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論　文　内　容　の　要　旨

氏　名	（CARBAJAL MEJIA Jeison B.）
論文題名	CAD/CAM restorations fabricated over intraoral-scan-aided reverse tapered preparations 「口腔内スキャナー支援によるリバーステーパー型支台歯形成でのCAD/CAM歯冠修復」

論文内容の要旨

BACKGROUND: The digital restorative workflow, which starts with the generation of a 3-D replica of the clinical situation through intraoral scanning, aims to avoid the error-prone multistep process of conventional impressions, gypsum cast production, and extraoral digitalization by using a more reliable, standardized and predictable approach. In this regard, the present study aimed at developing a new minimally invasive concept to create dental restorations with the aid of intraoral scanners.

EXPERIMENT 1

Purpose: To evaluate the volumetric differences among different abutment tooth geometries and their influence on the accuracy of conventional and digital dental impressions in terms of trueness and precision.
Material and methods: Crown preparations with a total occlusal convergence (TOC) angle of −8, −6, −4, 0, 4, 8, 12, 16, and 22 degrees were digitally created from a maxillary left central incisor and printed in acrylic resin. Each of these 9 reference models was scanned with a highly accurate reference scanner (Rexscan DS) and saved as STL files. Then, 5 conventional polyvinyl siloxane (PVS) impressions were made from each reference model, poured with Type IV dental stone, scanned with both the reference scanner (PVS group) and the KaVo Arctica scan (extraoral group), and saved as STL files. Also, reference models were scanned directly with the TRIOS scanner (intraoral group) and their STL files exported. All STL files were compared with the reference model (trueness) and within each test group (precision). Volumetric differences were calculated by superimposing models. Data were analyzed using 2-way ANOVA with the post hoc LSD test ($\alpha = 0.05$).
Results: Overall trueness values were 19.1 μm (intraoral), 23.5 μm (extraoral), and 26.2 μm (PVS group), whereas overall precision values were 11.9 μm (intraoral), 18.0 μm (PVS), and 20.7μm (extraoral). Scans from TRIOS were significantly more accurate than those of the PVS and extraoral scanner groups when the TOC angle was less than 8 degrees ($p < 0.05$). Volumetric analysis revealed that a -8-degree preparation could save 28 mm^3 and 18.2 mm^3 of dental structure relative to a 22 and 12-degree preparation, respectively.
Conclusion: Only intraoral scanning can accurately record abutment tooth preparations with a TOC angle below 0 degrees. Also, 28 mm^3 of dental structure could be saved if -8-degree preparations were used.

EXPERIMENT 2

Purpose: To evaluate the marginal and internal fit of CAD/CAM zirconia crowns fabricated over conventional and reverse tapered preparations.
Material and methods: 3D printed casts (-8, -4, 0, 8, 12, 16, and 22 degrees) were scanned with TRIOS intraoral scanner and crowns were designed with KaVo multiCAD software using default parameters (50 μm cement space) on abutments with positive TOC angles whereas reverse tapered abutments (negative TOC angles) were digitally blocked out at 0 degrees and had an extra mesiodistal gap set to 50 μm. Then, zirconia crowns were fabricated, and their marginal and internal discrepancies were examined with the silicone replica technique under a stereomicroscope at a magnification of ×50. Normally distributed marginal fit values were analyzed with the 1-way ANOVA/post hoc Tukey test, whereas non-normal axial and incisal fit values with the

Kruskal–Wallis and the Dunn/Bonferroni multiple comparison test ($\alpha = 0.05$).

Results: The mean marginal fit of -8-degree crowns (58.2 ±6.0 μm) was statistically different ($p < 0.0001$) from all the remaining crowns (range 42.1 - 47.3 μm). Also, the internal fit was significantly different when comparing crowns fabricated over abutments with positive and negative TOC angles ($p < 0.0001$). The largest median axial discrepancies were found in the -8 (165.5 μm) and -4 (130.8 μm) degree groups; however, they showed the smallest incisal fit discrepancies (67.3 μm and 81.8 μm, respectively).

Conclusion: The marginal and internal fit of zirconia crowns fabricated over inverse tapered preparations was within clinically accepted values.

EXPERIMENT 3

Purpose: To evaluate the retentive strength of CAD/CAM crowns fabricated on reverse tapered preparations after 1-year of water storage.

Material and methods: Six different resin abutments (-8, -4, 0, 12, 16, and 22 degrees) were scanned with the TRIOS scanner and zirconia crowns (n =10 per TOC angle) were designed with KaVo multiCAD software, milled with KaVo Arctica, stored in water for 1 year, and removed from their abutments using a universal testing machine under tension, with a crosshead speed of 0.5 mm/min. Collected data were analyzed with 1-way ANOVA and post hoc Tukey test ($\alpha = 0.05$).

Results: The mean retentive force of crowns made on -8-degree abutments (409.4 ± 62.5 N) after 1 year of water storage was statistically greater than all the remaining groups (range 186.1 - 352.1 N). The TOC angle impacted significantly the retentive strength ($p < 0.0001$). Crowns from -8 and -4 degree groups showed significantly higher dislodging forces (409.4 and 352.1 N, respectively) than 12 (239.2 N), 16 (238.7 N), and 22 (186.1 N) degree groups ($p < 0.05$).

Conclusion: The retentive strength of crowns fabricated over reverse tapered preparations was statistically significantly higher than that of crowns made over abutments with a TOC angle higher than 12 degrees after 1-year water storage.

EXPERIMENT 4

Purpose: To evaluate the fracture strength of CAD/CAM crowns fabricated on reverse taper preparations with or without 1-month of water storage.

Material and methods: Three different resin abutments (-8, 0, and 12 degrees) were scanned with the TRIOS scanner and glass ceramic crowns (n =20 per TOC angle) were designed with KaVo multiCAD software, milled with KaVo Arctica, stored in water for either 1 or 30 days, and submitted to fracture test in a universal testing machine at a crosshead speed of 0.5 mm/min. Collected data were analyzed with repeated measures ANOVA and post hoc Tukey test ($\alpha = 0.05$).

Results: Mean loads to fracture for specimens with 1day/30days of water storage were: 205.6/190.1 N (-8 degrees), 233.8/223.6 N (0 degrees), and 218.2/229.8 N (12 degrees). There was not a statistically significant difference between both test conditions (1 day versus 30 days of water storage). Also, the interaction between water storage and the TOC angle within subgroups were not statistically significant ($p = 0.471$) and neither was the multiple comparisons test.

Conclusion: The fracture strength of crowns made on reverse taper preparations was not statistically different from crowns fabricated over abutments with 0 or 12 degrees.

GENERAL CONCLUSION: Within the limitations of the study, it was demonstrated that intraoral scanners could accurately record individual reverse tapered preparations and that the fit, retentive and fracture strength of CAD/CAM restorations derived from this minimally invasive concept (reverse tapered preparations) were within clinically accepted values.

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論文審査の結果の要旨及び担当者

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論文審査の結果の要旨

本研究は，実用化された歯科用 CAD/CAM システムを用いて，支台歯の削除量の減少を可能とするリバーステーパーを有する支台歯の計測精度および CAD/CAM クラウンの適合性，維持力，破壊強度について測定し，評価を行ったものである．

その結果，リバーステーパー型支台歯は，口腔内スキャナーを用いることで正確な印象採得を行うことができること，同支台歯から製作したジルコニアクラウンは，臨床的に許容される内面および辺縁適合性を有すること，および 12 度以上のテーパーを有する支台歯よりも有意に高い維持力を有することが示された．さらに，同支台歯から製作したガラスセラミックス製 CAD/CAM クラウンの破壊抵抗は，従来方法で製作したクラウンと同等であった．

以上の研究成果は，デジタル化時代における支台歯形成の新たな方向性を示しており，博士（歯学）の学位取得に値するものと認める．