Biomechanical Aspects of Bone-Level Diameter Shifting at Implant-Abutment Interface

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Purpose: *To evaluate the effect of diameter shifting at implant-abutment interface on load distribution at periimplant bone and within implant-abutment complex.*

Materials: *Eight different implant-abutment connections were designed and simulated numerically. Implant-abutment microgap at bone level was hypothetically set-off inward toward the central axis of implant to create "diameter shifting" or "platform switching" concept. The conceptual design was further characterized with horizontal set-off distance, emergence angle, and restorative height. A control model of conventional implant-abutment connection with restorative relation was also involved for comparison of developed stresses in periimplant bone and within implant-abutment complex. A 14 mm × 16 mm acrylic cylinder with vertically placed implant-abutment complex was considered for all designs. Principal and Von Mises stresses under vertical and oblique static loading conditions were evaluated numerically and presented descriptively.*

Results: *Stress distribution at periimplant bone was almost identical with similar magnitudes for all designs. Increase in the horizontal set-off distance generated higher stress magnitudes and increased stress intensity within the implant-abutment complex.*

Discussion: *Platform switching based designs of implant-abutment connections need more mechanical studies to identify the optimum design for long-term mechanical stability.*

Conclusions: *Relocation of microgap and redefinition implant-abutment connection at bone level does not influence the stress characterization at periimplant marginal bone but may noticeably affect the mechanical properties of the implant-abutment connection. (Implant Dent 2009;18:239–248)*

Key Words: implant-abutment connection, platform-switching, diameter-shifting, biomechanics

The relationship between bone and implant has been the essence of osseointegration.[1,2] In this regard, marginal bone level changes have often been followed to interpret the outcomes of experimental and clinical studies.[3,4] Periimplantitis[5,6] and occlusal overloading[7,8] have been independent concerns as the primary causatives for crestal bone loss. However, several subsidiary factors claimed to have been involved in the stabilization of marginal bone levels.[9] Scientific arguments made on this topic remain inconclusive. A certain amount of bone loss during the first year of conventionally loaded dental implants has been accepted to characterize an implant as being successful.[9]

Scientific endeavors are still undertaken to reduce initial bone loss around implants, particularly for the esthetic region.[10] Accordingly, implant-abutment convergence particularly at bone level is currently being revisited to discuss the innovational ideas.[11,12] Historically, features of the implant-abutment connection were considered to influence the biological consequences[13,14] and the mechanical behavior[15,16] of implants. Stability of the implant-abutment connection has been addressed to eliminate screw loosing[17] and to distribute load more favorably in bone.[16] Although conical joint designs are approved in terms of mechanical stability,[18] the effect of implant-abutment design on marginal bone level is highly debatable.[19] Therefore, more information is required to clarify the perplexing relationship between crestal bone and implant-abutment complex, particularly for the recently introduced concept based on diameter changing at implant-abutment convergence.[11]

Diameter differences between the implant and the abutment at the bone level, which has appeared in some dental implant systems (e.g., Bicon, Boston, MA), is empirically conceptualized as platform switching (PS).[11] Shifting to a smaller diameter seems to be promising in the prevention of bone loss.[10–12] However, the current knowledge regarding the hypothesis of little, or no, crestal bone loss that occurs with PS is confined with case se-

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ISSN 1056-6163/09/01803-239
Implant Dentistry
Volume 18 • Number 3

DOI: 10.1097/ID.0b013e318198ffd1

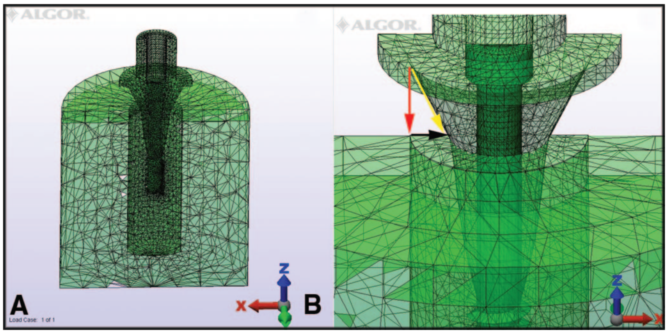

Fig. 1. Half-side back view of the finite element model (**A**) and close-up half-side front view of implant-abutment connection to identify the platform switching variables (**B**); horizontal set-off distance, emergence angle, and restorative height illustrated with black, yellow, and red arrows, respectively.

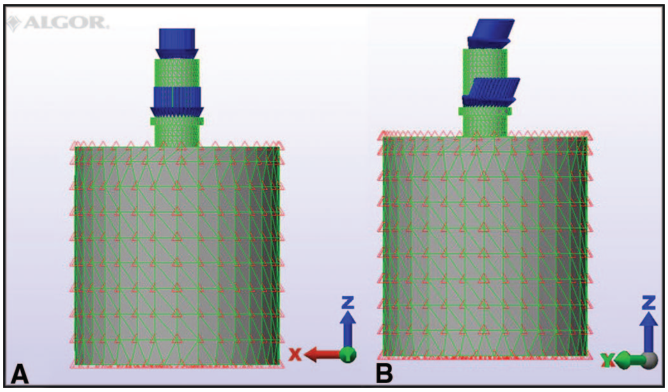

Fig. 2. Vertical (**A**) and oblique (**B**) loading applied through the virtual restoration rests on implant-abutment complex.

ries.[20–22] Biological rationale of horizontal set-off at the implant-abutment interface was hypothetically explained in a case study in which the consequences of horizontal repositioning of the microgap were discussed.[12] Similarly, increased space for more connective tissue to improve the biologic seal was the author-advocated assertion based on coincidentally evaluated radiographic data.[11] The effect of the variables to be controlled in diameter shifting at implant-abutment interface on stress generation in bone and on the implant-abutment complex is unknown. The purpose of this study was, therefore, to numerically simulate the load distribution at, and around, an implant with smaller diameter abutments.

Materials and Methods

The effect of diameter shifting of the implant-abutment connection on load distribution was simulated using 3-D finite element analysis. A 4 mm × 12 mm cylindrical implant was modeled to receive abutments set-off centrally at bone level. PS of implant-abutment connection was characterized with horizontal set-off distance, emergence angle and restorative height (Fig. 1). Totally 8 different PS implant-abutment connection designs with 3 variables for each were created (Table 1). Biomechanical performance of various PS designs was benchmarked against a conventional (C) implant-abutment design. The implant-abutment complexes were embedded vertically in the center of a Ø 14 mm × 16 mm cylinder to simulate periimplant trabecular bone with 1.5 mm cortical bone layer. Computer aided design modeling of the designs were completed with Rhinoceros 4.0 (McNeel & Associates, Seattle, WA) and converted into finite element models composed of tetrahedral elements using Algor Fempro (ALGOR, Inc., Pittsburgh, PA).

Bond relationship between implant and bone, and within the components of implant-abutment complex defined as linear. All materials were assumed to be homogenous, isotropic, and linearly elastic. The following values were assumed for Young's module and Poisson ratio's, respectively: implant-abutment complex 114 GPa and 0.369; cortical bone 22.5 GPa and 0.3; trabecular bone 13.4 GPa and 0.3. Boundary conditions were established by constraining the bone cylinder from its lateral surfaces. Static loading was considered by the nodes on the abutment occlusal surface and the restoration margin. A total of 150 N was separately applied parallel and with an inclination of 30° to the implant axis to simulate vertical and oblique loading conditions, respectively (Fig. 2). Algor Sparse Solver (ALGOR, Inc., Pittsburgh, PA) was run to process the defined analyses.

To facilitate the evaluation of postprocessing results, periimplant bone and implant-abutment complex were separately analyzed. Principal stress maximum and minimum were evaluated to express tensile and compression nature in periimplant bone. Von Misses stress was considered to identify the overall mechanical characterization of the implant-abutment complex. The outcomes are presented numerically and descriptively.

Results

Stress Magnitudes

Highest principal stresses (tensile and compressive) at periimplant bone and Von Misses stresses within implant-abutment complex under oblique and vertical loading conditions are presented at Table 2.

Oblique loading generated remarkably higher values of stresses for all designs. Under oblique loading, principal stresses were similar for all PS designs initially spelled-out at M&M section except design-6 which presented slightly higher values, whereas C design developed the highest. Differences in Von Misses stress values between the designs were remarkable in which the highest and the

Table 1. Platform Switching Specifications at Implant-Abutment Intermediate

Design	Horizontal Set-Off (mm)	Emergence Profile	Restoration Height (mm)
1	0.5	Straight	1.5
2	0.5	Straight	2.0
3	0.5	Angled	1.5
4	0.5	Angled	2.0
5	0.75	Straight	1.5
6	0.75	Straight	2.0
7	0.75	Angled	1.5
8	0.75	Angled	2.0

Table 2. Highest Stress Values Recorded Under Vertical and Oblique Loading

	Bone					
	Tensile Stress		Compressive Stress		I/A Von Misses Stress	
Design	VL	OB	VL	OB	VL	OB
1	2.4573	16.3560	4.2845	17.6573	67.3481	137.5087
2	2.4217	16.5819	4.1631	17.5915	40.1985	149.5098
3	2.4220	16.1412	4.1474	17.1686	59.3979	114.0925
4	2.3996	16.2653	4.2461	17.7843	42.3246	109.4303
5	2.3388	17.2561	4.4219	16.4339	86.7445	294.5805
6	2.4701	18.0909	4.1584	18.3443	106.5150	342.1106
7	2.3588	16.0367	3.8151	16.9205	68.9654	218.3663
8	2.3721	16.4184	3.9122	17.0835	78.4143	221.5926
Conventional	2.3045	19.3468	4.4774	19.8266	72.5940	169.3358

I/A indicates implant-abutment complex; VL, vertical loading; OB, oblique loading.

lowest were with PS design-6 and PS design-4, respectively. Under vertical loading, all designs developed similar tensile stresses but compressive stresses tolerably differed among the designs. Tensile stresses for PS design-5 and C design were slightly higher, whereas lower for PS design-7 and PS design-8. Values recorded for Von Misses stresses differed widely among the designs where PS design-6 and PS design-4 presented the highest and the lowest, respectively.

Stress Distribution

The general distribution of vertical load induced tensile and compressive stresses were similar for all PS designs and C design. Stresses were basically confined in the cortical bone with a symmetric distribution. The intensity of stresses was higher around the implant neck at cortical bone (Fig. 3). Von Misses related stress distribution within implant-abutment complex was similar in general (Fig. 4, A and B) but some differences were evident. For PS design-5 and PS design-6, the intensity of stresses tended to be somewhat higher at the abutment part resting above the bone level (Fig. 4, C and D). Oblique load induced stresses were distributed in the cortical bone without any particular difference among the designs. However, in contrast with vertical load situation, nonsymmetric distribution identified the tensile and compressive stress localizations. For each design, compressive stresses were naturally remarkable around the implant neck on the compression side, the side opposite the location of force application (Fig. 5, A). Similarly, tensile stresses were more intensely localized on the side of load application (tension side) around the implant neck (Fig. 5, B). The difference in Von Misses stress characterization among the implant-abutment designs was striking. Stress distribution with PS design-3 and PS design-4 was favorable and was also acceptable for PS design-2 and C design. Stress intensity considerably increased at the lateral sides of the abutment section resting above bone level for the PS designs-5 and PS design-6 (Fig. 6, A and B). Slight but visible stress intensity was localized at the horizontal set-off corner of implant-abutment connection for the PS designs-7 and PS design-8 (Fig. 6, C and D).

DISCUSSION

Marginal bone level stability around a functioning dental implant has been considered to be criteria of success.[9,23,24] It is perceived that initial bone turnover around an implant after establishment of biological contact with bone results in a certain amount of bone loss. In essence, discussions continue in pursuit of scientific efforts to identify the underlying key factors. They are traditionally based on biological[5,25] and mechanical issues.[26,27] Both relate mostly to the implant abutment complex, and its meeting point with the restoration, namely the microgap.[19] Earlier biological concerns included the vertical location of the microgap with regards to the bone crest.[28] Scientific evidence supports the fact that bone loss is due to combined and sustained activation of inflammatory cells that appear with the microgap at the bone level.[25] However, current belief is that of the replacement of the microgap toward the long axis of the implant influences bone crest level.[19] Although the body of evidence in this regard is growing rapidly,[20–22] further substantiation with experimental and clinical outcomes is still needed.

Mechanical properties of the implant abutment connection have been frequently addressed to understand the relationship between crestal bone level and periimplant load transfer.[29] Available knowledge so far suggests that the implant abutment connection does not have a prevailing affect on the mechanical environment in periimplant bone. However, there is little knowledge about generated stresses around implants with a horizontally set-off abutment. Outcomes of the current study clearly presented that horizontal replacement of the implant abutment connection toward the implant long axis at the bone level and its variables including the abutment

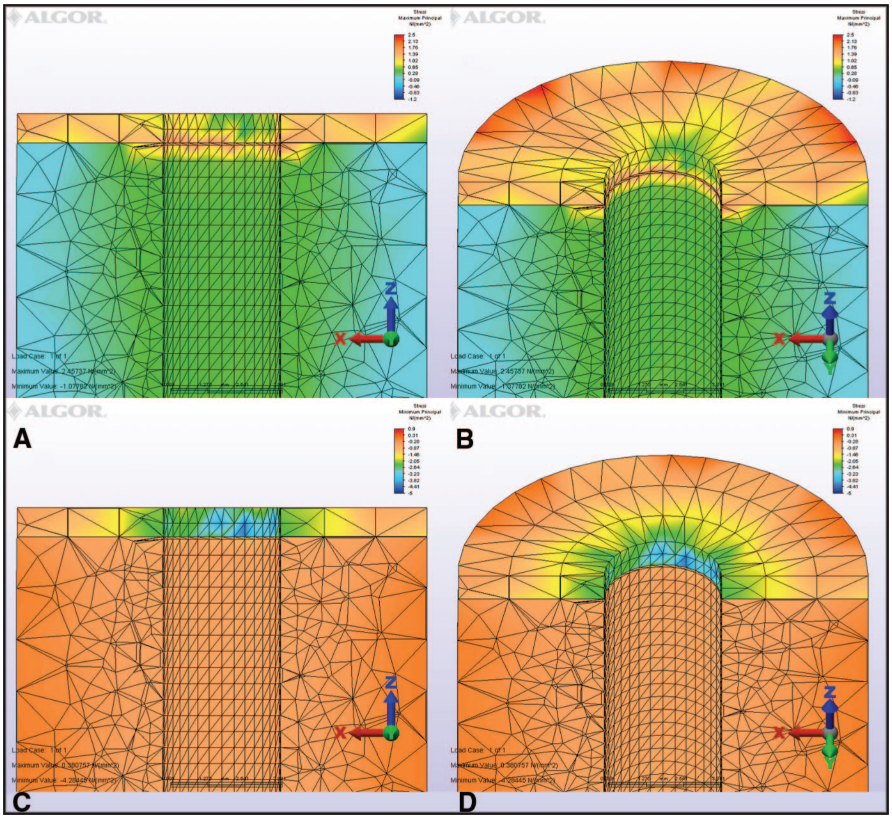

Fig. 3. Tensile (**A** and **B**) and compressive (**C** and **D**) stress distribution under vertical loading of PS design-2.

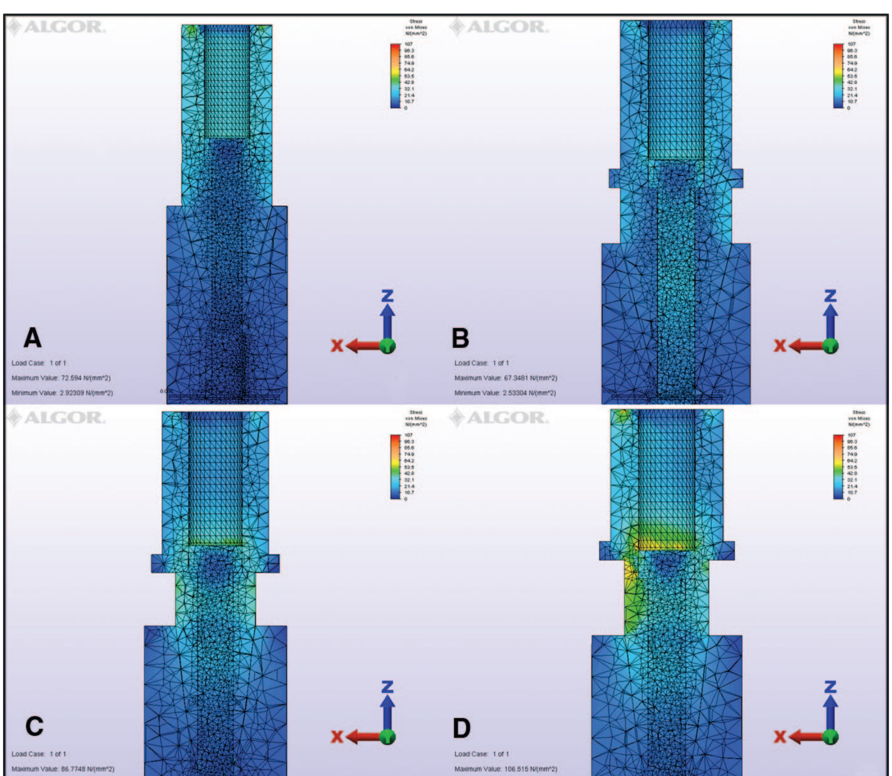

Fig. 4. Von Misses stress distribution for C (**A**) and PS design-1 (**B**), and PS design-5 (**C**) and PS design-6 (**D**). Note the increased intensity for PS design-5 and PS design-6.

emergence angle, set-off distance and height do not alter the mechanical environment created in the vicinity of implants. This finding, from a certain point of view, may seem to contradict with the unique data presented recently.[30] Maeda et al[30] claimed lateral shifting of stress concentration toward the center of an implant with PS design. However careful visualization of stress generation and distribution in periimplant bone displays that relocation of stress concentration at the implant abutment complex does not dramatically alter stress mapping at bone.

Current findings demonstrated that PS might risk the mechanical properties of abutments particularly of the ones with increased set-off distance and straight emergence (PS design-5 and PS design-6). Decrease in horizontal set-off distance notably reduced stress generation within the implant-abutment complex. In addition, angled emergence of the abutment further favored the stress distribution (PS design-3 and PS design-4). Observed similar stress characterization at periimplant bone may indicate nearly equivalent load transfer with all implant-abutment designs. This suggestion can be further justified with the finding of similar mechanical behaviors of all implant-abutment designs under bone. Eventually, the compact nature of conical implant-abutment mating design has been confirmed once more. Its high stability in terms of stress distribution within the conical region and transferred periimplant load is not affected by the variables acting above bone level.

Time-dependent periimplant bone stress mapping is invaluable to have better insight into bone-implant interactions. Simulations that are likely to offer the history of the bone-implant interface are not based on validated theories as applied in the field of orthopedics and require more sophisticated engineering approaches.[31,32] Because of above-outlined issues, load transfer under static loading without its biological concerns was considered in the current study. Within the restrictions of employed finite element analyses, it may be speculated that the

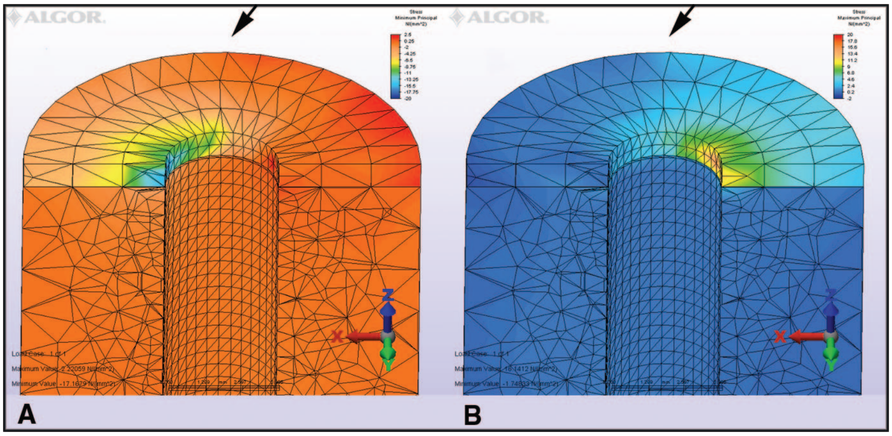

Fig. 5. Compressive (**A**) and tensile (**B**) stress distribution under oblique loading for PS design-3.

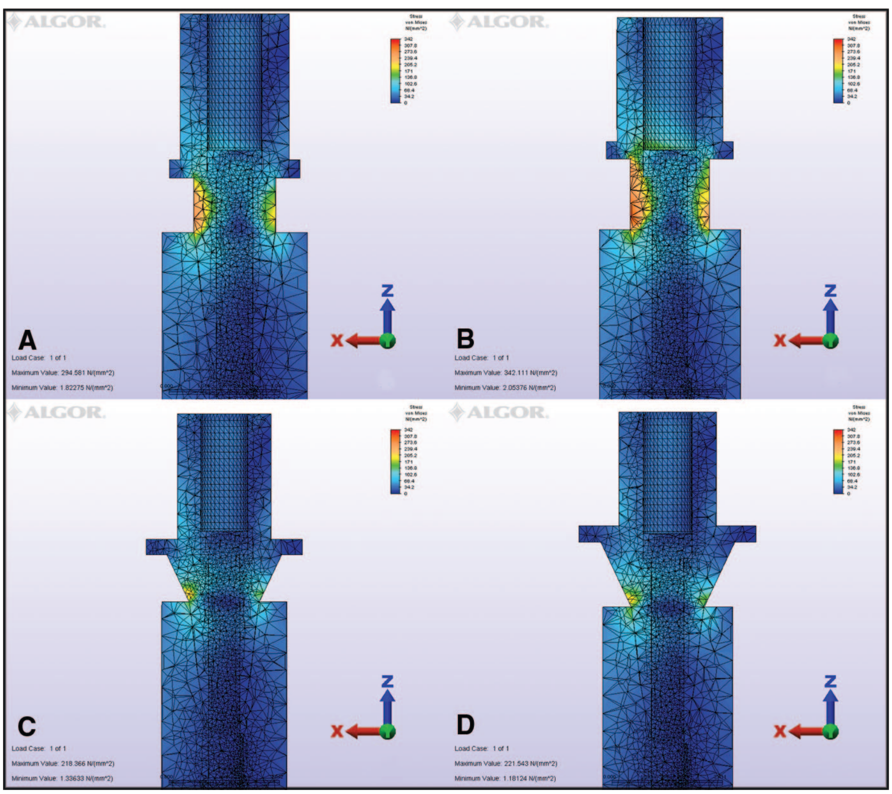

Fig. 6. Increased intensity in Von Misses stresses under oblique loading for PS design-5 (**A**) and PS design-6 (**B**), and PS design-7 (**C**) and PS design-8 (**D**).

promising leadership of the PS concept in the implant-abutment connection is not related to changes in load transfer. Therefore, more studies should focus on the biological perspectives of PS to explore the perplexing nature of marginal bone reactions.

CONCLUSION

Concept of PS at implant-abutment interface is an effective factor on mechanical properties of implant-abutment complex rather than the load induced stresses developed at marginal bone around implants.

Disclosure

The authors claim to have no financial interest, directly or indirectly, in any entity that is commercially related to the products mentioned in this article.

ACKNOWLEDGMENTS

This study was partially supported by the Scientific Research Unit, Hacettepe University, Ankara, Turkey, and the authors thank Ay Tasarım Tıbbi ve Endüstriyel Ürünler Makine San. Tic. Ltd. çSti. (Ankara/Turkey) for their kind cooperation in performing the finite element analysis.

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ID Abstract Translations

GERMAN / DEUTSCH

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Biomechanische Aspekte der Durchmesserverschiebung auf Knochenebene an der Schnittstelle zwischen Implantat und Stützapparatur

ZUSAMMENFASSUNG: Zielsetzung: Die Auswirkungen einer Durchmesserverschiebung an der Schnittstelle zwischen Implantat und Stützapparatur bei einer Belastungsverteilung am das Implantat umlagernden Knochengewebe und innerhalb des Implantat-Stützapparatur-Komplexes sollen beurteilt werden. ***Materialien und Methoden:*** Es wurden acht verschiedene Implantat-Stützapparatur-Verbindungen geschaffen und in numerischer Reihenfolge simuliert. Die Mikrospalte zwischen Implantat und Stützzahn wurde hypothetisch auf Knochenebene nach innen verlagert hin zur zentralen Achse des Implantats, um darüber das Konzept einer "Durchmesserverschiebung" bzw. "Plattformverschiebung" zu verwirklichen. Das Konzeptdesign war weiterhin durch die horizontale Aufrechnungsentfernung, den Ausgangswinkel und die Wiederherstellungshöhe bestimmt. Zusätzlich wurde ein Kontrollmodell mit konventioneller Implantat-Stützzahn-Verbindung mit wiederherstellender Beziehung zu Vergleichszwecken der entwickelten Belastungen am Knochengewebe um das Implantat herum und innerhalb des Komplexes zwischen Implantat und Stützapparatur herangezogen. Für alle Designs wurde ein 14 mm × 16 mm Acrylzylinder mit vertikal eingesetztem Implantat-Stützapparatur-Komplex vorgesehen. Belastungen allgemeiner Natur und nach von Mises unter vertikaler und indirekter statischen Belastungsbedingungen wurden numerisch festgehalten und beschreibend vorgestellt. ***Ergebnisse:*** Die Stressverteilung am das Implantat umlagernden Knochengewebe stimmte annähernd genau mit ähnlichen Größenordnungen aller möglichen Designs überein. Ein Ansteigen der horizontalen Aufrechnungsentfernung verursachte höhere Belastungsgrößen sowie eine gesteigerte Belastungsintensität innerhalb des Implantat-Stützzahn-Komplexes. ***Diskussion:*** Designs hinsichtlich Implantat-Stützzahn-Verbindungen, die auf eine Plattformverschiebung abzielen, bedürfen intensiverer mechanischer Studien, um das optimale Design für eine langfristige mechanische Stabilität zu ermitteln. ***Schlussfolgerungen:*** Die Verlagerung der Mikrospalte sowie die Neubestimmung der Implantat-Stützzahn-Verbindung auf Knochenebene nimmt keinen Einfluss auf die Stresssituation im das Implantat umlagernden marginalen Knochengewebe. Es kann aber sein, dass dadurch die mechanischen Eigenschaften der Implantat-Stützapparatur-Verbindung beeinträchtigt werden.

SCHLÜSSELWÖRTER: Implantat-Stützapparatur-Verbindung, Plattformverschiebung, Durchmesserverschiebung, Biomechanik

SPANISH / ESPAÑOL

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Aspectos biomecánicos del cambio en el diámetro a nivel del hueso en el interfaz entre el implante y el pilar

ABSTRACTO: Propósito: Evaluar el efecto del cambio en el diámetro en el interfaz entre el implante y el pilar sobre la distribución de la carga en el hueso periimplante y dentro del complejo del implante y el pilar. ***Materiales y Métodos:*** Se diseñaron y simularon numéricamente ocho conexiones diferentes entre implantes y pilares. El pequeño espacio entre el implante y el pilar se desplazó hipotéticamente hacia el eje centro del implante para crear el concepto del cambio de diámetro o cambio de plataforma. El diseño conceptual se caracterizó además con un cambio en la distancia horizontal, ángulo de aparición y altura de la restauración. También se usó un modelo de control de la conexión convencional entre el implante y el pilar con relación restaurativa para la comparación de las tensiones creadas en el hueso periimplante y dentro del complejo del implante y el pilar. En todos los diseños, se usó un cilindro de acrílico de 14 mm × 16 mm con un complejo de implante y pilar colocado verticalmente. Se evaluaron numéricamente las tensiones principales y de Von Mises bajo condiciones de carga estática vertical y oblicua y se presentaron descriptivamente. ***Resultados:*** La distribución de la tensión en el hueso periimplante fue casi idéntica con magnitudes similares para todos los diseños. El aumento en la distancia horizontal generó magnitudes más altas de la tensión y aumentó la intensidad de la tensión dentro del complejo del implante y el pilar. ***Discusión:*** Los diseños con cambios en la plataforma de las conexiones entre el implante y el pilar necesitan más estudios mecánicos para identificar el diseño óptimo de la estabilidad mecánica a largo plazo. ***Conclusiones:*** El desplazamiento del pequeño espacio y la redefinición de la conexión entre el implante y el pilar a nivel del hueso no influencian la caracterización de la tensión en el hueso marginal periimplante pero podrían afectar notablemente las propiedades mecánicas de la conexión entre el implante y el pilar.

PALABRAS CLAVES: conexión entre el implante y el pilar, cambio en la plataforma, cambio en el diámetro, biomecánica

PORTUGUESE / PORTUGUÊS

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Aspectos Biomecânicos de Alteração de Diâmetro ao Nível do Osso em Interface de Suporte de Implante

RESUMO: Objetivo: Avaliar o efeito de alteração de diâmetro em interface implante-suporte sobre a distribuição de carga em osso de periimplante e dentro do complexo implante-suporte. ***Materiais e Métodos:*** Oito diferentes conexões implante-suporte foram projetadas e simuladas numericamente. A microlacuna implante-suporte ao nível do osso foi hipoteticamente provocada para dentro em direção ao eixo central do implante para criar o conceito de "alteração de diâmetro" ou "alteração de plataforma." O projeto conceitual foi ainda caracterizado com distância de compensação horizontal, ângulo de emergência e altura restauradora. Um modelo de controle de conexão convencional implante-suporte com relação restauradora também estava envolvido para comparação de tensões desenvolvidas em osso de periimplante e dentro do complexo implante-suporte. Um cilindro acrílico de 14 mm × 16 mm com complexo implante-suporte verticalmente colocado foi considerado para todos os projetos. As tensões principais e de Von Mises sob condições de carga oblíquas e estáticas foram avaliadas numericamente e apresentadas descritivamente. ***Resultados:*** A distribuição de tensão em osso de periimplante era quase idêntica com magnitudes semelhantes para todos os projetos. O aumento na distância de compensação horizontal gerou magnitudes de tensão e aumentou a intensidade da tensão dentro do complexo implante-suporte. ***Discussão:*** Projetos baseados em alteração de plataforma de conexões implante-suporte precisam de mais estudos mecânicos para identificar o projeto ótimo para estabilidade mecânica de longo prazo. ***Conclusões:*** O deslocamento da microlacuna e a redefinição da conexão implante-suporte ao nível do osso não influenciam a caracterização de tensão no osso marginal do periimplante, mas pode afetar notavelmente as propriedades mecânicas da conexão implante-suporte.

PALAVRAS-CHAVE: conexão implante-suporte, alteração de plataforma, alteração de diâmetro, biomecânica

RUSSIAN / РУССКИЙ

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Биомеханические аспекты преобразования диаметра на уровне костной ткани на границе имплантат-абатмент

РЕЗЮМЕ: Цель: Оценить эффект преобразования диаметра на границе имплантатабатмент на распределение нагрузки в периимплантатной костной ткани и внутри комплекса имплантат-абатмент.***Материалы и методы:*** Было сконструировано и смоделировано математически восемь различных связей имплантат-абатмент. Микрозазор в системе имплантат-абатмент на уровне костной ткани был гипотетически внутрь в направлении центральной оси имплантата, чтобы получить концепцию «преобразования диаметра» или «смены платформ». Проектная концепция в дальнейшем была охарактеризована с помощью горизонтального расстояния смещения, угла выхода зуба и реставрационной высоты. Контрольная модель обычной связи имплантат-абатмент с реставрационным отношением была также включена в сравнение возникших напряжений в периимплантатной костной ткани и внутри комплекса имплантат-абатмент. Для всех конструкций применялся акриловый цилиндр размером 14 мм × 16 мм с вертикально установленным комплексом имплантат-абатмент. Главные напряжения и напряжения по Мизесу при условиях вертикальной и диагональной статической нагрузки были оценены математически и представлены описательно.***Результаты:*** Распределение напряжения в периимплантатной костной ткани было почти идентично похожим значениям для всех конструкций. Увеличение горизонтального расстояния смещения вызывало большие величины деформаций и увеличило интенсивность напряжений внутри комплекса имплантат-абатмент. ***Обсуждение:*** Конструкции на основе смены платформ связей имплантат-абатмент требует дополнительных исследований механики, чтобы определить оптимальную конструкцию для долгосрочной механической устойчивости. ***Вывод:*** Перемещение микрозазора и пересмотр связи имплантат-абатмент на уровне костной ткани не влияет на характеристику напряжений в периимплантатной маргинальной костной ткани, но может заметно влиять на механические свойства связи имплантат-абатмент

КЛЮЧЕВЫЕ СЛОВА: связь имплантат-абатмент, смена платформ, преобразование диаметра, биомеханика

TURKISH / TÜRKÇE

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İmplant-Abutman Arayüzünde Kemik Düzeyinde Çap Oynamasının Biyomekanik Yönleri

ÖZET: Amaç: Bu çalışmanın amacı, implant-abutman arayüzünde çap oynamasının, peri-implant kemiği ve implant-abutman kompleksi içindeki yük dağılımı üzerine etkisini değerlendirmekti. ***Gereç ve Yöntem:*** Sekiz değişik implant-abutman bağlantısı tasarlanarak, bunların sayısal simülasyonu yapıldı. "Çap oynaması" veya "platform değişimi" kavramlarını yaratma amacıyla kemik düzeyinde implant-abutman arasındaki mikro aralık, varsayımsal olarak implantın eksenine doğru içeriye kaydırıldı. Kavramsal tasarım ayrıca, yatay ofset mesafesi, yüzeye çıkış açısı ve restoratif yükseklik ile karakterize idi. Peri-implant kemiğinde ve implant-abutman kompleksinin içinde gelişen streslerin karşılaştırılması için konvansiyonel implant-abutman bağlantısı ve restorasyon bağı olan bir kontrol modeli de hazırlandı. Tüm tasarımlarda, 14 mm x 16 mm boyutlarında akrilik bir silindir ve dikey yerleştirilmiş implant-abutman kompleksi göz önüne alındı. Dikey ve oblik statik yükleme koşulları altındaki asal ve Von Mises stresleri sayısal olarak değerlendirilip, tanımlandı. ***Bulgular:*** Peri-implant kemiğindeki stres dağılımı tüm tasarımlar için benzer magnitüt göstererek hemen hemen aynıydı. Yatay ofset mesafesindeki artış, implant-abutman kompleksi içinde daha yüksek stres magnitüdü ve artmış stres kuvveti yarattı. ***Tartışma:*** Platform değişimi bazındaki implant-abutman bağlantı tasarımlarında uzun vadede mekanik stabilite sağlamak için optimum tasarımın belirlenebilmesi için daha fazla sayıda mekanik çalışmalar gereklidir. ***Sonuçlar:*** Mikro aralığın yerinin değiştirilmesi ve implant-abutman bağlantısının kemik düzeyinde yeniden tanımlanması peri-implant marjinal kemiğindeki stresi etkilememekle beraber, implant-abutman bağlantısının mekanik özelliklerini fark edilebilir bir şekilde etkileyebilir.

ANAHTAR KELİMELER: implant-abutman bağlantısı, platform değişimi, çap oynaması, biyomekanik

JAPANESE / 日本語

インプラント-アバットメント接触面でのボーンレベルDiameter Shifting生体力学要因

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研究概要:
目的: インプラント周辺骨とインプラント-アバットメントコンプレックスでの負荷分布に関して、インプラント-アバットメント接触面diameter shiftingの影響を検討する。

素材と方法: 8種の異なるインプラント-アバットメント接続をデザインし、数値模擬実験をおこなった。ボーンレベルでのインプラント-アバットメントマイクロギャップはインプラント中心軸に向け仮定的に内側にずらせ、 diameter shiftingまたはplatform switchingの概念を設定した。概念設計はさらに水平面オフセット距離と、エマージェンスアングルそして修復高径で特徴づけた。従来のインプラント-アバットメント接続と修復処置コンビネーションの対象モデルも要件として、インプラント周辺骨とインプラント-アバットメントコンプレックスで発生する応力を比較した。14mm X 16mmのアクリルシリンダー1本と垂直に植立したインプラント-アバットメントコンプレックスを全デザインで考察し、垂直面と傾斜面静荷重状態での主応力ならびにVon Mises応力を数値評価し、詳しく解説した。

結果: インプラント周辺骨での応力分布はすべてのデザインで同様のマグニチュードを示し、ほぼ同一という結果が出た。水平面オフセット距離を増加すると、応力マグニチュードが上がりインプラント-アバットメントコンプレックスでの応力強度が増加した。

論考: platform switching ベースのインプラント-アバットメント接続デザインは今後さらに力学的研究を進め、構造面で長期安定性をもたらす最適デザインを確定する必要がある。

結論: ボーンレベルのインプラント-アバットメント接続マイクロギャップ再配置と platform switchingは、インプラント周辺骨での応力描写に影響を及ぼさない。ただしインプラント-アバットメント接続の力学的特性には著しい影響を与える可能性がある。

キーワード: インプラント-アバットメント接続, platform-switching, diameter-shifting, 生体力学

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CHINESE / 中国語

植體支柱牙接觸面的骨水平直徑移位的生物力學

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摘要：
目的：評估植體支柱牙接觸面的直徑移位對植體周圍骨和植體支柱牙複合體內的負載分布的影響

資料與方法：設計仿造八種不同的植體支柱牙連接並以數字表示。假設骨水平的植體支柱牙微縫隙向內朝植體中心軸分離，以創造「直徑移位」或「平台轉換」概念。以水平分離距離、浮現角度和復形高度進一步劃分概念設計的特性。運用帶有復形關聯的傳統植體支柱牙連接的控制模型，比較植體周圍骨和植體支柱牙複合體內所發展的應力。所有設計均考慮帶有垂直置入植體支柱牙複合體的 14mm x 16mm 壓克力圓柱。以數字評估垂直與傾斜靜態載入條件的主要與等效應力，並以敘述方式說明。

結果：所有設計的植體周圍骨的應力分布強度幾乎都類似。水平分離距離增加產生較高的應力強度，植體支柱牙複合體內的應力強度也增加。

討論：平台轉換基礎的植體支柱牙連接設計需要更多的機械研究，確認長期機械穩定性最理想的設計。

結論：骨水平微縫隙改變位置以及植體支柱牙連接重新定義不影響植體周圍邊緣骨的應力特性，不過可能明顯影響植體支柱牙連接的機械屬性。

關鍵字：植體支柱牙連接、平台轉換、直徑移位、生物力學

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KOREAN / 한국어

임플란트 지대치 표면의 골 수준 직경 변이의 생체역학적 측면

저자: 시나이 캐니 (Senay Canay), Professor, DDS, PhD, 키반 아카 (Kıvanç Akça), Associate Professor, DDS, PhD

요약:
목적: 임플란트 주위 뼈와 임플란트 지대치 복합체 내의 응력(stress) 분산에 대한 임플란트 지대치 표면 직경 변이의 효과에 대한 평가

재료 및 방법: 8개의 각기 다른 임플란트 지대치 연결을 설계하고 모의실험을 수행하였다. 골 수준에서 임플란트-지대치 미세틈새를 "직경 변이" 또는 "플랫폼 전환" 컨셉으로 만들기 위해 임플란트의 중심축 안쪽으로 가상 이동시켰다. 개념적 설계는 나아가서 수평선상의 이동 거리, 탈출각 및 복원높이로 특징지워졌다. 복원 관계와 함께 전통적 임플란트 지대치 연결의 대조군 모델은, 임플란트 주위 뼈와 임플란트 지대치 복합체의 응력 증가를 비교하는 데에도 사용되었다. 모든 설계과정에서 수직으로 식립된 임플란트 지대치 복합체가 있는 14mm X 16mm 아크릴 실린더를 고려하였다. 수직 및 비스듬한 부하조건하에서 주요 그리고 폰 미세스 응력은 수치로 평가되었고 기술되었다.

결과: 임플란트 주위 뼈의 응력 분산은 모든 설계에서 거의 유사한 크기로 확인되었다. 수평적 전위거리 증가는 더 높은 응력 크기와 임플란트 지대치 복합체 내에서 응력 강도의 증가를 유발하였다. 토의: 플랫폼 변형 기반 임플란트 지대치 연결의 설계는 장기간의 기계적 안정성을 위한 최적 설계를 밝혀내기 위해 더 많은 기계적 연구가 필요하다.

결론: 뼈 수준에서 임플란트 지대치 연결의 재정의와 미세틈새의 재배치는 임플란트 주위 뼈의 응력 특성에 영향을 미치지는 않지만 임플란트 지대치 연결의 기계적 특성에 유의한 영향을 미칠 수 있다.

키워드: 임플란트 지대치 연결, 플랫폼 전환, 직경 변이, 생체역학

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