THE OVERALL ESTHETIC ASSESSMENT OF ANTERIOR SINGLE-TOOTH IMPLANT RESTORATION USING ESTHETIC SUSTAINABLE CRITERIA IN 5-YEAR CLINICAL CROSS-SECTIONAL STUDY

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การประเมินความสวยงามโดยรวมของงานบูรณะฟันด้วยรากเทียมบริเวณฟันหน้าแบบหนึ่งซี่โดยการใช้เกณฑ์ความสวยงามอย่างยั่งยืน โดยการศึกษาผลทางคลินิก ณ เวลา 5 ปี หลังการใส่รากฟันเทียม

น.ส.ธฤษวรรณ แสงประเสริฐกุล

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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ธฤษวรรณ แสงประเสริฐกุล : การประเมินความสวยงามโดยรวมของงานบูรณะฟันด้วยรากเทียมบริเวณฟันหน้าแบบหนึ่งซี่โดยการใช้เกณฑ์ความสวยงามอย่างยั่งยืน โดยการศึกษาผลทางคลินิก ณ เวลา 5 ปี หลังการใส่รากฟันเทียม . (THE OVERALL ESTHETIC ASSESSMENT OF ANTERIOR SINGLE-TOOTH IMPLANT RESTORATION USING ESTHETIC SUSTAINABLE CRITERIA IN 5-YEAR CLINICAL CROSS-SECTIONAL STUDY) อ.ที่ปรึกษาหลัก : รศ. ทพ.ประเวศ เสรีเชษฐพงษ์, อ.ที่ปรึกษาร่วม : รศ. ทพ. ดร.อาทิพันธุ์ พิมพ์ขาวขำ,ทพญ. ดร.วรีย์รัตน์ เจิ่งประภากร

วัตถุประสงค์: เพื่อเปรียบเทียบคะแนนความสวยงามโดยรวมของรากเทียมโดยใช้เกณฑ์ความสวยงามอย่างยั่งยืนระหว่างหลักยึดรากเทียมชนิดไทเทเนียม เซอร์โคเนีย และโลหะผสมทอง โดยการศึกษาผลทางคลินิก ณ เวลา 5 ปี หลังการใส่รากฟันเทียม

วัสดุและวิธีการทดลอง: การศึกษาแบบตัดขวางโดยทำการเรียกคนไข้ที่ทำการปักรากเทียมบริเวณฟันหน้าบนแบบหนึ่งซี่จำนวน 24 คน โดยแบ่งเป็น 8 คนต่อหลักยึดหนึ่งชนิด มาตรวจลักษณะเนื้อเยื่อรอบรากเทียม คราบจุลินทรีย์ การอักเสบ ระดับร่องลึกปริทันต์ และประเมินความสวยงามโดยรวมโดยใช้เกณฑ์ความสวยงามอย่างยั่งยืน ซึ่งสามารถแบ่งได้เป็น คะแนนความสวยงามของเหงือก ครอบฟัน และคุณภาพของกระดูกที่รองรับรากเทียม นอกจากนี้ทำการเปรียบเทียบความหนาและความสูงเฉลี่ยของกระดูกด้านริมฝีปากที่รองรับรากเทียม ณ เวลา 0-2 ปี และ 5 ปี ภายหลังใส่ครอบฟันบนรากเทียมสำเร็จ

ผลการศึกษา: หลักยึดบนรากเทียมแต่ละชนิดมีคราบจุลินทรีย์ การอักเสบของเนื้อเยื่อรอบรากเทียมและระดับร่องลึกปริทันต์ไม่แตกต่างกันอย่างมีนัยสำคัญ และให้ผลคะแนนความสวยงามอย่างยั่งยืน ได้แก่ คะแนนความสวยงามของเหงือก ครอบฟัน และคุณภาพของกระดูกรอบรากเทียมไม่แตกต่างกันอย่างมีนัยสำคัญ อย่างไรก็ตามพบว่าเส้นแกนรากเทียมของหลักยึดชนิดเซอร์โคเนียได้รับคะแนนสูงกว่าหลักยึดไทเทเนียมอย่างมีนัยสำคัญ โดยเป็นเส้นแกนรากเทียมที่ออกจากปุ่มคอฟัน นอกจากนี้เมื่อเปรียบเทียบความหนาและความสูงเฉลี่ยของกระดูกด้านริมฝีปากที่รองรับรากเทียม ณ เวลา 0-2 ปี และ 5 ปี หลังใส่ครอบฟัน พบว่าความหนาเฉลี่ยของกระดูกด้านริมฝีปากที่รองรับรากเทียมของหลักยึดไทเทเนียมและเซอร์โคเนียลดลงอย่างมีนัยสำคัญ และความสูงเฉลี่ยของกระดูกด้านริมฝีปากที่รองรับรากเทียมของหลักยึดเซอร์โคเนียและโลหะผสมทองลดลงอย่างมีนัยสำคัญ

สรุป: ภายใต้ข้อจำกัดของการศึกษาแบบตัดขวาง พบว่า ไม่มีความแตกต่างอย่างมีนัยสำคัญระหว่างหลักยึดสามชนิดในแง่คราบจุลินทรีย์ การอักเสบของเนื้อเยื่อรอบรากเทียม ระดับร่องลึกปริทันต์และคะแนนความสวยงามโดยรวมในแง่ของเหงือกและครอบฟัน อย่างไรก็ตามการเปรียบเทียบการเปลี่ยนแปลงของความหนาและความสูงของกระดูกด้านริมฝีปากยังไม่สามารถสรุปได้ชัดเจน เนื่องจากภาพเอกซเรย์ของกระดูก ณ เวลา 0-2 ปี ของแต่ละหลักยึดมีจำนวนไม่เท่ากัน จึงแนะนำทำการศึกษาเพิ่มเติมต่อไป

สาขาวิชา	ทันตกรรมบูรณะเพื่อความสวยงามและทันตกรรมรากเทียม	ลายมือชื่อนิสิต .....
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KEYWORD: dental implant abutment, esthetic evaluation

Tharitsawan Sangprasertkul : THE OVERALL ESTHETIC ASSESSMENT OF ANTERIOR SINGLE-TOOTH IMPLANT RESTORATION USING ESTHETIC SUSTAINABLE CRITERIA IN 5-YEAR CLINICAL CROSS-SECTIONAL STUDY . Advisor: Assoc. Prof. PRAVEJ SERICHETAPHONGSE, D.D.S., M.S. Co-advisor: Assoc. Prof. ATIPHAN PIMKHAOKHAM, D.D.S., M.S., Ph.D., WAREERATN CHENGPRAPAKORN, D.D.S., M.S., Ph.D.

Objective: To compare the esthetic score (using the Esthetic Sustainable Criteria) among titanium, zirconia and gold alloy abutments of single tooth implant in 5 years follow up.

Mateirals and Methods: 24 patients who were treated with single anterior implant at Faculty of Dentistry, Chulalongkorn University were recruited. There were 8 patients for each abutment material. Demographic data, biological parameters such as modified plaque index (mPI), modified sulcus bleeding index (mSBI), probing depth (PD), radiographic images (Periapical films and CBCT images) were collected. The esthetic score (gingival, prosthodontic and bone score) was evaluated according to the Esthetic Sustainable Criteria. The mean difference of modified sulcus bleeding index, gingival score, prosthodontic score and bone score were analysed by Kruskal-Wallis. While the mean differences of labial bone thickness, labial bone height, the distance from implant platform to the first bone-implant contact (DIB), pocket depth were compared by One-Way ANOVA. Furthermore, the comparison of labial bone thickness and height between 0-2 years and 5 years were analyzed by paired t-test, which 0.05 was the significant level.

Results: All abutment materials showed similar modified plaque index (mPI), modified sulcus bleeding index (mSBI), mean of probing depth (PD) and esthetic score (gingival, prosthodontic and bone score). Moreover, zirconia abutment illustrated better implant axis score than titanium abutment significantly. Furthermore, labial bone thickness was significantly reduced from 0-2 years to 5 years in titanium and zirconia abutments. And labial bone height was also shown to be significantly decreased in zirconia and gold alloy groups.

Conclusion: Within the limitations of this study, these three abutment materials showed the similar acceptable status for periodontal parameters such as modified plaque index, modified sulcus bleeding index, probing depth, esthetic score in term of peri-implant soft tissue and prosthesis during 5 years follow up period. However, the comparison of labial bone thickness and height alterations among abutment materials could not be concluded. Because the number of CBCT images at 0-2 years in each abutment group was not equal. It was suggested that more study with a larger sample size should be conducted.

Field of Study:	Esthetic Restorative and Implant Dentistry	Student's Signature .....
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		Co-advisor's Signature .....
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Tharitsawan Sangprasertkul

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Chapter I INTRODUCTION

Rationale and Significance of the Problem

Dental implant has been widely used due to its high success rate. Dental implant showed acceptable high success rate in many studies. Clinical study showed 90-95% success rate of single-tooth implant in anterior maxilla (1, 2). In anterior maxilla, esthetic outcome of dental implant is as important as its function. In order to evaluate the quality of anterior single implant in term of esthetic, many considerable factors should be qualified in long term usablility such as condition of prosthesis, peri-implant soft tissue stability and bone foundation.

Regarding soft tissue and crown condition, pink and white esthetic score (PES/WES), proposed by Belser et al (3), is well known objective index to evaluate esthetic outcome of single tooth implant (4, 5) and inclusively covered both peri-implant soft tissue and prosthetic component. However, this criteria fails to thoroughly show charecteristic of bone foundation. Rokn and colleagues reported soft tissue stability around anterior maxillary single tooth implant in long term 12 years follow

up. They found that pink esthetic score was statistically significant decreased over the following 12 years. But majority of implants still presented as acceptable and almost perfect soft tissue outcome. Inadequate bone support was one of the risk factor that effected soft tissue stability from this study (6). The Esthetic Sustaiable Criteria (ESC) is a new modified objective index that realize the significant of bone parameter and provide dentist in more detail of bone quality (7). All of gingiva, prosthodontic and bone parameters are evaluated in this criteria. Although, this criteria shows more accurate parameters, it still need the long term clinical study.

For long term success in implant restoration, there are multifactorial factors to promote successful esthetic outcomes. Abutment materials possible influence the soft tissue stability around implant. Transmucosal zone of the peri-implant soft tissue is critical area for emergence profile of abutment contour. The biocompatibility of material is a significant factor in this particular transmucosal area (8). Various materials such as titanium, zirconia and gold alloy have been used as implant abutment material. Each material shows different advantages and disadvantages on peri implant

soft tissue response. Previous studies showed different outcome in term of histological analysis, soft tissue parameters and marginal bone loss (9-11).

In order to clarify the long term effect of abutment materials, the Esthetic Sustaiable Criteria is used to evaluate all soft tissue, prosthesis and bone support around each abutment implant. Therefore, the objective of this study is to evaluate and compare soft tissue, prosthesis and bone support of anterior single tooth implant using different abutment material in a cross-sectional study.

Research Questions

Are there any difference in the gingival, prosthodontic and bone score (using Esthetic Sustainable Criteria) among different abutment materials?

Research Objectives

To compare the gingival, prosthodontic and bone score (using Esthetic Sustainable Criteria) among different abutment materials of single tooth implant in 5 years follow up.

Hypotheses

Null hypothesis

There are no difference in the gingival, prosthodontic and bone score (using Esthetic Sustainable Criteria) in different abutment materials.

Alternative hypothesis

There are a statistically significant difference in the gingival, prosthodontic and bone score (using Esthetic Sustainable Criteria) in different abutment materials.

Conceptual Framework

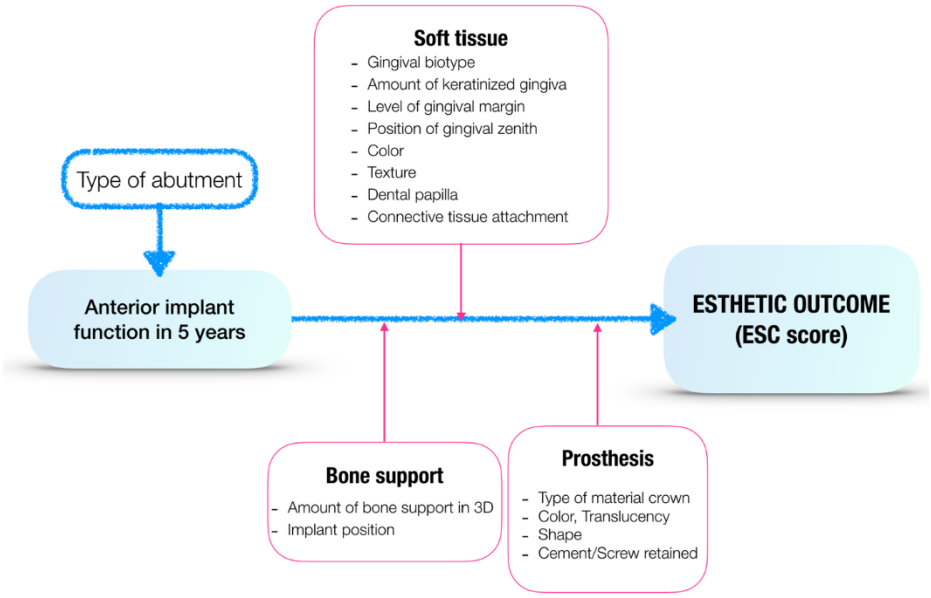

Figure 1 Conceptual framework

Expected Benefit of the Study

All gingival, prosthodontic and bone score from different abutment materials will be compared. And provide useful information for abutment selection in anterior esthetic zone.

CHAPTER II REVIEW OF LITERATURES

Loss of teeth is one of major dental problem that patient concern about. Many treatment options for replace missing teeth such as removable partial denture, fix partial denture and dental implant are presented. Dental implant has been become well known treatment nowadays. It has been developed in decades in term of surface characteristic, thread design and its ability of osteointegration. Moreover, dental implant also showed acceptable high success rate in many studies. It was reported that the success and survival rate of single tooth implant reached to 95% (1, 2). Nowadays, the function of implant itself is not only the most essential issue that dentist should be aware about. But esthetic appearance also plays significant role too. It has been published that multifactorial factors promote successful esthetic result. In this study, review literature will focus on the implant abutment material.

Implant abutment material

Abutment material is another factor that influence the soft tissue stability around implant. Transmucosal part of the peri-implant soft tissue was critical area for

emergence profile of abutment contour. The biocompatibility of material play significant role in this transmucosal part (8). Various materials have been used as implant abutment and show different outcome on peri implant soft tissue response.

Titanium has been used as implant abutment for decades due to its strength and biocompatibility to soft tissue. It is considered as a gold standard abutment because of high success rate and its properties (12, 13). However, titanium abutment in anterior region possibly showed greyish color of soft tissue around implant and effect to esthetic outcome (14). Recently, either coated titanium abutment with nitride or anodized with chemico-electrical discharge made yellow gold color for titanium and enhanced pink color at transmucosal zone. However, this color interfered ceramic color of Glass restoration such as Emax.

Zirconia has been introduced as abutment recently with prefabricated and customized design. Due to its white color, zirconia abutment is a better choice for thin biotype patient. Zirconia abutment is recommended for high translucent ceramic restoration. Moreover, it was reported that zirconia showed good biocompatibility to

soft tissue and lower plaque accumulation (15). However, zirconia abutment was reported for abutment fracture (16) especially in small diameter of dental implant.

Gold alloy abutment has been used as implant abutment by customized casting technique for decades. The emergence profile of abutment can be designed and fabricated to fit to gingival contour of each patient. Abutment contour is designed to maintain gingival architecture. Furthermore, because of the yellow color of gold is a complementary color with pink, this abutment enhance warm soft tissue color (10). However, the biocompatibility of gold alloy is still controversy. Sampatanukul et al, compared inflammatory number cell response of human tissue around different implant material over 8 weeks follow up. They reported that the area of inflammation and amount of inflammation cells were higher found in the soft tissue around the gold alloy abutments than titanium and zirconia abutments. Gold alloy showed the worst epithelium attachment compare to titanium and zirconia (9). However, one animal study showed different result in histological analysis. There was no significant

difference of epithelium attachment length between titanium and gold abutment in dogs over 6 months follow up (8).

Esthetic index for anterior maxillary implant-support restorations

To evaluate esthetic result, there are various methods reported. Overall, Esthetic outcome can be easily grouped by subjective and objective method. Subjective method is personal satisfaction. The score from each patient cannot compare with another patient's score. Patient interview and questionaire are usually used to evaluated subjective outcome. Moreover, it also provided patient's quality of life after function. Whereas, objective method is a certain index contained significant prerequisites that good quality of anterior implant should be present. There are various index that was proposed to determined esthetic outcome.

1. Pink and white esthetic score

Pink and white esthetic score was proposed by Belser at al(3). This index combined pink esthetic score with restorative evaluation. It was proven that pink esthetic score was both high inter-rater reliability and intra-rater reproducibility (17).

So, it was well known and universal widely used to evaluate esthetic outcome. Implants were evaluated by intraoral photographs and study models.

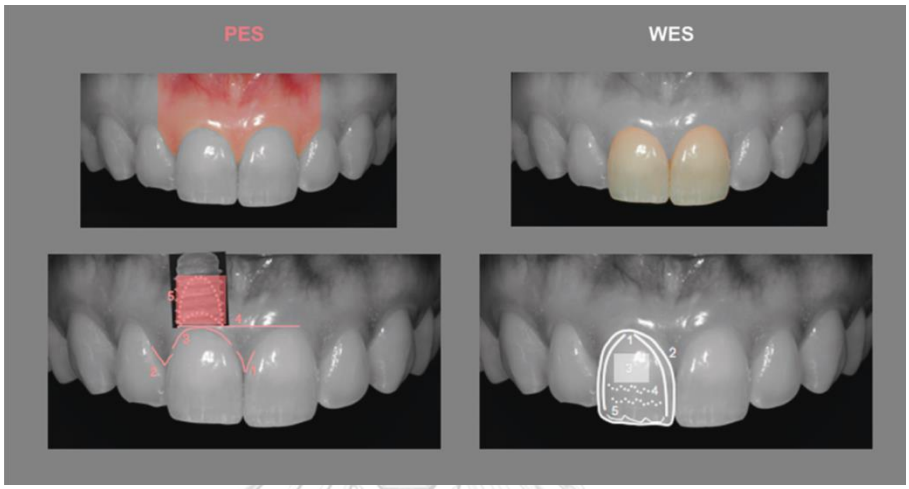

Figure 2 Variables in the pink and white esthetic score

Table 1 Pink and White esthetic score

Variables	Score		
	0	1	2
Pink esthetic score (PES)			
Mesial papilla	Absent	Incomplete	Complete
Distal papilla	Absent	Incomplete	Complete
Curvature of facial mucosa	Major Discrepancy	Minor Discrepancy	No Discrepancy
Level of facial mucosa	Major Discrepancy	Minor Discrepancy	No Discrepancy
Root convexity/ soft tissue color and texture	Major Discrepancy	Minor Discrepancy	No Discrepancy
Maximum score of PES	10		
White esthetic score (WES)			
Tooth form	Major Discrepancy	Minor Discrepancy	No Discrepancy
Tooth volume/outline	Major Discrepancy	Minor Discrepancy	No Discrepancy
Color (hue/value)	Major Discrepancy	Minor Discrepancy	No Discrepancy
Surface texture	Major Discrepancy	Minor Discrepancy	No Discrepancy
Translucency	Major Discrepancy	Minor Discrepancy	No Discrepancy
Maximum score of WES	10		

The maximum total score is 20. Excellent overall esthetic outcome is accepted if score is 17 or above. In addition, if score is less than 12 which means less favorable outcome and unacceptable clinical threshold (3).

2. Esthetic Sustainable Criteria (ESC)

Bone foundation is also important factor to support soft tissue stability. It should be another consideration for successful of single tooth implant at anterior maxilla. Esthetic sustainable criteria is proposed Komutpol et al, 2017. The objective of this criteria is to combine this invisible part which is underlining bone support with visible parts which are soft tissue and restoration (7). This system is a modified objective criteria from pink and white esthetic score. So, this criteria composes of 3 main parameters, which are gingival score, prosthodontic score, bone foundation score. The score of 2, 1, or 0 is assigned in each variables.

2.1 Gingival score

Gingival assessment is done by 7 variables which are mesial papilla, distal papilla, soft tissue level, soft tissue contour, labial soft tissue convexity, soft tissue

color and soft tissue texture. In detail, all variables are similar to pink esthetic score index but this assessment provides more detail of soft tissue.

Dental papilla is observed both mesial and distal side compared to adjacent tooth. Score 2 means papilla capable fill all of gap. While incomplete papilla fill is score 1. And score 0 means loss of papilla.

Soft tissue level is the position of the gingival zenith that should be same level with contralateral tooth. Score 2 means that implant gingival zenith equal to contralateral tooth or the difference is less than 1 mm. Score 1 implies that the discrepancy is between 1-2 mm. While score 0 means that the distance is more than 2 mm.

Soft tissue contour is contour line of gingival margin at buccal side. Symmetrical gingival margin compared to contralateral tooth is scored to 2. While score 1 is slightly detected unsymmetrical curve. And score 0 is apparent unsymmetrical curve of free gingival margin.

labial soft tissue convexity is soft tissue contour in occlusal view when compare to adjacent teeth. Score 2 is harmonious contour of soft tissue. Score 1 is slightly different of soft tissue harmony. While score 0 is no harmony of soft tissue.

Soft tissue color is determined by compare it with adjacent tooth. Score 2 means that the color of implant site similar to adjacent soft tissue. Score 1 interprets that the difference of soft tissue color is moderate. Score 0 is obvious mismatch of soft tissue color.

soft tissue texture is compared with adjacent tooth. Score 2 would be given if the texture is the same with adjacent tooth. Score 1 means that a moderate difference of soft tissue texture is found. While score 0 is clearly obvious difference.

Table 2 Summary of gingival score of Esthetic Sustainable Criteria

Variables	Reference	Score		
		0	1	2
1. Mesial papilla	Adjacent tooth	Absent	Incomplete	Complete
2. Distal papilla	Adjacent tooth	Absent	Incomplete	Complete
3. Soft tissue level	Contralateral tooth	Discrepancy > 2 mm	Discrepancy 1-2 mm	Discrepancy < 1 mm
4. Soft tissue contour	Contralateral tooth	Asymmetry	Slightly Symmetry	Symmetry
5. Soft tissue convexity	Adjacent tooth	No harmony	Slightly harmony	Harmony
6. Soft tissue color	Adjacent tooth	Obvious Difference	Moderate Difference	No difference
7. Texture	Adjacent tooth	Obvious difference	Moderate difference	No difference
Maximum gingival score		14		

2.2 Prosthodontic score

Restorative assessment consists of 6 parameters, which are tooth shape or outline, tooth form, labial contour, color, texture, translucency and characteristics. These variables can examined by both photograph and cast model.

Tooth shape or outline is outer border of tooth. Perfect restoration should be the same shape as contralateral tooth and would be given as score 2. While score 1 is restoration that moderate difference of tooth shape is presented. And score 0 is obviously different tooth shape.

Tooth form is the prosthodontic line angle that should be the same line angle with contralateral tooth and would be given as score 2. Score 1 is restoration that moderate difference of tooth form is presented. And score 0 is obviously different tooth form.

Labial contour of restoration is compared with contralateral tooth in both vertical and horizontal direction. A study model is used to exam both side. Score 2 means that restoration shows the same contour in both directions. Score 1 is restoration that slightly different labial tooth contour is presented. And score 0 is obviously different labial tooth contour.

Color of restoration is evaluated by using intraoral photograph. Score 2 means that the color restoration and contralateral tooth are the same. Score 1 is slightly

different restoration color from control. And score 0 is obviously different restoration color.

Texture of restoration is compared with contralateral tooth. Score 2 means that the texture of restoration and contralateral tooth are the same. Score 1 is slightly different restoration texture from control. And score 0 is obviously different restoration texture.

Translucency and characteristics of restoration are evaluated by using intraoral photograph and compared with contralateral tooth. Score 2 means that the translucency and characteristics of restoration and contralateral tooth are the same. Score 1 is slightly different translucency and characteristics from control. And score 0 is obviously different translucency and characteristics.

Table 3 Summary of prosthodontic score of Esthetic Sustainable Criteria

Variables	Reference	Score		
		0	1	2
1. Tooth shape/outline	Contralateral tooth	Obvious unidentical	Slightly unidentical	Identical
2. Tooth form	Contralateral tooth	Obvious unidentical	Slightly unidentical	Identical
3. Labial contour	Contralateral tooth	Obvious unidentical	Slightly unidentical	Identical
4. Color	Contralateral tooth	Obvious unidentical	Slightly unidentical	Identical
5. Texture	Contralateral tooth	Obvious unidentical	Slightly unidentical	Identical
6. Translucency and characteristic	Contralateral tooth	Obvious unidentical	Slightly unidentical	Identical
Maximum prosthodontic score		12		

2.3 Bone score

Bone support is assessed by both periapical film and dental CBCT. Six parameters are evaluated, which are labial bone thickness, labial bone height, distance from base of contact point to bone (DCB) at mesial side, distance of contact point to

bone (DCB) at distal, distance from implant platform to the first visible bone-implant contact (DIB), implant position in 3 dimension (mesiodistal, orofacial, apicocoronal), and implant axis. The distance from base of contact point to bone (DCB) and the distance from implant platform to the first visible bone-implant contact (DIB) are measured by periapical radiograph. While the others are done by CBCT images evaluation.

Labial bone thickness is calculated from implant platform surface to outer cortex of labial bone. Score 2 would be given when the distance is more than 2 mm. While score 1 would be given when the distance is between 1 to 2 mm. And score 0 would be given when the distance is less than 1 mm or dehiscence is found.

Labial bone height is determined from the implant platform to the highest point of labial wall. This parameter can be both positive value and negative value. If the peak of labial bone is higher than implant platform, positive value is given. While negative score means the peak of labial is below implant platform. In conclusion, the score 2 would be given if labial bone height is more than 0 mm. Score 1 means that

the height is more than -2 mm but less than or equal to 0 mm. Score 0 means that the height is less than -2 mm.

Distance from base of contact point to bone or DCB is measured by long cone paralleling technique. XCP is recommended to use in order to ensure parallel of the film. Ligature wire size 0.1 mm is used to ligate at both mesial and distal contact. Score 2 is given if the distance is less than 5 mm. While score 1 is given if the distance is between 5-7 mm. And score 0 is given if the distance is more than 7 mm. Distance must be measure separately between mesial and distal.

Distance from implant platform to the first bone-implant contact or DIB is also used periapical radiograph. DIB is derived from the average distance from mesial and distal aspect. This parameter can be both positive value and negative value. If the first bone-implant contact position is higher than implant platform, positive value is given. While negative score means the first bone-implant contact position is lower than implant platform. DIB was derived from the average distance from mesial and distal aspect. Score 2 is given if the distance is more than -0.6 mm. Score 1 is given if

the distance is between -0.6 mm to -2.5 mm. And score 0 is given if the distance is less than -2.5 mm.

All distance from periapical radiograph is calibrated with actual implant length in order to assure the distance.

Implant position is considered in 3 dimension by using dental CBCT. Score 2 is given if implant is located in all 3 dimensions. While score 1 is given if position of implant is corrected only 2 dimensions. And score 1 is given if implant position is corrected only 1 dimension or wrong in all 3 dimensions.

In mesiodistal direction, implant should be placed at least 1.5 mm. away from adjacent tooth. The distance is measured from the surface of implant platform to adjacent tooth in cross-sectional view. Correct implant should be placed correctly in both mesial and distal part. If distance is less than 1.5 mm only 1 side, implant immediately considered to wrong position in mesiodistal view.

In buccolingual direction, implant position is determined by distance between labial surface of single tooth implant to the imaginary line. Imaginary line is the curve

that touches the labial surface of 4 adjacent teeth of anterior maxilla in occlusal view. Correct position is considered if the distance is showed in range of 2-3 mm. In contrast, if the distance is more than 3 mm or less than 2 mm, implant position is considered to wrong position in buccolingual view.

In Apicocoronal direction, implant position is measured by distance between implant platform to the imaginary line which is level of contralateral CEJ. Correct implant platform should be below this line 3-4 mm. However, if distance is less than 3 or more than 4 mm, wrong position of implant in apicocoronal view is given.

Taken together in 3 dimension, score 2 is given when implant position must be corrected in all dimension above. Score 1 is given if implant position is corrected only 2 dimension. In the other hand, score 0 means that implant position is corrected only 1 direction or wrong in all directions.

Implant axis is evaluated in sagital view. Imaginary line is drew cross in the middle of implant. If this line pass through cingulum area, implant axis is called cingulum position. On the other hand, incisal and labial position is given if the imaginary

line is pass through incisal or labial area. Score 2 is considered when cingulum position is presented with no fenestration. While score 1 means that incisal position is found without fenestration. And score 0 means that labial position is shown. In addition, if there is any fenestration, score 0 will be given definitely.

Table 4 Summary of bone score of Esthetic Sustainable Criteria

Variables	Reference	Score		
		0	1	2
1. Labial bone thickness	Implant platform	<1	1-2	>2
2. Labial bone height	Implant platform	< -2	Between 0 to -2 mm	>0
3. DCB: Mesial	Distance between base of contact point to the connecting line of bone contact to adjacent root	>7	5-7	<5
4. DCB: Distal	Distance between base of contact point to the connecting line of bone contact to adjacent root	>7	5-7	<5
5. DIB: Mesial and distal	Distance between implant platform to the first bone-to implant contact	<-2.5	Between -0.6 to -2.5 mm	>-0.6
6. Implant position	Mesiodistal, orofacial, and apicocoronal position correction	Number of correct dimension		
		1 or 0	2	3
7. Implant axis	Midsagittal view for the position and move plane for observing a sign fenestration	Fenestration		
		Yes	No	No
		Implant axis		
		Labial	Incisal	Cingulum
Maximum bone score	14			

Komutpol et al, applied this Esthetic Sustaiable Criteria to evaluated 26 anterior single tooth implants. All implants were scored as acceptable clinical threshold by the pink and white esthetic score index. They found that they were catagorized into 3 groups according to ESC criteria. First, an excellent group, which total score were 32-36, interpreted that both of bone and gingival score were high. Second, a medium group, which total score were 24-27, meant that both of bone and gingival score were low. These two group represented that quality of bone was directly associated with quality of soft tissue. If there was something harm to bone, it definitely showed the result through gingiva too. Lastly, a divergent group, which total score were 29-33, meant that gingival and bone score showed contrast result. Authors described that there were another factors such as gingival biotype, type of abutment or amount of attach gingiva might be the contributing factors which improved gingival appearance.

CHAPTER III MATERIALS AND METHODS

Research design

This study is cross-sectional study.

Research methodology

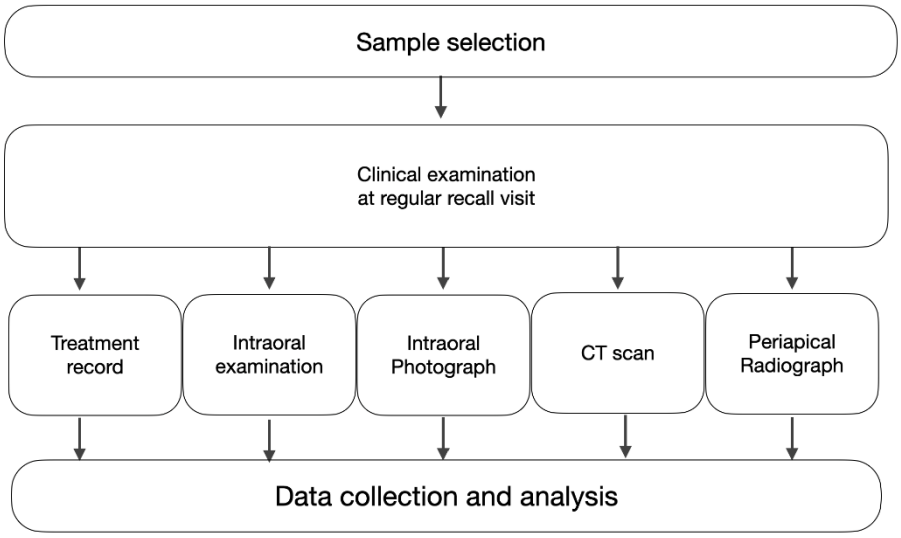

Figure 3 Research methodology

Participants

In this cross-sectional study, samples are patients who were treated with anterior single tooth implant in maxillary region at Faculty of Dentistry, Chulalongkorn University between January 2010 and December 2017. In detail, adjacent teeth must

not be a major restoration, veneer, or crown. Moreover, all recruited patients would be excluded if they presented only one of exclusion criteria which were active periodontal disease, heavy smoker (>10 cigarettes/day), uncontrolled systemic disease and no posterior tooth support. The study protocol was approved by the Human Research Ethics Committee of the Faculty of Dentistry, Chulalongkorn University (Study code : HREC-DCU 2019-029). All included participants signed an informed consent form. Patient were recalled for regular maintenance program.

Examiner

One examiner was assigned to measure all intraoral photographs, study models, CBCT images and periapical radiographs. Post graduated dental student in Esthetic restorative and implant dentistry program is chosen to be examiner. The examiner must not be involved in any part of treatment. Intra-examiner reliablity had done by re-evaluate score 3 times every week.

History taking from treatment record

All demographic data are collected, for example, demographic data, treatment time, Implant size and length, abutment material and design, surgical procedure, flap design, GBR technique, bone augmentation technique, restoration material and type of retention.

Intraoral examination

Clinical parameters were examined according to previous study (18, 19). Modified plaque index (mPI), modified sulcus bleeding index (mSBI) and probing depth (PD) were recorded at mesial, distal, buccal and palatal side. Width of keratinized gingiva was recorded at midbuccal area of implant.

Table 5 Modified plaque index (mPI)

Clinical examination	Score
No bleeding	0
Isolated bleeding spots	1
Blood forms a confluent red line	2
Heavy or profuse bleeding	3

Table 6 Modified sulcus bleeding index (mSBI)

Clinical examination	Score
No plaque	0
Plaque recognized by running a probe	1
Plaque can be seen by naked eye	2
Abundance of soft matter	3

Gingival biotype was determined by using Kan's recommendation (20). Periodontal probe was introduced into gingival sulcus at midbuccal area of adjacent natural tooth. Thin biotype would be given if shadow of the probe label reflected through gingiva. On the other hand, no noticeable ban of the probe on gingiva was found in thick biotype.

To evaluate the esthetic outcome of single implant, Intraoral photograph was taken with digital camera (NikonD750; Nikon,Tokyo, Japan), using a 105-mm lens (AF-S Micro-Nikkor 105mm 1:2.8G; Nikon) and a dual-point wireless flash (R1C1; Nikon). Upper and lower impression was done by alginate impression material. Then, study model was fabricated by type III stone. Standardized upper anterior teeth photographs and study models were taken according to previously published methods (4). The Esthetic

sustainable criteria was used in this study. This index composes of 3 parts, which are gingival, prosthesis and bone score. All parameters can examined by both photograph and cast model.

Esthetic Sustainable criteria

Part I Gingival score

Gingival assessment was done by 7 variables which were mesial papilla, distal papilla, soft tissue level, soft tissue contour, labial soft tissue convexity, soft tissue color and soft tissue texture.

Dental papilla was observed both mesial and distal side compared to adjacent tooth. Score 2 means papilla was completely filled all of gap. While incomplete papilla fill was score 1. And score 0 implied that papilla was totally lost.

Level of facial mucosa was the position of the gingival zenith that should be same level with contralateral tooth. Score 2 showed that implant gingival zenith equal to contralateral tooth or the difference was less than 1 mm. Score 1 implied that the

discrepancy was between 1-2 mm. While score 0 showed that the distance was more than 2 mm.

Curvature of facial mucosa was contour line of gingival margin at buccal side. Symmetrical gingival margin compared to contralateral tooth is scored to 2. While score 1 was slightly detected unsymmetrical curve. And score 0 showed apparent unsymmetrical curve of free gingival margin.

Root convexity, soft tissue color and texture were evaluated separately. Labial soft tissue convexity was soft tissue contour in occlusal view when compare to adjacent teeth. Score 2 showed harmonious contour of soft tissue. Score 1 was slightly different of soft tissue harmony. While score 0 showed no harmony of soft tissue.

Soft tissue color was determined by compare it with adjacent tooth. Score 2 meant that the color of peri-implant tissue was similar to adjacent soft tissue. Score 1 interpreted that the difference of soft tissue color was moderate. Score 0 was obvious dismatch of soft tissue color.

soft tissue texture was compared with adjacent tooth. Score 2 would be given if the texture was the same with adjacent tooth. Score 1 meant that a moderate difference of soft tissue texture was found. While score 0 was clearly obvious difference.

Part II Prosthodontic score

Restorative assessment consisted of 6 parameters, which were tooth shape or outline, tooth form, color, texture, translucency and characteristics.

Tooth shape or outline was outer border of tooth. Perfect restoration should be the same shape as contralateral tooth and would be given as score 2. While score 1 was restoration that moderate difference of tooth shape was presented. And score 0 was obviously different tooth shape.

Tooth form was the prosthesis line angle that should be the same line angle with contralateral tooth and would be given as score 2. Score 1 was restoration that moderate difference of tooth form was presented. And score 0 was obviously different tooth form.

Labial contour of restoration was compared with contralateral tooth in both vertical and horizontal direction. A study model and intraoral photograph were used. Score 2 meant that restoration showed the same contour in both directions. Score 1 was restoration that slightly different labial tooth contour was presented. And score 0 was obviously different labial tooth contour.

Color of restoration was evaluated by using intraoral photograph. Score 2 meant that the color restoration and contralateral tooth were the same. Score 1 was slightly different restoration color from control. And score 0 was obviously different restoration color.

Texture of restoration was compared with contralateral tooth. Score 2 showed that the texture of restoration and contralateral tooth were the same. Score 1 was slightly different restoration texture from control. And score 0 was obviously different restoration texture.

Translucency and characteristics of restoration were evaluated by using intraoral photograph and compared with contralateral tooth. Score 2 illustrated that

the translucency and characteristics of restoration and contralateral tooth were the same. Score 1 was slightly different translucency and characteristics from control. And score 0 was obviously different translucency and characteristics.

Part III Bone score

Bone support was assessed by both periapical film and dental CBCT. Four parameters that related to transmucosal area were evaluated, which were labial bone thickness, labial bone height, distance from implant platform to the first visible bone-implant contact (DIB), and implant axis. Only the distance from implant platform to the first visible bone-implant contact (DIB) was measured by periapical radiograph. While the others were done by CBCT images.

All radiographic images were interpreted by INFINITT program. Implant was adjusted to be centered in all views; sagittal, coronal and transverse plane. In sagittal view, horizontal reference line (blue line) was located at platform of implant, while vertical reference line (yellow line) was moved to the center of fixture and bisected implant equally in antero-posterior dimension. Implant was rotated until fixture was

parallel with vertical reference line or perpendicular with horizontal plane on both sagittal and coronal plane (figure 4).

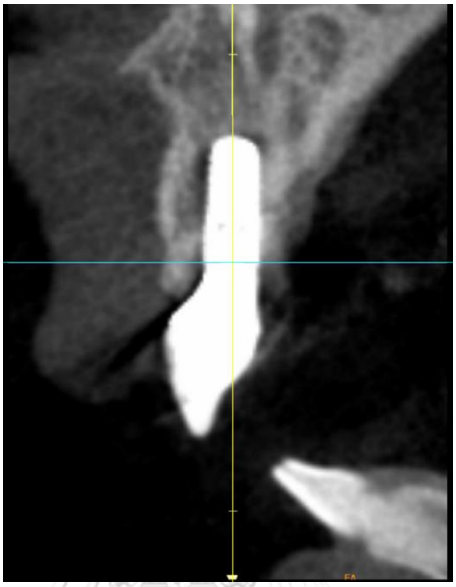

Figure 4 Adjustment of CBCT image in sagittal view

Labial bone thickness was calculated from implant platform surface to outer cortex of labial bone (figure 5). Score 2 would be given when the distance was more than 2 mm. While score 1 would be given when the distance was between 1 to 2 mm. And score 0 would be given when the distance was less than 1 mm or dehiscence.

Labial bone height was determined from the implant platform to the highest point of labial wall (figure 5). This parameter can be both positive value and negative value. If the peak of labial bone is higher than implant platform, positive value is given. While negative score meant the peak of labial is below implant platform. In conclusion, the score 2 would be given if labial bone height is more than 0. Score 1 means that the height was less than 0 but more than or equal to -2 mm. Score 0 means that the height is less than -2 mm.

Figure 5 Measurement of labial bone thickness and height from CBCT image (pink arrow)

Distance from implant platform to the first bone-implant contact or DIB is also used periapical radiograph. DIB is derived from the average total distance from mesial and distal aspect. This parameter can be both positive value and negative value. If the first bone-implant contact position is higher than implant platform, positive value is given. While negative score means the first bone-implant contact position is lower than implant platform. Score 2 is given if the distance is more than -0.6 mm. Score 1 is given if the distance is between -0.6 mm to -2.5 mm. And score 0 is given if the distance is less than -2.5 mm.

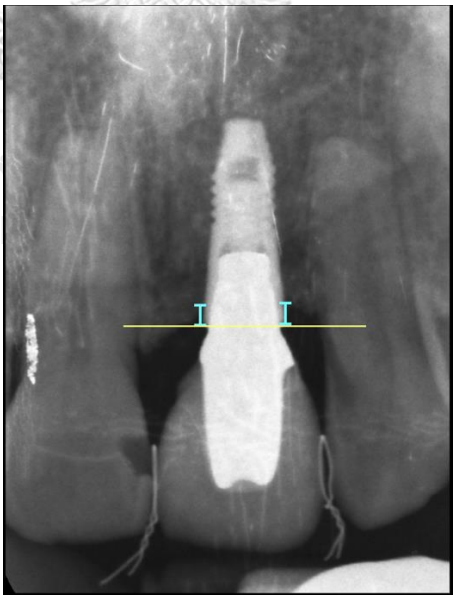

Figure 6 Measurement of the distance from implant platform (yellow line) to the first bone-implant contact (blue arrow)

All distance from periapical radiograph was calibrated with actual implant length in order to assure the distance.

Implant axis was evaluated in sagittal view. Imaginary line was drew cross in the middle of implant. If this line passed through cingulum area, implant axis was called cingulum position. On the other hand, incisal and labial position was given if the imaginary line was passed through incisal or labial area, respectively. Score 2 was considered when cingulum position was presented with no fenestration. While score 1 meant that incisal position was found without fenestration. And score 0 meant that labial position was shown. In addition, if there was any fenestration, score 0 will be given.

Further analysis of the labial bone thickness and height alterations, the earlier CBCT images, which were taken at 0-2 years after crown delivery, were used as comparisons and compared to 5-year CBCT images as a retrospective analysis to demonstrate the amount of labial bone resorption of each abutment material.

Statistical analysis

All data were analyzed by statistical software (SPSS 21.0, SPSS, Chicago, IL, USA). The Shapiro-Wilk test was used to test normality. Mean differences of labial bone thickness, labial bone height, distance from implant platform to the first bone-implant contact (DIB), pocket depth and observation time of each abutment were compared by One-Way ANOVA, followed by Tukey post hoc analysis. While, mean difference of modified sulcus bleeding index, gingival score, prosthodontic score and bone score were analysed by Kruskal-Wallis, followed by Dunn's post hoc test. Furthermore, the comparison of labial bone thickness and height between 0-2 years and 5 years were analyzed by paired t-test. P-value less than 0.05 would be considered statistically significant.

CHAPTER IV RESULTS

According to the inclusion criteria, 24 patients were recruited for the experiment. The youngest patient in this study was 24 while the oldest one was 68 years old, an average age was 48.5. The mean of observation period was 73.96±31.72 months after prosthesis was completely done which 14 months was minimum and 113 months was maximum time of implant use. Regarding to abutment material, there were no significant difference in term of observation time among abutment materials (p-value<0.05). The clinical information associated with anterior single implant are shown in Table 7. 18 implants were placed as central incisor while the others were placed as lateral incisor and canine position. Regarding implant system, 12 of the implants were used by Straumann system (Institute Straumann, Basel, Straumann, Switzerland), while 12 of them were used by Astratech system (Densply Implant, Mölndal, Sweden). Majority of implant were placed at healed site as delayed placement. Six implants were immediate implant placement and only one was early implant placement. Guided bone regeneration was done simultaneously in most of samples. Both of deproteinized bovine bone mineral (Bio-Oss Collagen , Geistlich

Pharma AG) and biphasic calcium phosphate ceramic bone (Straumann Bone Ceramic, Institut Straumann AG) were used as bone substitute in GBR technique. Autogenous bone graft harvested from mandibular ramus was done in 5 cases prior to implant placement. While alveolar ridge expansion was performed in 4 cases. Connective tissue graft was done in 10 cases. (Table 7)

Table 7 Demographic data, Implant system and detail of treatment

Variables	Subjects (n=24)
Age (years), mean±SD	48.5±12.56
Gender, N (%)	
- Male	8 (33.3%)
- Female	16 (66.6%)
Implant site, N (%)	
- Central incisor	18 (75%)
- Lateral incisor	5 (21%)
- Canine	1 (4%)
Reason for extraction, N (%)	
- Infection: Periapical lesion/fistula/root resorption	12 (50%)
- Unrestorable tooth/trauma	5 (21%)
- Other	7 (29%)
Implant system, N (%)	
- Straumann	12 (50%)
- Astratech	12 (50%)
Abutment material, N (%)	
- UCLA abutment (Gold alloy)	8 (33.3%)

- Titanium abutment	8 (33.3%)
- Zirconia abutment	8 (33.3%)
Observation period (months)	73.96±31.72
- Gold alloy abutment	87.63±20.31*
- Titanium abutment	59.13±32.45*
- Zirconia abutment	75.13±37.06*
Implant placement, N (%)	
- Immediate placement	6 (25%)
- Early placement (6-8 weeks)	1 (4%)
- Delay placement	17 (71%)
Bone augmentation technique, N (%)	
- Bone block graft, followed by implant placement with guided bone regeneration	5 (21%)
- Guided bone regeneration only	15 (63%)
- Ridge expansion	1 (4%)
- Ridge expansion and guided bone regeneration	3 (12%)
Soft tissue graft after implant integrated, N (%)	10 (42%)

*No significant difference among abutment groups (*p*-value>0.05), using One-Way ANOVA

All of 24 maxillary anterior implants showed good osseointegration, no mobility and suppuration. 15 cases showed no any functional problem after loading. However, there were some problems in 9 cases. Most of problems were resin composite dislodgement at screw hole and dislodgement of crown restoration in cemented type

crown. Clinical parameters such as modified plaque index (mPI), modified sulcus bleeding index (mSBI) and mean of probing depth (PD) were listed on table 8. In summary, patients presented good oral hygiene and healthy gingiva. Modified sulcus bleeding index was low. There were no statistically significant difference of modified plaque index, modified sulcus bleeding index and probing depth among abutment materials, see Table 8.

Table 8 Modified plaque index (mPI), modified sulcus bleeding index (mSBI) and probing depth

	Gold alloy (n=8)	**Zirconia (n=8)**	**Titanium (n=8)**	**P-value**
mPI	0	0	0	-
mSBI[a]	0.13±0.25	0.13±0.44	0.25±0.69	0.759
mPD[b]	1.63±0.38	1.66±0.63	1.95±0.53	0.257

[a]Differences among abutment materials, analysed using Kruskal-Wallis

[b]Differences among abutment materials, analysed using One-Way ANOVA

Regarding to esthetic evaluation, All patients were recruited and calculated using Esthetic sustainable criteria (ESC). There were 3 parts which were gingival, prosthodontic and bone score. (Table 9)

Among the gingival parameters, there were no significant difference among abutment materials in term of mesial and distal papilla, soft tissue level, soft tissue contour, convexity, color and texture. Likewise, three abutment materials showed similar all prosthodontic score which were tooth shape or outline, tooth form, labial contour, color, texture, translucency and characteristic.

According to bone support, all abutment materials showed similar bone score in term of labial bone thickness, labial bone height, the distance between implant platform to the first bone to implant contact (DIB). However, zirconia abutment showed the significant highest score of implant axis. Zirconia abutment illustrated better implant axis than titanium abutment significantly. Most of zirconia abutment showed cingulum implant axis. While, majority of gold alloy and titanium abutment showed labial axis (table 10). By further analysis of the data, the exact amount of bone dimension was shown in table 11. Zirconia abutment showed the highest labial bone thickness (2.23±0.93 mm) with significant difference with titanium abutment group (1.13±0.96 mm). On the other hand, there were no significant difference among three

abutment groups in term of labial bone height on CBCT image and the distance between implant platform to the first bone to implant contact (DIB) on periapical film. An average labial bone height of gold alloy, zirconia and titanium were 0.42±0.65, 0.76±1.08, 0.41±1.03 mm., respectively above implant platform. The distance from implant platform to the first bone-implant contact of gold alloy, zirconia and titanium were 0.27±0.28, 0.14±0.29, 0.31±0.51mm., respectively which the first bone-implant contact located below implant platform (table 11).

Table 9 Comparison of gingival, prosthodontic and bone score among different abutment materials.

Gingival score	**Gold alloy Med (IQR) (n=8)**	**Zirconia Med (IQR) (n=8)**	**Titanium Med (IQR) (n=8)**	**P-value**
- Mesial papilla	1.5 (1.0)	2.0 (0)	2.0 (1.0)	0.081
- Distal papilla	1.0 (1.0)	2.0 (0)	2.0 (1.0)	0.078
- Soft tissue level	2.0 (1.0)	2.0 (0.8)	1.0 (2.0)	0.147
- Soft tissue contour	1.5 (1.0)	2.0 (0)	1.5 (1.0)	0.216
- Soft tissue convexity	1.5 (1.0)	2.0 (1.0)	1.0 (0.8)	0.298
- Soft tissue color	2.0 (1.0)	2.0 (0)	1.5 (1.0)	0.078
- Texture	2.0 (0)	2.0 (0)	2.0 (0.8)	0.232
Prosthodontic score				
- Tooth shape/outline	1.0 (1.8)	2.0 (1.0)	2.0 (0.8)	0.287
- Tooth form	2.0 (1.0)	2.0 (0.0)	2.0 (0.8)	0.505
- Labial contour	2.0 (0)	2.0 (0)	2.0 (0)	1.000
- Color	1.5 (1.0)	2.0 (1.0)	1.5 (1.0)	0.851
- Texture	2.0 (0)	2.0 (0)	2.0 (0)	0.368
- Translucency and characteristic	1.5 (1.0)	2.0 (0)	2.0 (0)	0.147
Bone score				
- Labial bone thickness	1.0 (1.0)	1.5 (1.0)	0.5 (1.8)	0.085
- Labial bone height	2.0 (1.0)	2.0 (0.8)	2.0 (0)	0.528
- DIB	2.0 (0)	2.0 (0)	2.0 (0.8)	0.334
- Implant axis	0 (1.8)^{A,B}	2.0 (0.8)^{A}	0 (0.8)^{B}	0.010*

IQR, Interquartile range

*Differences among abutment materials, analysed using Kruskal-Wallis, followed by Dunn's post hoc test.

[A,B]Same superscript letter means no significant difference in same row (*p*-value>0.05)

Table 10 Implant axis

Implant axis	Gold alloy (n=8)	Zirconia (n=8)	Titanium (n=8)
Cingulum position, number	2 (25%)	6 (75%)	-
Incisal position, number	1 (12.5%)	1 (12.5%)	2 (25%)
Labial position or fenestration, number	5 (62.5%)	1 (12.5%)	6 (75%)

Table 11 The actual bone dimension

Bone parameter (Mean±SD, mm)	Gold alloy (n=8)	Zirconia (n=8)	Titanium (n=8)	P-value
Labial bone thickness	1.25±0.53[A,B]	2.23±0.93[A]	1.13±0.96[B]	0.029*
Labial bone height	0.42±0.65	0.76±1.08	0.41±1.03	0.699
DIB	-0.27±0.28	-0.14±0.29	-0.31±0.51	0.662

[*]Differences among abutment materials, analysed using One-Way ANOVA, followed by Tukey post hoc analysis

[A,B]Same superscript capital letter means no significant difference in same row (*p*-value>0.05)

In order to compare the amount of labial bone resorption from the beginning after loading. Previous CBCT images, which had been taken at 0-2 years after crown delivery, were used as reference films to calculate the exact number of labial bone

resorption. However, the initial CBCT images could not be found in some cases, due to the limitation of the retrospective study. Statistical analysis showed, the labial bone thickness of zirconia and titanium abutments reduced significantly after five years of crown delivery (Table12). In addition, labial bone height was also statistically significant reduced in the gold alloy and zirconia groups (Table 13).

Table 12 The comparison of the labial bone thickness between 0-2 years and 5 years of each abutment.

Labial bone thickness (Mean±SD, mm)	**0-2 years**	**Average 5 years**	**P-value**
Gold alloy abutment (n=7)	1.76±0.46	1.34±0.50	0.067
Zirconia abutment (n=6)	2.54±1.03	2.36±1.03	0.001*
Titanium abutment (n=4)	1.76±1.06	1.31±1.10	0.005*

*Differences of labial bone thickness between 0-2 years and 5 years of each abutment, analysed using Paired t-test.

Table 13 The comparison of the labial bone height between 0-2 years and 5 years of each abutment.

Labial bone height (Mean±SD, mm)	**0-2 years**	**Average 5 years**	**P-value**
Gold alloy abutment (n=7)	0.85±0.69	0.50±0.67	0.009*
Zirconia abutment (n=6)	1.26±1.16	0.76±1.27	0.005*
Titanium abutment (n=4)	1.18±1.37	0.94±1.14	0.177

*Differences of labial bone height between 0-2 years and 5 years of each abutment, analysed using Paired t-test.

Regarding to intraclass correlation coefficient, the result of this study interpreted as excellent reliability which having a score of 0.91, 0.92, 0.99 for gingival, prosthodontic and bone parameter, respectively.

CHAPTER V DISCUSSION AND CONCLUSION

Discussion

This cross-sectional study aimed to observe and compare the overall esthetic outcome of single implants in anterior region using the Esthetic Sustainable Criteria (ESC) in long term follow up among abutment materials. In this criteria, It comprehensively composed of gingiva, prosthodontic and bone variables. Bone support was intensively focused in this criteria. ESC score was first used to evaluate 26 anterior single tooth implants by Komutpol et al, 2017 (7). The result implied that bone foundation was an important factor effecting esthetic outcome. However, the observation time was 30 months after loading, so bone alterations still need to observe in long term clinical study. In this study, three dimensional bone response of gold alloy, zirconia and titanium abutment was observed. Type of abutment materials was one of factor that influence the soft tissue stability around implant. Transmucosal zone of the peri-implant soft tissue was critical area for emergence profile of abutment contour. The biocompatibility of material was a significant factor in this particular

transmucosal area. So, bone parameters related transmucosal area were focused, which were labial bone thickness and height at platform level, the distance between implant platform to the first bone to implant contact (DIB) at mesial and distal side and implant axis.

Total of 24 upper anterior implant cases was recruited in this study with average 73.96±31.72 months of function. Even gold alloy abutment showed the longest period of function. But statistical analysis showed no significant difference of observation time among three abutment materials. Two implant systems were used in this study. Straumann bone level implants create biologically horizontal microgap to crestal bone in order to prevent bone resorption. Moreover, SLAactive surface modification can promote osseointegration. Astratech bone level fixtures show MicroThread neck and Conical Seal design, with Osseospeed technology to maintain marginal bone. Although, these two implant systems have different design. Only bone level implants with platform switching design were recruited in this study. Moreover, the number of both implant systems and abutment materials also equal.

Good osseointegration was found in all cases. No mobility, no gingival abscess were showed. Prosthodontic issues, for example, crown dislodgement for cemented retained restoration or resin composite dislodgement at screw access for screw retained restoration were frequented found in maintenance visits. Although, zirconia abutment was reported for abutment fracture especially in small diameter of dental implant (16). But no abutment fracture was found in this study with diameter 3.5 (AstraTech system, Densply Implant, Mölndal, Sweden). Clinical examination of peri-implant soft tissue for all abutments were healthy. All patient showed good oral hygiene. Dental plaque did not accumulated on any implants. Some of uncompliant patients presented mild gingival inflammation. Modified sulcus bleeding index and the average periodontal pocket of each abutment material was low. Buser and colleages found that pocket depth showed 2.78 mm in healthy peri-implant soft tissue in one year observation (21). Moreover, there were no statistical difference of all periodontal parameters among three abutment groups from our results. Similar to previous studies, no difference of inflammatory response and number of blood vessel were found between titanium and zirconia abutment after 3 months follow up with split mouth

design (22). Furthermore, titanium and zirconia abutment also showed similar outcomes such as plaque score, bleeding score, pocket depth and amount of gingival recession in one year clinical trial (23). The biocompatibility of gold alloy, on the other hand, was still controversy between histological and long-term clinical study. In histological biopsy, there were the larger amount of inflammation cells and inflammatory area of peri-implant soft tissue of gold alloy when compared to titanium and zirconia abutment. This finding was done in 2 months in vivo study. Similar to animal studies, the gold alloy abutment groups had more soft tissue recession and bone resorption (24, 25). However, in a four-year clinical trial, gold alloy abutment showed no clinical difference from titanium abutment in terms of plaque formation, gingival inflammation, and probing bleeding (10). Hosseini and colleagues also reported that all three abutment materials (gold alloy, titanium and zirconia) exhibited a low score of modified Plaque Index (mPl) and modified Sulcus Bleeding Index (mBI) with median score were 0. There were no clinically important differences between gold alloy, titanium, and zirconia abutment in 3-year prospective study (11).

Regarding clinical examination, all gingival and prosthodontic score showed no significant difference among abutment materials in this study. Gingival parameters still showed as clinical acceptable outcome in long term follow up. All implant-crown restoration exhibited favorable outcome. Various materials were used as implant-crown. In this study, most of cases were UCLA baked with porcelain, Lithium disilicate crown on either UCLA abutment or zirconia abutment, and Porcelain fused to metal crown. All materials showed acceptable color, texture, translucency and characteristic. Our result agreed with a previous studies, the implant crown aesthetic index (ICAI) was used to compare gingiva and crown quality between zirconia and titanium abutment. Both of abutment exhibited similar acceptable outcomes (23). Likewise, a clinical study by Hosseini and colleagues suggested that gold alloy, zirconia and titanium abutment all demonstrated the same mucosal discoloration and papilla characteristic in 3 years observation time (11).

In order to evaluate three dimensional bone response in long term follow up. Labial bone thickness and height, the distance between implant platform to the first

bone to implant contact (DIB) at mesial and distal side of implant platform and implant axis were observed. Regarding bone score of ESC, there was no significant difference of bone scores among abutment materials except an implant axis. However, the actual labial bone thickness from CBCT image found some differences. Zirconia abutment showed the highest labial bone thickness (2.23±0.93 mm.) and significant difference from titanium group (1.13±0.96 mm.). While, gold alloy showed similar labial bone thickness with both titanium and zirconia group. Although, It was recommended that optimal buccal bone thickness should be 2 mm in order to maintain soft tissue stability and prevent further bone resorption (26). Our result exhibited that the remaining labial bone thickness of gold alloy and titanium abutment were 1.25±0.53 and 1.13±0.96 mm., respectively. Resemble to Miyamoto and Obama study, the proper minimum thickness of labial bone should be at least 1.2 mm in order to provide sufficient amount of underlying cancellous bone promoting adequate blood supply (27).

To compare bone alteration among abutment materials, none of previous studies using measurement from 3D image. Marginal bone loss was observed at mesial

and distal side during longitudinal studies using periapical radiograph. Gold alloy and titanium abutment revealed similar bone resorption in 1 years (28) and 4 years follow up time (10). Moreover, zirconia and titanium also displayed the same marginal bone alterations in 1 year (23) and 3 years observation period (29). Our results suggested that the distance between implant platform to the first bone-to implant contact (DIB) showed no differences among three abutment materials which agreed with previous studies. However, these previous studies did not compare bone resorption among three abutment materials.

On the other hand, a study by Hosseni et al, compared alveolar bone resorption between gold, zirconia and titanium abutment using periapical films in 3 years prospective study. Marginal bone was more reduced in gold alloy group than others (11). However, gold alloy abutment was usually used in improper angulated implant in order to correct its path. So, marginal bone loss might be a consequence of other factors such as inappropriate fixture position or angle of abutment. This condition most likely occurred in our research as well. Normally, casting of gold alloy

abutment was selected to use in complex cases, for example, buccoversion of implant fixture. This situation probably compromise labial bone support. In addition, all of titanium and most of gold alloy abutments also showed incisal or labial axis. However, zirconia presented appropriate implant axis, with 75% of fixture axis was cingulum, which can promote stability of labial bone thickness.

Although zirconia showed the largest of labial bone thickness and height from current CBCT images (table 11). It did not imply that zirconia abutment showed the best results for maintaining labial bone. In order to illustrate the amount of labial bone resorption of each abutment materials in this study, the earlier CBCT images, which had been taken at 0-2 years following crown delivery, were used as references and compared to 5-year CBCT images as retrospective study. Although, the number of each abutment groups were not equal and too small. Labial bone thickness and height showed a tendency to decrease in some abutments from 0-2 years to 5 years (table 12, 13). Similar to previous studies, Degidi and colleagues (30) also reported 29% and 26% of initial bone width and height was resorbed horizontally and vertically after 1

year recall of immediate implant placement. Moreover, Cho et al suggested that the mean of labial bone height resorption was 1.32 ± 0.86 mm. in 3 years after immediate implant placement (31). In our study, the rate of labial bone height resorption was slower than the estimated resorption rate reported by Cho et al. However, Cho's study focused on bone response after implant placement, which has a tendency to resorb more than after crown delivery due to surgical procedure. Furthermore, Yang and colleagues proposed that the initial thickness of the labial bone influenced the rate of labial bone resorption. Horizontal bone resorption were 0.37 ± 0.39, 0.46 ± 0.35 mm in group of 0.5-1 mm and ≥1 mm preoperative labial bone thickness in 1 year-recall (32). The rate of horizontal bone resorption was closed to our findings, which showed that bone resorption was less than 0.5 mm. However, no related studies compared labial bone alteration using three different abutment materials in CBCT images.

Rate of bone resorption depended on many factors such as grafting technique and bone graft material. To gain labial bone thickness, 23 cases in this study were augmented by guided bone regeneration simultaneously with implant placement.

Chappuis and colleagues, observed facial bone wall alterations after 10 years of function. Guided bone regeneration was done with a 2-layer composite technique graft. Autogenous bone chip, followed by deproteinized bovine bone mineral and covered with collagen membrane were simultaneous augmented at same day of early implant placement. They found that labial bone thickness was stable in 10 years follow up (33). However, they did not mention about abutment material used. Moreover, different bone substitute materials such as Bio-Oss and Straumann bone Ceramic also showed similar successful outcome in split mouth dehiscence defects (34). In this study, only one zirconia abutment did not augment with GBR technique. GBR procedures were done in both gold alloy and titanium abutment groups (Table 14).

Table 14 Bone augmentation technique of each abutment materials.

Bone augmentation technique	Gold alloy	Zirconia	Titanium
Bone block graft and guided bone regeneration	2	2	1
Guided bone regeneration only	6	5	3
Ridge expansion only	-	1	-
Ridge expansion and guided bone regeneration	-	-	4

Besides abutment materials, there were several possible explanations for labial bone alteration. Bone remodeling process spontaneously induced labial bone reduction after GBR technique (35). Moreover, immediate implant placement showed both more vertical and horizontal bone resorption than delayed implant placement (36).

Limitation and suggested further studies

In this study, our limitation was the small number of samples of each abutment. Secondly, due to cross-sectional design, it was difficult to control confounding factors such as, implant system, connection design, bone augmentation technique, loading protocol. Lastly, there were no reference radiographic images at 0-2 years to compare the amount of bone change from the start after loading in every cases. So, each abutment group had an insufficient and unequal sample size (table 12, 13). A prospective study or randomised control trial with larger sample size was recommended for further studies.

Conclusion

Within the limitations of this study, these three abutment materials showed the similar acceptable status for periodontal parameters such as modified plaque index, modified sulcus bleeding index, probing depth, esthetic score in term of peri-implant soft tissue and prosthesis during 5 years follow up period. However, the comparison of labial bone thickness and height alterations among abutment materials could not be concluded. Because the number of CBCT images at 0-2 years in each abutment group was not equal. It was suggested that more study with a larger sample size should be conducted.

Clinical implication

According to the findings of this study, there were various factors to consider when choosing an abutment for the anterior esthetic zone. Periodontal parameters, peri-implant soft tissue, and esthetic zone restoration were all satisfactory with zirconia, gold alloy, and titanium abutments in this study. However, a long-term prospective research of bone response is still needed.

Declaration of Conflicting interest

The authors declare that there is no conflict of interest.

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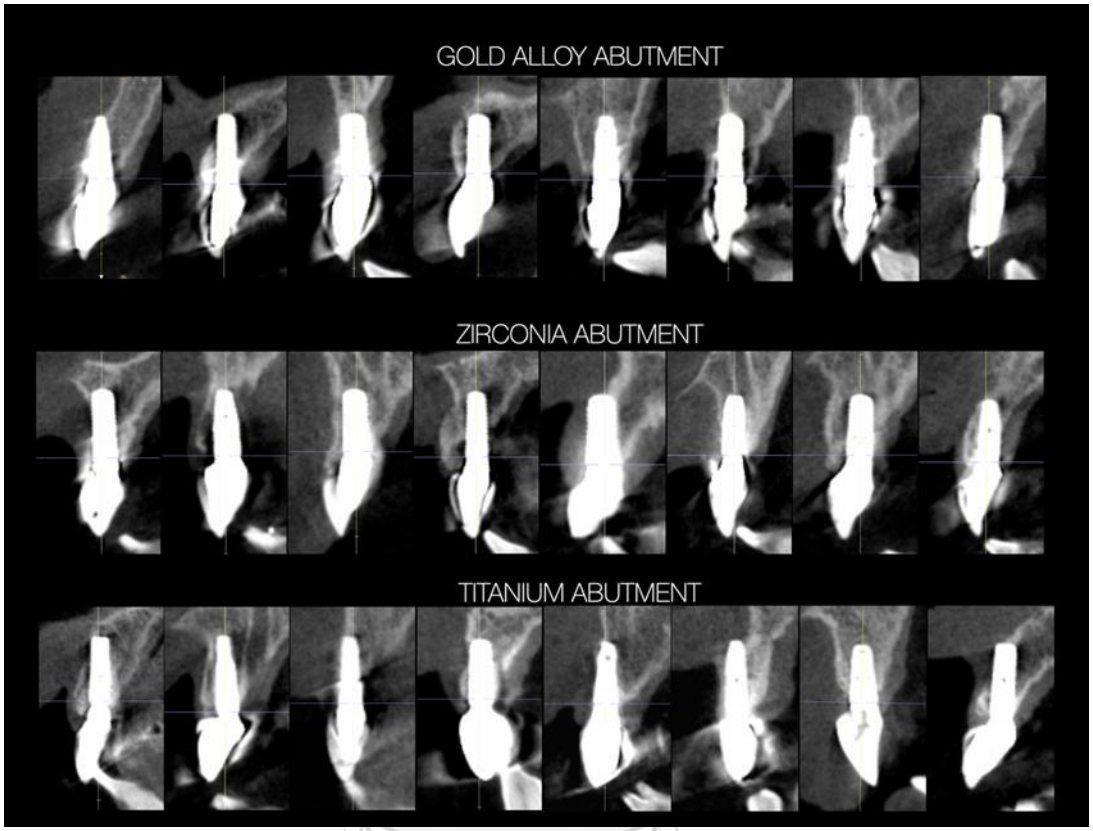
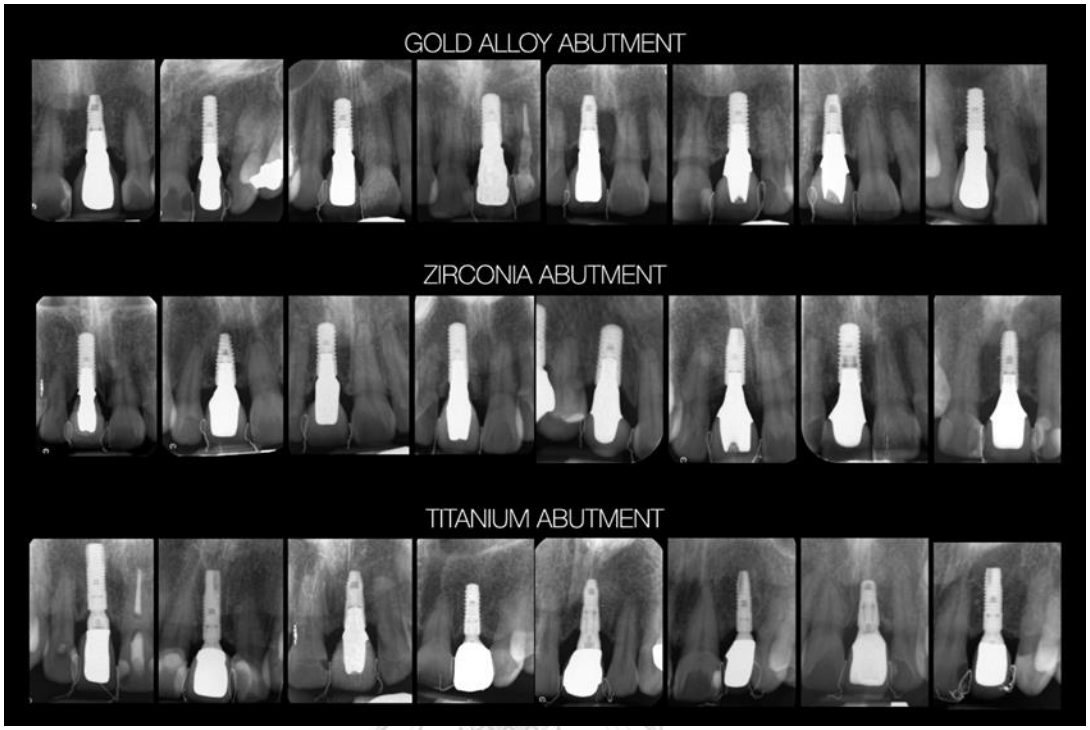
APPENDIX

APPENDIX A. Intraoral photograph of gold alloy, zirconia and titanium abutment

APPENDIX B. CBCT images of gold alloy, zirconia and titanium abutment showed labial bone thickness and height of each abutment



APPENDIX C. Periapical radiograph of gold alloy, zirconia and titanium abutment



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