32)	34.36(8.13)	-1.54	0.14
Severity of malocclusion levels (DI)	17.29(4.39)	17.21(6.50)	0.03	0.97
Effective levels (ABOI)	27.64(4.90)	26.50(5.60)	0.57	0.57
Unit cost (baht)	(30,751.19)	(35,985.30)	-11.88	0.001*
Capital cost (baht)	(6,218.33)	(7,214.74)		1.00
Labour cost (baht)	(15,261.16)	(18,160.24)		1.00
Material cost (baht)	(9,271.70)	(10,610.32)	-3.04	0.005*

* Statistically significant at 1%

CHAPTER V
DISCUSSION

This study was a pioneer study on the cost and effectiveness of fixed orthodontic treatment in the Orthodontic Clinic of Orthodontic Department, Faculty of Dentistry, Mahidol University in the period of fiscal 2005. The study assessed cost and treatment results from complete cases from 1988 to 2005 in a Orthodontic Clinic for Class I malocclusion patients treated by using closing loop mechanics and sliding mechanics. In the study, costs such as cost of durable articles, clinic renovation, orthodontic material, salary or wage were identified for their utilization in activities of each treatment method. These included their actual useful lives, the depreciation, and the cost of actual used area.

This study used data that were involved with all activities in the Orthodontic Clinic. Most data were collected by researcher but some data were obtained from the interview and observation.

Characteristics of complete cases

The patients in this study were consecutively treated patients by postgraduate students in orthodontics. In the present study, there were initial differences between both treatment methods. For closing loop mechanics, more than 60% of the patients were female. For sliding mechanics, more than 70% were female. This might be because women to seek orthodontic treatment primarily for esthetic reasons.

For the closing loop mechanics group, the average pre-treatment age was 14.38 $\pm$ 1.36 years. The average treatment durations were 32.61 $\pm$ 7.92 months. The median DI scores were 16.00.

For the sliding mechanics group, the average pre-treatment age was 14.03 $\pm$ 1.65 years. The average treatment durations was 34.36 $\pm$ 8.14 months. The median DI scores were 15.00.

There was no statistically significant difference in characteristic of complete cases between closing loop mechanics and sliding mechanics treatments.

Component parts of total cost of fixed orthodontic treatment

1. Labour cost

It was found that the major component part of total cost of fixed orthodontic treatment for both treatment methods was the labour cost, which was found to be 694,734.26 baht (68.11%) for closing loop mechanics and 254,243.35 baht (63.12%) for sliding mechanics. It should be pointed out that the salary was the main component part of the labour cost. The latter component part of the labour cost was medical care. For the closing loop mechanics the salary of orthodontist was found to be high. This may be explained that most orthodontists who supervised postgraduate students were senior instructors.

The labour cost of orthodontist in this study was the estimated cost of orthodontist during supervision with postgraduate students when they treated their patients in short interval per visit; it was calculated from the consulting time with orthodontist from the beginning to completion of treatment. In other words, costs were calculated in terms of the treatment durations. In summary, the salaries and welfare were the major factors influencing the labour cost in this study. Though the salaries and wage could not be controlled, but the administrator could manage the utilization of instructors and staffs for example, frequency of working, number of hours per visit to achieve the highest efficiency to control cost.

2. Material cost

The total material cost for fixed orthodontic treatment of both treatment methods was 325,284.08 baht (31.89%) for closing loop mechanics and 148,544.46 baht (36.88%) for sliding mechanics. Orthodontic material was the main source of the material cost which was 189,699.96 baht (58.32%) for closing loop mechanics and 71,259.27 baht (47.97%) for sliding mechanics. Orthodontic material cost was high because they were most imported and preformed such as preformed band and

archwires. Since it was expensive material the postgraduate students should be careful when selected to use this material.

3. Capital cost

The total capital cost was classified by types of durable articles. It was indicated that capital cost was spent on durable articles which equaled to 149,029.75 baht (76.54%) for closing loop mechanics and 84,536.61 baht (83.69%) for sliding mechanics. The highest capital costs were found in orthodontic care section at 144,720.39 baht (74.32% of capital costs) for closing loop mechanics and 82,016.62 baht (81.20% of capital costs) for sliding mechanics. That was included depreciation of all related items. In this study, they were furniture, the office supplies, dental equipment, dental supplies, clinical renovation and consultancies. The capital cost was the lowest cost of all cost components. The capital cost was low because the Orthodontic Clinic was built long time ago and most dental equipments were gradually expired. It was found that the proportion of depreciation cost of sliding mechanics was a slightly higher than that of the closing loop mechanics. This was because treatment method of sliding mechanics spent more treatment duration in orthodontic care section than closing loop mechanics in depreciation calculated.

Unit cost of fixed orthodontic treatment

Total cost of fixed orthodontic treatment was 1,214,731.36 baht or 36,810.04 baht on average per complete case for closing loop mechanics and for sliding mechanics was 503,794.19 baht or 35,985.30 baht on average per complete case. There was statistically significant difference in average per complete case between closing loop mechanics and sliding mechanics treatments. It was found that for both complete treatment methods, closing loop mechanics caused the higher cost per complete case than sliding mechanics because most orthodontists in the Orthodontic Clinic used this method in treating their patients. This can be seen from the proportion of salary cost in treatment with closing loop mechanics which was higher than that of sliding mechanics. Because there were 11 instructors (78.57%) who supervised postgraduate students to treat the patients with closing loop mechanics whereas only 3

instructors (21.43%) supervised postgraduate students to treat the patients with sliding mechanics. The main contributor of costs is the level of seniority and the number of instructors.

In this study, the unit cost per complete case of fixed orthodontic treatment used the estimated cost of orthodontist by calculating the time the instructors spent during consulting and supervising postgraduate students when they treated their patients. This does not calculate the total working time of orthodontist spent on orthodontic clinic. Therefore the information from the number of complete cases was based on the mean treatment durations.

The unit cost of fixed orthodontic treatment was composed of capital cost of 5,900.39 baht, and recurrent cost of 30,909.65 baht (16.03, 83.97 respectively) for closing loop mechanics. For sliding mechanics it was 7,214.74 baht for capital cost and recurrent cost of 28,770.56 baht (20.05, 79.95 respectively). It was shown that the recurrent cost was higher than the capital cost. Labour cost was the largest component of the recurrent cost, therefore, recurrent cost was higher. Labour cost fluctuating according to the number of instructors the orthodontic clinic and the number of treatment duration. When comparing with the study of Pietila, T., et al. (1998), it was found that the unit cost of the orthodontic treatment per complete case at health centers in Finland was, on average, FIM 7358 which was equivalent to 55,158.24 baht. When they estimated, the personnel costs of orthodontist and dentists, a full-time equivalent (FTE) was used to calculate the total working time of the orthodontists and dentists spent on orthodontic treatment.

The study of Richmond, S., et al. (2004) found that the mean cost in the Hospital Dental Service was £903 (67,688.88 baht) and the Community Dental Service was £505 (37,854.80 baht). The study of Järvinen, S. & Widström, E. (2002) found that the average cost of orthodontic treatment in the Finnish public health service was 1565 Euros (79,220.30 baht) per complete case. Their study estimated the unit cost according to timing of treatment, class of malocclusion, type of appliances used and treatment method.

The results of this study would not be able to directly compared with those of Pietila, T., et al. (1998); Richmond, S., et al. (2004) and Järvinen, S. & Widström, E.

(2002), because the unit cost of complete case in this study was estimated by selecting patients who fit inclusion criteria. Those studies were designed as an outcome assessment of patients who had all classes of malocclusions and all patients were treated in a university clinic. The results in this study were similar to the findings of Richmond, S., et al. (2004), which with cost differences reflecting differences in remuneration of provider in orthodontic care and approved with the study of Järvinen, S. & Widström, E. (2002) that the total costs increase in relation to increasing treatment duration.

Effectiveness level in fixed orthodontic treatment

One examiner scored the ABOI index for all cases used in this study. The overall mean ABOI score for both treatment methods was 27.92 $\pm$ 5.02 points. According to ABO guidelines, a case score of 30 or more points will be unacceptable, and a score less than 20 will generally be acceptable. Similar scores for closing loop mechanics and sliding mechanics were 28.52 and 26.50, respectively. Although the score for sliding mechanics treatment seemed to be smaller than that of the closing loop mechanics, there was no statistical difference ($p > 0.05$). The results of this study cannot be directly compared with those of Deguchi, T., et al. (2005); Pinskaya, Y.B., et al.(2004) and Abei, Y., et al.(2004), because of the difference in sample selection. Those studies were designed as an outcome assessment of patients who had all classes of malocclusions. The difference in sample that was selected with the difference criteria then cannot be directly compared with this study.

Of the 8 components used in the ABOI, there was no significant difference in all components between both treatment methods. This confirmed that the treatment results between two treatment methods were similar. Marginal ridge was found to be the most significant component which lost the most score, and contact point was second factors. This result was not consistent with the studies of Abei, Y., et al. (2004) and Deguchi, T., et al. (2005), which found alignment and buccolingual inclination to be most significant point lost, respectively.

The strength and weakness of this study

The strength of the study were as follows:

1. This study received good cooperation from the administrators, staffs and postgraduate students of the Orthodontic Clinic. Then, some data was received by staffs and postgraduate students of the clinic.

2. The researcher found that valid measures of treatment result is important for both dental health care providers and dental health care consumers and could be used as evidence-based decisions in clinical situations.

3. This study used the ABOI to evaluate treatment outcome by using 8 categories. The ABOI could be used as the outcome measures that separate specialists from general practitioners. Moreover, it could be apply to self-assess the outcome of the orthodontist so that he or she would be helped to improve the quality of treatment over the life span of a practice.

The weakness of the study:

1. This study was retrospective study, therefore selection of the providers who have similar skills for both treatment was impossible.

2. This study was performed in patients with class I malocclusion, so the result could not be implemented to all classes of malocclusions.

3. The number of orthodontists, samples and the level of skill for supervising postgraduate students were different between both treatment methods.

4. The number of samples in this study was small.

CHAPTER VI
CONCLUSION AND RECOMMENDATIONS

The purpose of this study was to analyse cost and effectiveness of fixed orthodontic treatment in the Orthodontic Clinic of the Orthodontic Department, Faculty of Dentistry, Mahidol University. The study was done by using both primary and secondary sources of data in the fiscal year 2005 (October 1, 2004 – September 30, 2005). This study was conducted by means of provider's perspective. The population of this study included all complete cases from 1988 to 2005. Data were obtained by using record forms. Details of collected data of cost were composed of capital cost, labour cost, material cost and the clinic performance. All data were complied to analyse in order to identify each activity. The capital cost allocation was conducted by using direct distribution method. Details of collected data of effectiveness were composed of dental records, dental casts, panoramic radiographs and summary report of treatment results. Data of cost and effectiveness were analysed and recorded using Software packages for Windows.

Moreover, this study analysed the cost per complete case of each treatment method in the Orthodontic Clinic and also included the comparison of the effectiveness level per cost between two treatment methods.

Conclusion of the study

1. Cost in fixed orthodontic treatment

Orthodontic Clinic provides service for education by serving patients mostly on fixed orthodontic treatment activities under educational service which emphasized on dental health promotion and development. The result of the study showed that unit cost of fixed orthodontic treatment was 36,564.37 baht per complete case at mean treatment duration of 33.13 months. The unit cost of closing loop mechanics was

36,810.04 baht per complete case at mean treatment duration of 32.61 months and unit cost for sliding mechanics was 35,985.30 baht per complete case mean treatment duration of 34.36 months.

Total cost of fixed orthodontic treatment with closing loop mechanics was 1,214,731.36 baht. The distribution of the total costs for closing loop mechanics was 83.97% for recurrent cost and 16.03% for capital cost. The recurrent cost included the labour cost of 694,734.26 baht and material cost of 325,284.08 baht. The proportion of labour cost and material cost was 68.11, 31.89.

Total cost of fixed orthodontic treatment with sliding mechanics was 503,794.19 baht. The distribution of the total costs for sliding mechanics was 79.95% for recurrent cost and 20.05% for capital cost. The recurrent cost included the labour cost of 254,243.35 baht and material cost of 148,544.46 baht. The proportion of labour cost and material cost was 63.12, 36.88.

The capital cost of fixed orthodontic treatment with closing loop mechanics was 194,713.02 baht. The proportion of durable articles, clinic renovation and consultant was 76.54, 15.25, 8.21.

The capital cost of fixed orthodontic treatment with sliding mechanics was 101,006.38 baht. The proportion of durable articles and clinic renovation was 83.69, 16.31.

The study found among the recurrent cost, which was most half of the total cost, the cost of labour was the highest component for closing loop mechanics was 68.11% and 63.12% for sliding mechanics. Those were calculated in terms of the treatment durations. The salaries and welfare were the major factors influencing of the labour cost. Though the salaries and wage could not be controlled, but the administrator could manage the utilization of instructors and staffs for example, frequency of working, number of hours per visit to achieve the highest efficiency to control cost. Furthermore, treatment duration of postgraduate students was the first cause of increasing cost.

2. Characteristics of complete cases

The samples of both closing loop mechanics and sliding mechanics groups had similar characteristics. Most of them were 12-17 years old and DI score were 10-30 points. The mean pre-treatment DI scores of fixed orthodontic treatment for 47 complete cases was 16.00 $\pm$ 5.08. The closing loop mechanics method's median DI score was 16.00 and median DI score was 15.00 for sliding mechanics. No significant difference was found between both treatment methods assessed for severity of malocclusion ($p > 0.05$).

3. The comparison of unit cost and effectiveness levels of fixed orthodontic treatment in the Orthodontic Clinic

The mean treatment costs were 36,810.04 baht was composed of capital cost, labour cost and material cost (5,900.39, 21,052.55, 9,857.10 baht respectively) for closing loop mechanics and 35,985.30 baht was composed of capital cost, labour cost and material cost (7,214.74, 18,160.24, 10,610.32 baht respectively) for sliding mechanics. When testing for statistically significant differences between closing loop mechanics and sliding mechanics treatments, statistical difference at p-value < 0.05.

The overall mean ABOI score for both treatment groups was 27.92 $\pm$ 5.02 points. For the effectiveness level of closing loop mechanics, the mean scores was 28.52 $\pm$ 4.71. The effectiveness level which less than or equal 30 scores was 63.64% and more than 30 scores was 36.36%.

For the effectiveness level of sliding mechanics, the mean scores were 26.50 $\pm$ 5.60. The effectiveness level which was less than or equal 30 scores was 78.57% and more than 30 scores was 21.43%.

The study found that the treatment outcome between two methods was similar. Marginal ridge was found to be the most significant component which lost the most score, and contact point was second factors. So, the administrator should review teaching process in part of clinical practice of graduate program.

Recommendations

The Orthodontic Clinic should be emphasized on the quality of clinical performance and the utilization of the limited resources at the highest benefit for the customers and organization.

1. Recommendation from findings

1.1 The main factor of the cost calculation in the respective activities is the labour cost. Therefore, further research should focus on labour such as orthodontists. In this study the labour cost was stable and difficult to be changed. The seniority and the number of instructors in the closing loop mechanics made the treatment cost higher than that of sliding mechanics. If the number of instructors in treatment with closing loop mechanics equaled to the number of instructors in treatment with sliding mechanics, unit cost of closing loop mechanics would have been lower than that of sliding mechanics.

1.2 If every activity had efficiency resources used, then the unit cost of each treatment method would have been decreased.

1.3 For collecting data on the cost, it was found that some data in complete folder of postgraduate students were not in detail. It is recommended that recording the data should be standardized.

1.4 From the result of the ABO score, it is recommended that instructors should pay more attention in marginal ridge and contact points before appliance removal.

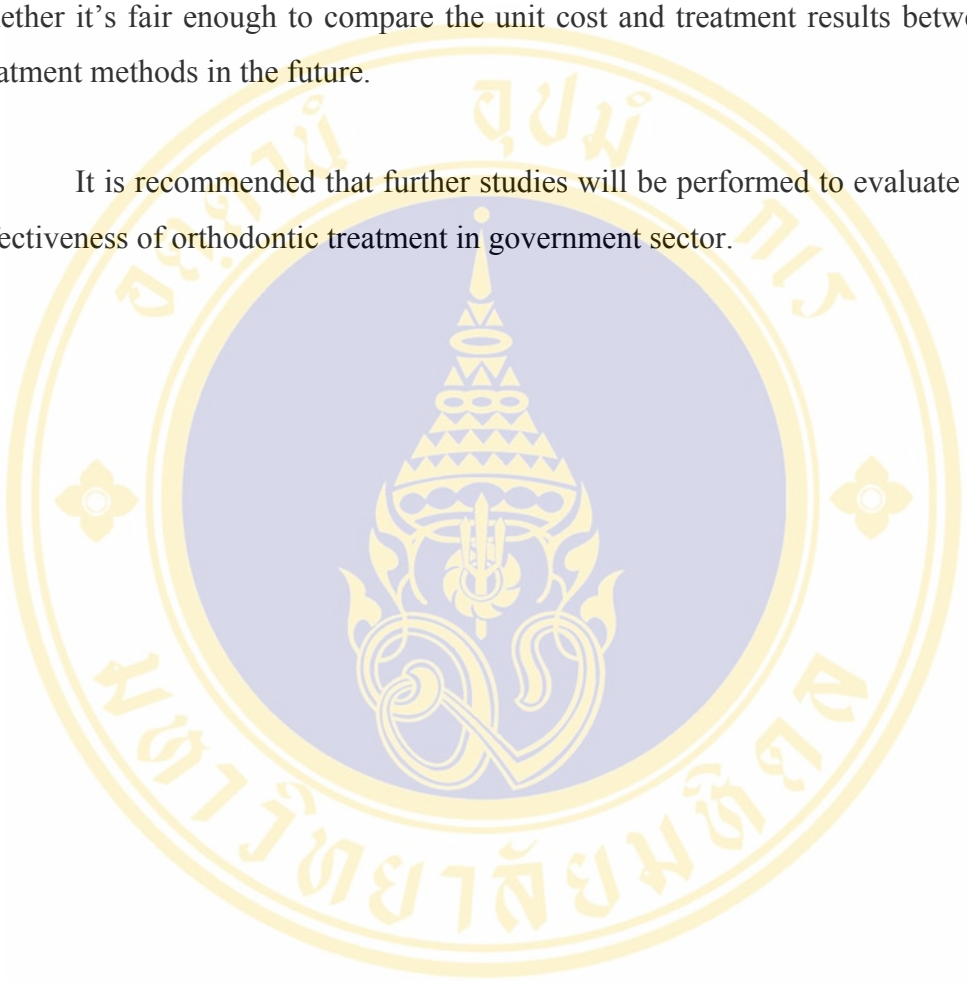
2. Recommendation for further study

The study method should be careful about difference of the number staff in each treatment method. The salaries and wage could not be controlled, but the administrator could manage the utilization of staffs for example, frequency of working, number of hours per visit to achieve the highest efficiency to control cost.

To collect the information of patient for effectiveness analysis is a difficult task in retrospective study and then caused for the selection of sample to represent the population group and to control the skill of provider in both treatment methods. The

effectiveness analysis should be experimental study and were randomly selected that it would be reliable. However, the difference in sample size and selection methods between both treatment methods might have some effect on these results or the assessment results. Thus, further research is necessary to have larger samples and whether it's fair enough to compare the unit cost and treatment results between both treatment methods in the future.

It is recommended that further studies will be performed to evaluate cost and effectiveness of orthodontic treatment in government sector.



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APPENDIX

DOCUMENT OF ETHICAL CLEARANCE

No. 160/2005

Documentary Proof of Ethical Clearance
The Committee on Human Rights Related to
Human Experimentation
Mahidol University, Bangkok

Title of Project: Cost and Effectiveness Analysis in Orthodontic Treatment with Fixed Appliance in Orthodontic Clinic, Faculty of Dentistry Mahidol University (Thesis for Master Degree)

Principle Investigator: Miss Sukanda Sodamuk

Name of Institution: Faculty of Public Health

Approved by the Committee on Human Rights Related to Human Experimentation

Signature of Chairman: .....
(Professor Dr.Srisin Khusmith

Signature of Head of the Institute: .....
(Professor Dr.Pornchai Matangkasombu

Date of Approval: 28 NOV 2005

DATA COLLECTING FORM IN THIS STUDY

Part	Form Code	Objective of Record Form
I		**RESEARCH TOOLS**
	CC-1	Capital cost for clinic renovation
	CC-2	Capital cost for durable articles and consultancies
	LC-1	Labour cost record
	LC-2	Using time record for activity of staff who works more than 1 department
	MC-1	Material cost: Orthodontic material, waste orthodontic material and orthodontic instruments
	MC-2	Public utility cost: Electrical supply
	MC-3	Public utility cost: Water supply and maintenance
	ABO-1	ABOI for treatment result record
	ABO-2	DI for severity of malocclusion record
II		**TABLE OF GENERAL STUDIED INFORMATION**
		Structure administration of Orthodontic Department
		Master plan of building
		Total capital cost
		Total labour cost
		Total material cost
		Total cost and unit cost
		Examination in calculation of electrical supply
		Examination in calculation of durable articles
		All complete cases data in effectiveness analysis
		Examination in effectiveness analysis

PART I

Record form code CC-1

Capital cost for clinic renovation

All usage are in this study……m^2

Type of treatment……..

Name of activity	Area (m^2)	Proportion (%)	Building modify per minute:second (baht)	Working time per visit (minute:second)	Building modify cost per treatment method (baht)
Total clinic renovation cost					

Record form code CC-2

Capital cost for durable articles and consultancies

Type of treatment……..

Item	Number	Price/ Unit	Total	Start year	Useful life (year)	Used in year	Depre./minute (baht)	Working time per visit (min.:sec.)	Depre. per treat. method (baht)
Total durable articles cost & consultancies cost									

Record form code LC-1

Labour cost record

Type of treatment……

No	Code	Level(C)	Position	Salaries		Remuner-ation for high position	Medical care	Child education	Training & conference	Total
				Oct.-Mar. 05	Apr.-Sep. 05					
Total labour cost										

Record form code LC-2

Using time record for activity of staff who works more than 1 department

Type of treatment……

No.	Activity	Working time per visit (minute: second)					Average working time (minute: second)	Working time per treat. method	Total
		Person …..	Person …..	Person ….	Person ….	Person …			
Total									

Record form code MC-1

Material cost: Orthodontic material, waste orthodontic material and orthodontic instrument

Type of treatment……

Code of patient:…… Treatment duration:…….months

No.	Item	Number	Unit	Price/Unit	Total
Total					

Record form code MC-2

Public utility cost: Electrical supply

Type of treatment……..

Item	Number	Unit	Model (watt)	Power (watt)	Working time (minute: second)	Used interval per time (minute/treatment method)	Price Electric per unit (baht)	Service price per minute (baht)	Ft value Per unit (baht)	Total (baht)
Total										

Record form code MC-3

Public utility cost : Water supply and maintenance

Water value in fiscal year 2004……. Baht.

Type of treatment……

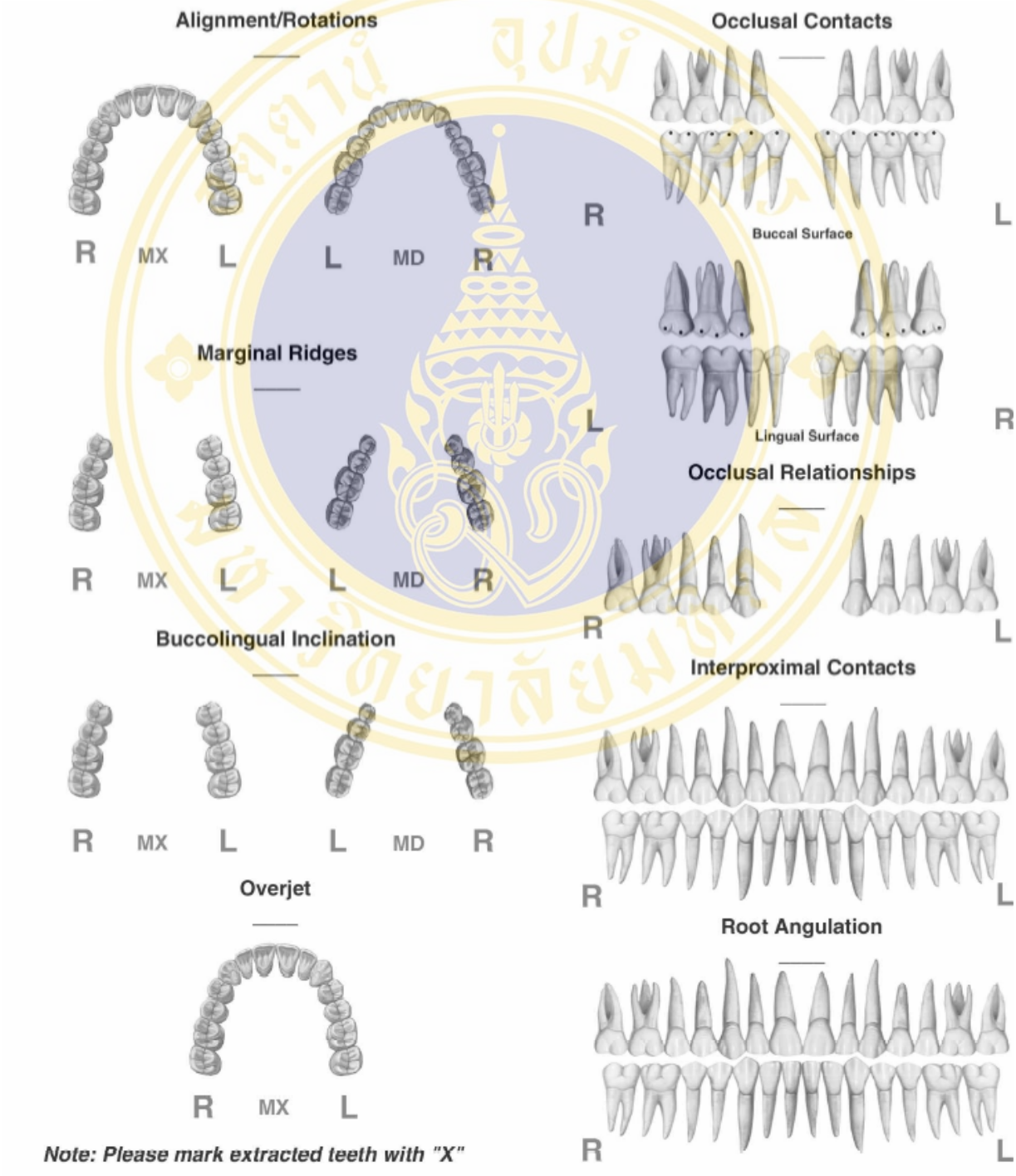
No.	Activity	Area (m^2)	Proportion (%)	Water supply per minute:second (baht)	Working time per visit (minute:second)	Water supply cost per treat. method (baht)
Total						

Record form code ABO-1

Type of Treatment : _____

Ortho. No.:_____ Complete No.:_____

Total Score :_____



Adapted from American Board of Orthodontic, 2004

Record form code ABO-2

DISCREPANCY INDEX

Type of treatment :_____
Ortho. No. _____Complete No._____
Total DI Score:_____

Sex :_____Age:_____
Treatment duration: _____

OVERJET = _____

0 mm. (edge to edge) = 1 pt.
0 - 3 mm. = 0 pt.
3.1 - 5 mm. = 2 pts.
5.1 – 7 mm. = 3 pts.
7.1 – 9 mm. = 4 pts.
> 9 mm. = 5 pts.
Negative OJ(x-bite) 1 pt. per mm. per tooth =
Total = _____

OVERBITE = _____

0 – 3 mm. = 0 pts.
3.1 – 5 mm. = 2 pts.
5.1 – 7 mm. = 3 pts.
Impinging (100%) = 5 pts.
Total = _____

ANTERIOR OPENBITE = _____

0 mm. (edge to edge) = 1 pt.
Then 2 pts. per mm. per tooth
Total = _____

LATERAL OPENBITE = _____

2 pts. per mm. per tooth
Total = _____

CROWDING Upper: _____ Lower :_____

1 -3 mm. = 1 pt.
3.1 – 5 mm. = 2 pts.
5.1 – 7 mm. = 4 pts.
> 7 mm. = 7 pts.
Total = _____

OCCLUSION = _____

Class I to end on = 0 pt.
End on Class II or III = 2 pts. per side
Full Class II or III = 4 pts. per side
Beyond Class II or III = 1 pt. per mm. Additional
Total = _____

LINGUAL POSTERIOR X-BITE =_____

1 pt. per tooth Total = _____

BUCCAL POSTERIOR X-BITE = _____

2 pts.per tooth Total = _____

***CEPHALOMETRICS : ANB : _____**
SN-MP :_____
IMPA :_____

ANB >5.5 or < -1.5 = 4 pts.
Each Additional Degree = 1 pt.
SN-MP 27 deg. – 37 deg. = 0 pts.
SN-MP > 37 deg. = 2 pts.per degree
SN-MP < 27 deg. = 1 pt.per degree
IMPA > 103 deg. = 1 pt.per degree
Total =_____

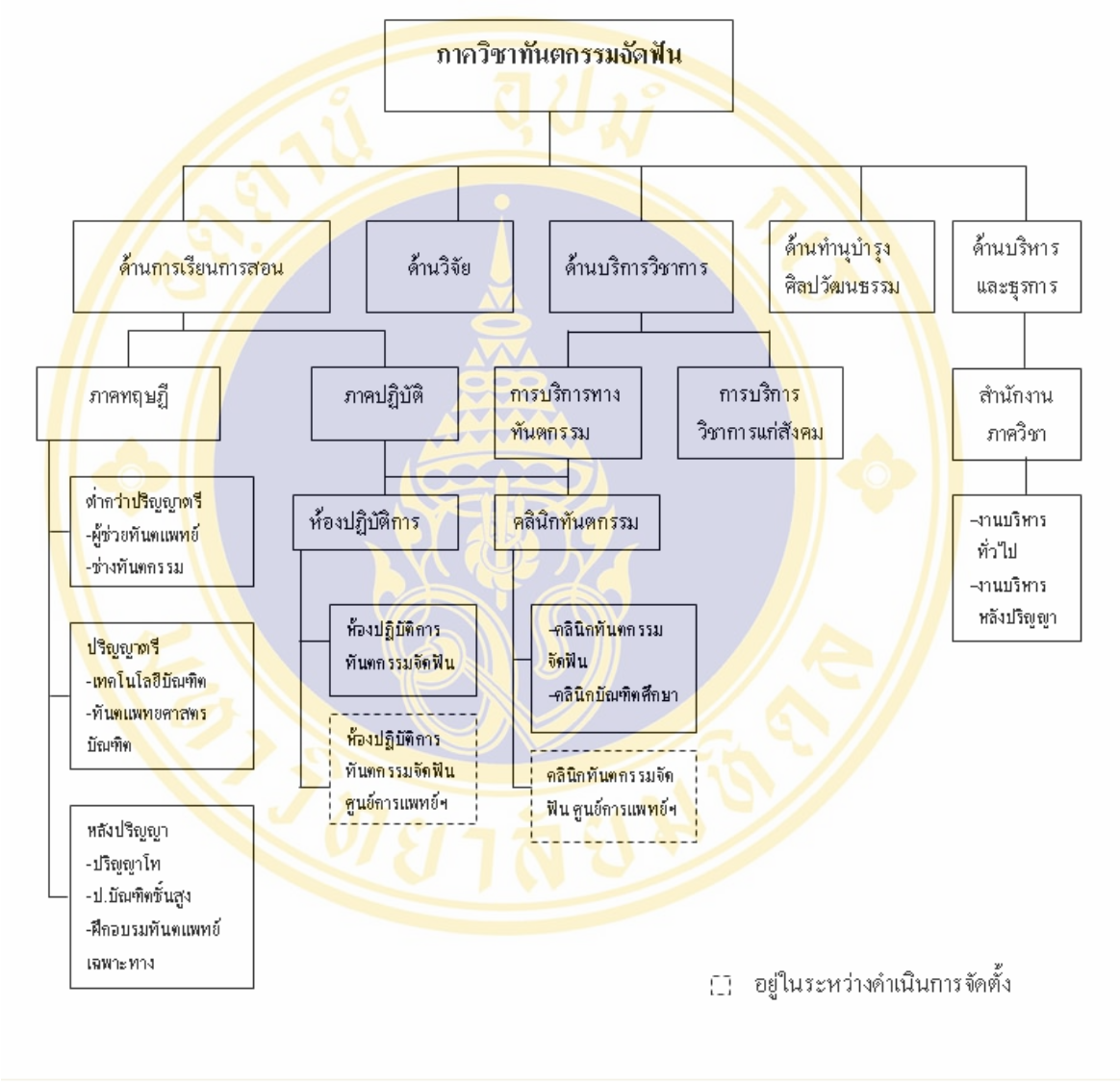
OTHER 2 points = _____
(See instructions)

INDICATE PROBLEM_____

*Was modified to fit for Thai population. Source : Data from Dechkunakorn S. et al.,1994. Adapted from American Board of Orthodontics, 2004

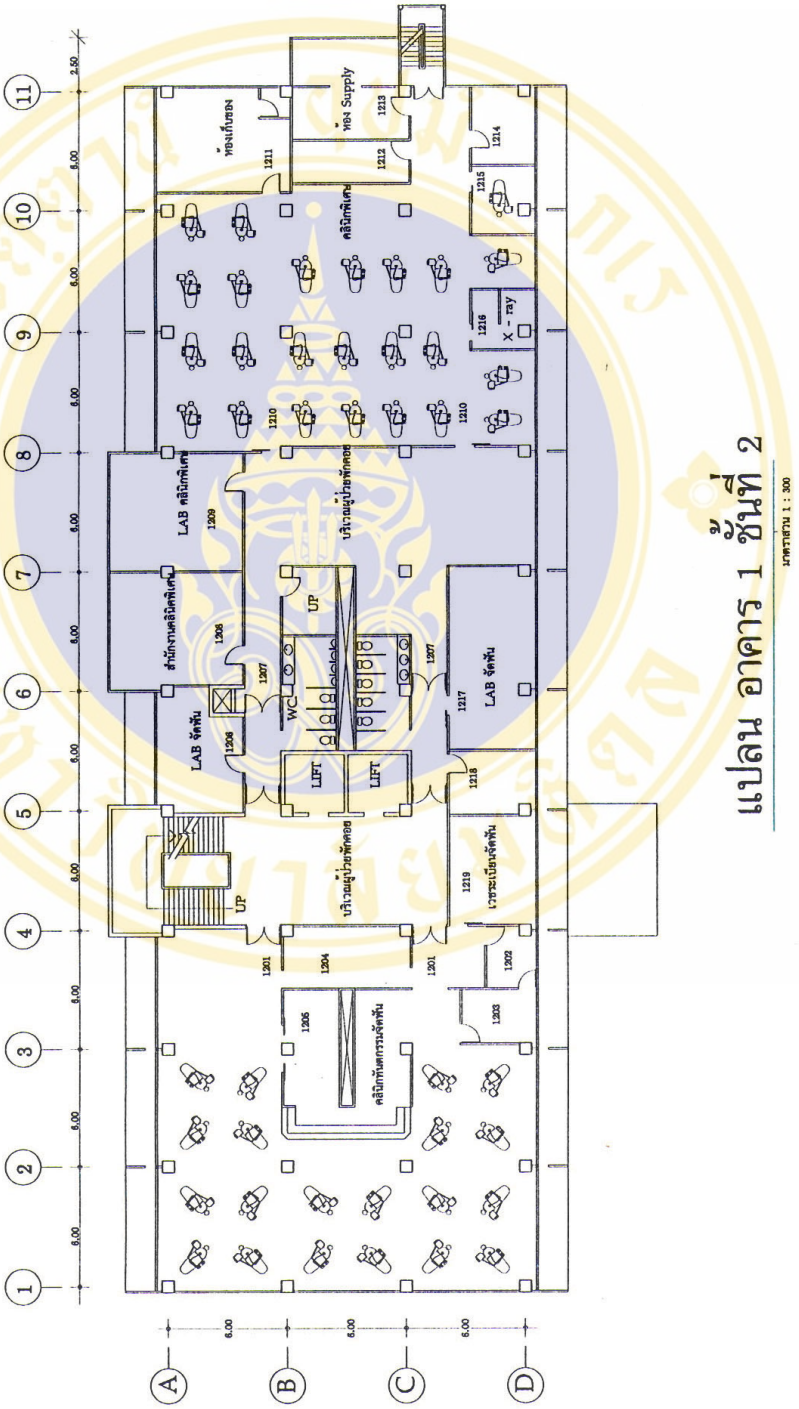
PART II

Structure administration of Orthodontic Department



ที่มา : รายงานประจำปี ภาควิชาทันตกรรมจัดฟัน คณะทันตแพทยศาสตร์ มหาวิทยาลัยมหิดล, 2547

Master plan of building



Total Capital cost of orthodontic treatment with fixed appliance used closing loop mechanics and sliding mechanics
Fiscal year 2005

Type of capital cost	Type of treatment				Total cost
	Closing loop mechanics	%	Sliding mechanics	%	(Baht)
Durable articles	149,029.75	76.54	84,536.61	83.69	233,642.90
Clinic renovation	29,698.94	15.25	16,469.78	16.31	46,183.97
Consultancies	15,984.33	8.21		-	15,992.54
Total capital cost	**194,713.02**	**100.00**	**101,006.38**	**100.00**	**295,719.41**

Total Labour cost of orthodontic treatment with fixed appliance used closing loop mechanics and sliding mechanics
Fiscal year 2005

Type of labour cost	Labour cost (baht:minute)		Using time (minute:second)		Total labour cost			
	Closing loop mechanics	Sliding mechanics	Closing loop mechanics	Sliding mechanics	Closing loop mechanics	%	Sliding mechanics	%
Salary								
Orthodontist	18.60	5.75	5,380.24	1,339.84	100,058.81		7,708.76	
Dental technician	2.32	2.32	12,879.19	5,176.59	29,940.60		12,034.16	
Dental assistant and Other staff	9.12	9.12	40,639.58	20,377.65	370,808.00		185,931.91	
Total salary					500,807.41	72.09	205,674.82	80.90
Remuneration of high position	0.95	1.14	5,380.24	1,339.84	5,116.32	0.74	1,522.02	0.60
Medical care	2.82	1.69	58,899.01	26,894.08	166,012.36	23.90	45,354.37	17.84
Child education	0.13	0.01	58,899.01	26,894.08	7,929.80	1.14	149.15	0.06
Training and conference	0.25	0.06	58,899.01	26,894.08	14,868.37	2.14	1,542.98	0.61
Total labour cost	**34.20**	**20.09**	**240,976.28**	**108,916.15**	**694,734.26**	**100.00**	**254,243.35**	**100.00**

used closing loop mechanics and sliding mechanics
Fiscal year 2005

Type of material cost	Type of treatment				Total cost (Baht)
	Closing loop mechanics	%	Sliding mechanics	%	
Orthodontic material					
Clinic material	167,950.11	51.49	63,418.86	42.69	231,368.97
Laboratory material	21,749.85	6.67	7,840.41	5.28	29,590.26
Waste orthodontic material	20,594.37	6.31	11,688.49	7.87	32,282.86
Orthodontic instruments	4,636.69	1.42	3,059.23	2.06	7,695.91
Utility:		-		-	-
Electric	42,678.24	13.08	23,081.80	15.54	65,760.04
Water	2,673.09	0.82	1,530.74	1.03	4,203.82
Maintenance	65,920.92	20.21	37,924.95	25.53	103,845.87
Total material cost	**326,203.27**	**100.00**	**148,544.46**	**100.00**	**474,747.73**

Total cost of orthodontic treatment with fixed appliance used closing loop mechanics and sliding mechanics Fiscal year 2005

Type of cost	Type of treatment				Total cost (Baht)
	Closing loop mechanics	%	Sliding mechanics	%	
Recurrent cost:					
Labour cost					
Salary	500,807.41	72.09	205,674.82	80.90	706,482.23
Remuneration of high position	5,116.32	0.74	1,522.02	0.60	6,638.34
Medical care	166,012.36	23.90	45,354.37	17.84	211,366.74
Child education	7,929.80	1.14	149.15	0.06	8,078.95
Training and conference	14,868.37	2.14	1,542.98	0.61	16,411.34
Total labour cost	694,734.26	68.11	254,243.35	63.12	948,977.61
Material cost					
Orthodontic material	189,699.96	58.32	71,259.27	47.97	260,959.23
Waste orthodontic material	20,594.37	6.33	11,688.49	7.87	32,282.86
Orthodontic instruments	4,636.69	1.43	3,059.23	2.06	7,695.91
Utility	44,432.14	13.66	24,612.53	16.57	69,044.67
Maintenance	65,920.92	20.27	37,924.95	25.53	103,845.87
Total material cost	325,284.08	31.89	148,544.46	36.88	473,828.54
Total recurrent cost	**1,020,018.34**	**83.97**	**402,787.81**	**79.95**	**1,422,806.149**
Capital cost:					
Durable articles	149,029.75	76.54	84,536.61	83.69	233,566.36
Clinic renovation	29,698.94	15.25	16,469.775	16.31	46,168.72
Consultancies	15,984.33	8.21	0.00	0.00	15,984.33
Total capital cost	**194,713.02**	**16.03**	**101,006.38**	**20.05**	**295,719.407**
Full cost	1,214,731.364		503,794.192		1,718,525.557
Unit cost per complete case	**36,810.04**		**35,985.30**		**36,564.37**

Remark: Labour cost this research an estimated cost of specialist orthodontist at the consulting with postgraduate between treated patient

Record form code MC-2
Public utility cost: Electrical supply
หลักสูตรเทคนิคการแพทย์ คณะเทคนิคการแพทย์ศาสตร์ มหาวิทยาลัยมหิดล

Item	Number	Unit	Model watt	Power watt	Working time (minute second) Closing	Working time (minute second) Sliding	Used interval per treatment method (minute second) Closing	Used interval per treatment method (minute second) Sliding	Price E. per unit (Baht)	Service price per minute (baht) 228.17	PI value per unit (baht)	Total (baht) Closing	Total (baht) Sliding
งานห้องปฏิบัติการ													
เครื่อง Trimmer	2	เครื่อง	1000	2000	2,838.00	1190.00	94.60	39.77	2.14	0.03	0.43	246.07	103.44
[illegible]	4	หลอด	22	88	21,760.00	10,080.00	34.85	14.78	2.14	0.03	0.43	90.85	38.46
[illegible]	1	เครื่อง	1600	1600	154.50	42.00	4.12	1.12	2.14	0.03	0.43	10.72	2.91
[illegible]	1	เครื่อง	65	65	856.00	311.00	0.93	0.36	2.14	0.03	0.43	2.42	0.93
[illegible]	1	เครื่อง	500	500	268.00	117.00	2.20	0.93	2.14	0.03	0.43	5.72	2.43
[illegible]	1	เครื่อง	2200	2200	1,240.00	95.00	45.47	3.48	2.14	0.03	0.43	118.27	9.06
[illegible]	2	เครื่อง	250	500	317.20	83.20	2.64	0.69	2.14	0.03	0.43	6.88	1.80
[illegible]	2	หลอด	22	44	2,194.18	676.68	1.61	0.42	2.14	0.03	0.43	4.19	1.10
[illegible]	1	เครื่อง	500	500	38.00	6.00	0.32	0.07	2.14	0.03	0.43	0.82	0.17
[illegible]	1	เครื่อง	125	125	317.20	83.20	0.56	0.15	2.14	0.03	0.43	1.44	0.38
[illegible]	1	เครื่อง	2200	2200	12,879.19	5,176.59	472.24	189.81	2.14	0.03	0.43	1,228.37	493.72
[illegible]	2	เครื่อง	225	450	12,879.19	5,176.59	96.59	38.82	2.14	0.03	0.43	251.28	100.99
[illegible]	1	เครื่อง	3200	3200	12,879.19	5,176.59	686.89	276.08	2.14	0.03	0.43	1,786.73	718.14
[illegible]	1	ตู้	25	25	12,879.19	5,176.59	5.37	2.16	2.14	0.03	0.43	13.96	5.61
[illegible]	6	หลอด	40	240	12,879.19	5,176.59	51.52	20.71	2.14	0.03	0.43	134.00	53.86
รวม							-					3,901.47	1,533.01
งานห้องปฏิบัติการเฉพาะทาง					32.61	34.36							
[illegible]					1,076.13	481.04							
หลอดไฟแขวน	3	เครื่อง	250	750	2,656.04	1,188.17	33.23	14.85	2.14	0.03	0.43	86.42	38.63
[illegible]	3	เครื่อง	18	54	2,656.04	1,188.17	2.39	1.07	2.14	0.03	0.43	6.22	2.78
[illegible]	1	เครื่อง	315	315	2,656.04	1,188.17	13.95	6.24	2.14	0.03	0.43	36.30	16.23
[illegible]	1	เครื่อง	45	45	1,076.13	481.04	0.81	0.36	2.14	0.03	0.43	2.10	0.94
[illegible]	1	เครื่อง	5	5	538.07	240.52	0.04	0.02	2.14	0.03	0.43	0.12	0.05
[illegible]	1	เครื่อง	75	75	1,076.13	481.04	0.13	0.06	2.14	0.03	0.43	0.35	0.16
[illegible]	1	เครื่อง	50	50	1,111.25	1,393.94	2.60	1.16	2.14	0.03	0.43	6.76	3.02
ไดรไฟร์	2	หลอด	40	80	1,111.25	1,393.94	4.16	1.86	2.14	0.03	0.43	10.81	4.83
รวม					-	-						149.09	66.64
งานรายวิชา					-	-							-
เครื่องปั่นเหวี่ยง	1	เครื่อง	1813	1813	4,295.01	2,143.33	127.06	64.76	2.14	0.03	0.43	330.51	168.46
ไดรไฟร์	3	หลอด	40	120	4,295.01	2,143.33	8.41	4.29	2.14	0.03	0.43	21.88	11.15
ตะเกียง	2	หลอด	40	80	4,295.01	2,143.33	5.61	2.86	2.14	0.03	0.43	14.58	7.43
รวม					-	-						366.97	187.05
งานปฏิบัติการเฉพาะทางเคมีคลินิก					-	-							-
Hot air oven	2	เครื่อง	1450	2900	1,076.13	481.04	50.22	22.45	2.14	0.03	0.43	130.63	58.39
เครื่อง Seal	1	เครื่อง	500	500	161.42	72.16	1.35	0.60	2.14	0.03	0.43	3.50	1.56
ตู้เย็น	1	ตู้	145	145	30,474.69	-	73.85	-	2.14	0.03	0.43	191.57	-
ไดรไฟร์	1	หลอด	40	120	1,152.68	1,409.37	2.11	2.82	2.14	0.03	0.43	16.40	7.33
รวม					-	-						342.10	67.29
งานปฏิบัติการฯ													
ตู้อบความชื้น	20	ตู้	2000	40000	27,556.97	16,203.81	1,333.33	541.79	2.14	0.03	0.43	3,468.22	1,409.29
ไฟส่องเข้า	20	หลอด	150	3000	27,556.97	16,203.81	7.50	40.67	2.14	0.03	0.43	19.51	105.70
เครื่องปรับอากาศ 11.02 BTU/ชั่วโมง	1	เครื่อง	3660	19300	30,474.69	17,523.01	9,802.89	5,636.17	2.14	0.03	0.43	25,498.40	14,661.64
ไดรไฟร์	36	หลอด	40	1440	30,474.69	17,523.01	711.39	409.05	2.14	0.03	0.43	1,850.47	1,063.93
เครื่องปั่นผล	10	เครื่อง	2200	22000	30,474.69	17,523.01	1,117.41	642.51	2.14	0.03	0.43	2,906.55	1,671.27
เครื่องปั่นไฟฟ้า	1	เครื่อง	500	500	30,474.69	17,523.01	253.96	146.03	2.14	0.03	0.43	660.58	379.84
เครื่องทำความร้อน	1	เครื่อง	79	79	30,474.69	17,523.01	40.13	23.07	2.14	0.03	0.43	104.37	60.01
ตะเกียงไฟฟ้า	37	หลอด	40	960	30,474.69	17,523.01	182.85	105.14	2.14	0.03	0.43	475.62	273.48
ไฟฟ้า	1	เครื่อง	50	50	30,474.69	17,523.01	25.40	14.60	2.14	0.03	0.43	66.06	37.98
ไฟฟ้าส่อง	1	เครื่อง	150	150	30,474.69	17,523.01	76.19	43.81	2.14	0.03	0.43	198.17	113.95
ตะเกียงไฟฟ้า	1	เครื่อง	670	670	30,474.69	17,523.01	340.30	195.67	2.14	0.03	0.43	885.18	508.98
เครื่องความร้อน	1	เครื่อง	400	400	30,474.69	17,523.01	203.16	116.82	2.14	0.03	0.43	528.46	303.87
เครื่องผสม VDO	1	เครื่อง	400	400	30,474.69	17,523.01	203.16	116.82	2.14	0.03	0.43	528.46	303.87
เครื่องดูดฝุ่น	5	เครื่อง	2500	12500	8,222.03	2,780.41	259.17	115.85	2.14	0.03	0.43	674.14	301.35
เครื่อง Heat seal	1	เครื่อง	50	50		107.61	-	0.09	2.14	0.03	0.43	-	0.23
Glass bead	5	เครื่อง	170	850	215.23	215.23	0.61	0.61	2.14	0.03	0.43	1.59	1.59
Intercom	2	ตู้	45	90	215.23	215.23	0.32	0.32	2.14	0.03	0.43	0.84	0.84
รวม												37,910.62	21,227.81
รวมค่าไฟที่ใช้ของทุกกลุ่มงาน												42,676.24	23,581.80

Remark : Electrical value normal ratio (Electromotive force level 22-23 Kw)
Electrical price/unit 2.1412 baht, service price per month 228.17
PI value = 0.4328 baht/unit

CC-2 แบบบันทึกข้อมูลครุภัณฑ์
คลินิกทันตกรรมจัดฟัน คณะทันตแพทยศาสตร์ มหาวิทยาลัยมหิดล
ปีที่ผลิต/นับ 2546

ลำดับ	รายการ	จำนวนชิ้น	ราคาต่อหน่วย	ราคารวม	ปีที่เริ่มใช้งาน	อายุการใช้งาน (ปี)	ใช้งานเป็นปีที่	ค่าเสื่อมราคา/ปี	ค่าเสื่อมราคา/นาที (บาท)	เวลาปฏิบัติงาน/นาที/วิธี Closing	Sliding	ค่าเสื่อมราคา/วิธีการรักษา (บาท) Closing	Sliding
งานห้องปฏิบัติการ													
	เครื่อง Trimmer	1	124,120.00	124,120.00	2546	5	3	24,824	0.23736852	1,193.00	2,838.00	283.1806464	673.651865
	[illegible]	1	145,000.00	145,000.00	2546	5	4	29,000	0.27729987	18.50	63.50	5.130047985	17.6085294
	[illegible]	1	50,000.00	50,000.00	2546	5	3	10,000	0.09562058	275.00	726.00	26.29565953	69.4205393
	[illegible]	1	55,000.00	55,000.00	2546	5	3	11,000	0.10518264	112.00	264.00	11.78045615	27.7682167
	[illegible]	1		-	2534	8	15	-	0				
	[illegible]	7	42,000.00	294,000.00	2546	5	3	58,800	0.5622[illegible]	21.20	66.20	11.91967071	37.2205835
	[illegible]	1	9,630.00	9,630.00	2547	5	2	1,926	0.01841652	12,879.19	5,176.59	237.1898651	95.3347532
	[illegible]	2	34,000.00	68,000.00	2547	5	2	13,600	0.13004[illegible]	12,879.19	5,176.59	1674.860937	673.184135
	[illegible]	1	154,000.00	154,000.00	2547	5	2	30,800	0.29451138			0	0
	[illegible]	1	1,250.00	1,250.00	2548	5	1	250	0.00239051	12,879.19	5,176.59	30.78780487	12.3747084
	[illegible]	1	34,000.00	34,000.00	2527	5	22	-	0			0	0
	[illegible]	13	2,200.00	28,600.00	2546	5	3	5,720	0.05469[illegible]	12,879.19	5,176.59	704.4268059	283.133327
	[illegible]	1	14,000.00	14,000.00	2546	5	3	2,800	0.02677378	282.00	1,201.00	7.550200003	32.1552878
	รวมงานปฏิบัติการ								1.80455154	63,418.45	25,865.05	2,993.12	1,921.85
งานต้อนรับและเวชระเบียน				-									
	[illegible]	3	33,010.00	99,030.00	2546	5	1	19,806	0.18938612	2,658.04	1,188.17	503.3960796	225.022674
	[illegible]	3	9,630.00	28,890.00	2547	5	2	5,778	0.05524957	2,658.04	1,188.17	146.855627	65.6458149
	[illegible]	1	2,022.30	2,022.30	2544	5	3	404	0.00386747	2,658.04	1,188.17	10.27969369	4.59520705
	[illegible]	1		-	2526	5	21	-	0	1,076.13	481.04	0	0
	[illegible]	1	7,997.18	7,997.18	2546	5	1	1,599	0.01529[illegible]	538.07	240.52	8.229111965	3.67848869
	เครื่องรูด Credit card	1	5,000.00	5,000.00	2546	5	3	1,000	0.00956[illegible]	1,076.13	481.04	10.29001721	4.59973225
	[illegible]	1	36,738.45	36,738.45	2546	5	1	7,348	0.07025904	3,118.25	1,393.94	219.0853638	97.9366182
	รวมงานต้อนรับและเวชระเบียน			-					0.34361815			808.14	401.48
[illegible]				-									
	เครื่องปรับอากาศ (12,000 BTU)	1	15,000.00	15,000.00	2546	5	3	3,000	0.02868617	4,205.01	2,143.33	120.6257338	61.4840312
	[illegible]	2	980.00	1,960.00	2546	5	3	392	0.00374833	4,205.01	2,143.33	15.76176265	8.03391341
	[illegible]	1	1,780.00	1,780.00	2546	5	3	356	0.00340409	4,205.01	2,143.33	14.31425374	7.29610503
	[illegible]	1	600.00	600.00	2546	5	3	120	0.00114745	4,205.01	2,143.33	4.825029352	2.45936125
	[illegible]			-					0.03698604			155.53	79.27
[illegible]				-									
	[illegible]	2	29,960.00	59,920.00	2527	5	12	-	0				
	เครื่อง Seal	1	29,000.00	29,000.00	2544	5	5	5,800	0.05545993				
	[illegible]	1		-	2519	5	34	-	0				
	[illegible]	1	14,552.00	14,552.00	2544	5	5	2,910	0.02782941				
	[illegible]			-					0.08326935	3,152.68	1,409.33	262.58	117.38
งานบำบัดรักษา				-									
	[illegible]	4	430,000.00	1,720,000.00	2547	8	2	215,000	2.05584242				
	[illegible]	1	430,000.00	430,000.00	2548	8	1	53,750	0.5139606				
	รวมยูนิต								2.56980302	27,556.97	16,253.81	70,815.98	41,769.10
	เครื่องปรับอากาศ (36,000 BTU)	3	35,000.00	105,000.00	2546	5	3	21,000	0.20080321				
	เครื่องปรับอากาศ (36,000 BTU)	2	44,000.00	88,000.00	2547	5	2	17,600	0.16829222				
	รวมเครื่องปรับอากาศ								0.36909543	30,474.69	17,523.01	11,248.07	6,467.88
	[illegible]	1	1,450.00	1,450.00	2520	5	27	-	0				
	[illegible]	1	34,000.00	34,000.00	2527	5	22	-	0				
	เครื่อง glass bead	2	8,500.00	17,000.00	2536	5	13	-	0				
	[illegible]	10		-	2537	5	12	-	0				
	[illegible]	2	49,000.00	98,000.00	2544	5	5	19,600	0.18741633				
	[illegible]	2	22,200.00	44,400.00	2547	5	2	8,880	0.08491107				
	รวมเครื่องดูดฝุ่น								0.2723274	190.74	190.74	1,714.14	727.21
	[illegible]	1		-	2532	5	17	-	0				
	[illegible]	1		-	2532	5	17	-	0				
	[illegible]			-	2526	5	21	-	0				
	[illegible]	1	86,969.60	86,969.60	2548	5	1	17,394	0.16632167	30,474.69	17,523.01	5,068.60	2,914.46
	เครื่องเล่น VDO	1	31,370.00	31,370.00	2532	5	17	-	0				
	[illegible]	1	15,000.00	15,000.00	2540	5	6	-	0				
	[illegible]	1	15,000.00	15,000.00	2547	5	2	3,000	0.02868617	30,474.69	17,523.01	874.20	502.67
	[illegible]	2	25,900.00	51,800.00	2545	5	4	10,360	0.09906292	1,540.44	653.52	5,035.62	906.35
	[illegible]	1	88,000.00	88,000.00	2545	5	4	17,600	0.16829222				
	[illegible]	7	106,900.00	748,300.00	2546	5	3	149,660	1.43105756				
	[illegible]	1	21,000.00	21,000.00	2547	5	2	4,200	0.04016064				
	รวมเครื่องมือจัดฟัน								1.63951042	30,474.69	17,523.01	49,963.67	28,729.16
	รวมงานบำบัดรักษา			-						151,186.91	87,190.13	144,720.38	82,016.62

No.	CODE	SEX	AGE	TIME	APPOINT	DI	ABOI UP	METHOD	ALIGN	MARG RID	BUCCO LN	OVERJET	OCC CONT	OCC RELA	INTER CO	ROOT ANG
1	178	male	14.00	18.00	1.00	12.00	29.00	closing loop	4.00	4.00	6.00	1.00	4.00	2.00	2.00	6.00
2	183	male	12.00	24.00	1.00	13.00	21.00	closing loop	1.00	7.00	4.00	.00	1.00	2.00	1.00	5.00
3	216	female	12.00	20.00	1.00	17.00	21.00	closing loop	4.00	4.00	1.00	2.00	3.00	5.00	.00	2.00
4	231	female	16.10	24.00	2.00	14.00	23.00	closing loop	1.00	6.00	5.00	1.00	1.00	3.00	2.00	4.00
5	320	male	13.04	26.00	.00	19.00	22.00	closing loop	2.00	3.00	3.00	4.00	2.00	4.00	2.00	2.00
6	389	female	17.00	43.00	4.00	14.00	37.00	sliding mechanics	1.00	7.00	3.00	1.00	7.00	7.00	7.00	4.00
7	392	male	15.06	24.00	.00	20.00	36.00	closing loop	2.00	7.00	5.00	3.00	3.00	8.00	3.00	5.00
8	430	female	15.11	24.00	1.00	24.00	25.00	closing loop	2.00	3.00	1.00	1.00	2.00	7.00	3.00	6.00
9	446	female	13.05	37.00	.00	11.00	26.00	closing loop	1.00	6.00	7.00	2.00	1.00	1.00	5.00	3.00
10	447	male	13.03	41.00	4.00	25.00	36.00	closing loop	2.00	6.00	6.00	5.00	7.00	5.00	4.00	1.00
11	448	male	15.06	30.00	4.00	16.00	38.00	closing loop	2.00	6.00	9.00	1.00	5.00	5.00	5.00	5.00
12	449	female	14.11	36.00	1.00	18.00	27.00	closing loop	3.00	3.00	5.00	2.00	4.00	3.00	2.00	3.00
13	477	female	15.10	44.00	7.00	16.00	27.00	closing loop	1.00	7.00	3.00	3.00	3.00	.00	4.00	4.00
14	487	female	15.01	42.00	3.00	15.00	26.00	closing loop	.00	8.00	3.00	1.00	3.00	3.00	3.00	5.00
15	493	male	15.08	28.00	.00	24.00	28.00	closing loop	.00	6.00	3.00	2.00	6.00	5.00	3.00	3.00
16	500	female	13.03	26.00	.00	12.00	23.00	closing loop	1.00	5.00	2.00	1.00	2.00	5.00	2.00	5.00
17	509	female	12.10	21.00	4.00	15.00	28.00	closing loop	.00	6.00	3.00	3.00	3.00	3.00	3.00	5.00
18	521	female	16.08	27.00	3.00	12.00	25.00	closing loop	2.00	3.00	2.00	2.00	4.00	3.00	2.00	5.00
19	549	female	12.10	39.00	7.00	10.00	29.00	sliding mechanics	1.00	8.00	9.00	.00	2.00	2.00	3.00	4.00
20	626	female	14.06	43.00	2.00	11.00	17.00	sliding mechanics	1.00	4.00	2.00	1.00	1.00	4.00	2.00	2.00
21	653	male	15.00	31.00	.00	17.00	32.00	closing loop	1.00	8.00	4.00	5.00	4.00	3.00	4.00	3.00
22	659	male	15.00	31.00	.00	20.00	31.00	closing loop	1.00	8.00	4.00	3.00	6.00	.00	6.00	3.00
23	728	female	17.00	29.00	.00	15.00	34.00	closing loop	1.00	7.00	6.00	3.00	3.00	4.00	1.00	3.00
24	767	female	15.02	47.00	.00	27.00	26.00	closing loop	1.00	8.00	3.00	1.00	3.00	1.00	5.00	2.00
25	778	male	12.08	33.00	.00	10.00	33.00	closing loop	2.00	6.00	3.00	1.00	7.00	5.00	5.00	4.00
26	785	male	16.00	46.00	.00	22.00	31.00	closing loop	.00	6.00	1.00	1.00	9.00	5.00	3.00	6.00
27	786	male	15.00	45.00	.00	16.00	23.00	closing loop	2.00	4.00	3.00	2.00	3.00	2.00	3.00	4.00
28	794	female	16.00	30.00	.00	18.00	25.00	sliding mechanics	1.00	7.00	1.00	.00	3.00	4.00	4.00	6.00
29	807	female	14.00	28.00	.00	27.00	29.00	sliding mechanics	.00	8.00	5.00	2.00	2.00	6.00	3.00	3.00
30	818	female	12.00	25.00	.00	25.00	31.00	sliding mechanics	1.00	7.00	4.00	4.00	6.00	1.00	2.00	6.00
31	839	female	15.06	30.00	.00	24.00	37.00	closing loop	1.00	6.00	7.00	2.00	8.00	7.00	4.00	2.00
32	866	male	14.09	40.00	.00	16.00	33.00	closing loop	2.00	6.00	7.00	1.00	7.00	2.00	5.00	3.00
33	872	female	15.00	46.00	.00	12.00	19.00	sliding mechanics	1.00	3.00	2.00	1.00	3.00	1.00	2.00	4.00
34	883	female	15.05	18.00	1.00	16.00	23.00	sliding mechanics	1.00	4.00	1.00	5.00	2.00	3.00	3.00	4.00
35	892	female	14.00	36.00	1.00	14.00	29.00	closing loop	1.00	8.00	6.00	.00	3.00	4.00	4.00	3.00
36	913	female	14.10	36.00	.00	16.00	23.00	closing loop	.00	6.00	2.00	.00	4.00	2.00	6.00	3.00
37	938	female	15.04	34.00	.00	12.00	32.00	closing loop	.00	7.00	7.00	1.00	5.00	3.00	4.00	3.00
38	949	female	15.00	38.00	.00	15.00	25.00	closing loop	1.00	6.00	5.00	.00	5.00	5.00	.00	3.00
39	950	female	15.00	36.00	.00	12.00	28.00	closing loop	2.00	4.00	7.00	4.00	8.00	.00	1.00	2.00
40	953	male	14.05	42.00	.00	26.00	19.00	sliding mechanics	1.00	3.00	3.00	1.00	3.00	3.00	1.00	4.00
41	978	male	16.01	31.00	.00	13.00	30.00	sliding mechanics	2.00	5.00	7.00	3.00	6.00	2.00	3.00	2.00
42	983	female	16.10	32.00	.00	20.00	30.00	closing loop	1.00	6.00	5.00	5.00	5.00	4.00	2.00	2.00
43	984	male	14.02	32.00	.00	19.00	25.00	sliding mechanics	1.00	6.00	4.00	3.00	3.00	1.00	2.00	3.00
44	986	female	12.02	40.00	.00	15.00	31.00	closing loop	1.00	5.00	9.00	2.00	7.00	2.00	2.00	3.00
45	989	female	12.03	33.00	.00	10.00	30.00	sliding mechanics	2.00	7.00	5.00	2.00	6.00	4.00	.00	4.00
46	995	female	12.05	30.00	.00	27.00	26.00	sliding mechanics	1.00	6.00	4.00	1.00	6.00	3.00	1.00	4.00
47	1013	male	13.00	41.00	.00	13.00	31.00	sliding mechanics	2.00	7.00	4.00	4.00	6.00	2.00	3.00	3.00

Examination in effectiveness analysis

T-Test

Group Statistics

	1=closing, 2=sliding	N	Mean	Std. Deviation	Std. Error Mean
AGE	closing loops	33	14.3779	1.3637	.2374
	Sliding mechanics	14	14.0264	1.6509	.4412
TIME	closing loops	33	32.6061	7.9252	1.3796
	Sliding mechanics	14	34.3571	8.1392	2.1753
DI	closing loops	33	16.7879	4.4564	.7758
	Sliding mechanics	14	17.2143	6.5065	1.7389
ABOI_UP	closing loops	33	28.5152	4.7112	.8201
	Sliding mechanics	14	26.5000	5.5988	1.4963

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
AGE	Equal variances assumed	.352	.556	.759	45	.452	.3515	.4633	-.5817	1.2846
	Equal variances not assumed			.701	20.904	.491	.3515	.5010	-.6908	1.3937
TIME	Equal variances assumed	.026	.873	-.687	45	.495	-1.7511	2.5477	-6.8824	3.3802
	Equal variances not assumed			-.680	23.985	.503	-1.7511	2.5759	-7.0677	3.5655
DI	Equal variances assumed	5.059	.029	-.260	45	.796	-.4264	1.6373	-3.7242	2.8714
	Equal variances not assumed			-.224	18.393	.825	-.4264	1.9041	-4.4207	3.5679
ABOI_UP	Equal variances assumed	.485	.490	1.268	45	.211	2.0152	1.5896	-1.1865	5.2168
	Equal variances not assumed			1.181	21.206	.251	2.0152	1.7063	-1.5313	5.5616

T-Test of component ABOI score

Group Statistics

	1=closing, 2=sliding	N	Mean	Std. Deviation	Std. Error Mean
ALIGN	closing loops	33	1.3636	1.0252	.1785
	Sliding mechanics	14	1.1429	.5345	.1429
MARG_RID	closing loops	33	5.9091	1.4001	.2437
	Sliding mechanics	14	6.0000	1.5689	.4193
BUCCO_LN	closing loops	33	4.4545	2.2092	.3846
	Sliding mechanics	14	3.8571	2.2138	.5917
OVERJET	closing loops	33	2.0303	1.5306	.2664
	Sliding mechanics	14	2.0000	1.5689	.4193
OCC_CONT	closing loops	33	4.5758	2.1070	.3668
	Sliding mechanics	14	4.0000	2.0381	.5447
OCC_RELA	closing loops	33	3.4848	2.0174	.3512
	Sliding mechanics	14	3.0714	1.8172	.4857
INTER_CO	closing loops	33	3.0606	1.5996	.2785
	Sliding mechanics	14	2.5714	1.6508	.4412
ROOT_ANG	closing loops	33	3.6364	1.3652	.2376
	Sliding mechanics	14	3.9286	1.2067	.3225

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
ALIGN	Equal variances assumed	5.989	.018	.760	45	.451	.2208	.2906	-.3645	.8060
	Equal variances not assumed			.966	42.846	.340	.2208	.2286	-.2403	.6819
MARG_RID	Equal variances assumed	.764	.387	-.196	45	.845	-9.091E-02	.4628	-1.0230	.8411
	Equal variances not assumed			-.187	22.237	.853	-9.091E-02	.4850	-1.0961	.9143
BUCCO_LN	Equal variances assumed	.462	.500	.847	45	.401	.5974	.7051	-.8227	2.0175
	Equal variances not assumed			.847	24.526	.405	.5974	.7057	-.8574	2.0522
OVERJET	Equal variances assumed	.102	.751	.062	45	.951	3.030E-02	.4918	-.9601	1.0208
	Equal variances not assumed			.061	24.026	.952	3.030E-02	.4968	-.9950	1.0556
OCC_CONT	Equal variances assumed	.266	.609	.865	45	.392	.5758	.6658	-.7651	1.9167
	Equal variances not assumed			.877	25.344	.389	.5758	.6567	-.7758	1.9273
OCC_RELA	Equal variances assumed	.584	.449	.661	45	.512	.4134	.6257	-.8468	1.6736
	Equal variances not assumed			.690	27.136	.496	.4134	.5993	-.8160	1.6429
INTER_CO	Equal variances assumed	.203	.655	.950	45	.347	.4892	.5150	-.5480	1.5264
	Equal variances not assumed			.938	23.880	.358	.4892	.5217	-.5879	1.5663
ROOT_ANG	Equal variances assumed	2.492	.121	-.693	45	.492	-.2922	.4214	-1.1410	.5566
	Equal variances not assumed			-.729	27.640	.472	-.2922	.4006	-1.1133	.5289

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