UNIVERSIDADE FEDERAL DE SANTA MARIA
CENTRO DE CIÊNCIAS DA SAÚDE
PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS ODONTOLÓGICAS

Raquel Menezes da Rosa

ANÁLISE DE RESISTÊNCIA À FRATURA DOS DENTES TRATADOS ENDODONTICAMENTE RESTAURADOS COM PINOS USINADOS COMPARADOS A OUTROS RETENTORES INTRARRADICULARES

Santa Maria, RS
2021

Raquel Menezes da Rosa

ANÁLISE DE RESISTÊNCIA À FRATURA DOS DENTES TRATADOS ENDODONTICAMENTE RESTAURADOS COM PINOS USINADOS COMPARADOS A OUTROS RETENTORES INTRARRADICULARES

Dissertação apresentada ao Curso de Mestrado do Programa de Pós-Graduação em Ciências Odontológicas, área de concentração em Odontologia, ênfase em Prótese Dentária, da Universidade Federal de Santa Maria (UFSM, RS), como requisito parcial para a obtenção do grau de **Mestre em Ciências Odontológicas**

Orientador: Prof. Drº. Osvaldo Bazzan Kaizer
Coorientador: Prof. Drº. Vinicíus Felipe Wandscher

Santa Maria, RS
2021

This study was financied in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) – Finance Code 001

Rosa, Raquel
ANÁLISE DE RESISTÊNCIA À FRATURA DOS DENTES TRATADOS ENDODONTICAMENTE RESTAURADOS COM PINOS USINADOS COMPARADOS A OUTROS RETENTORES INTRARRADICULARES / Raquel Rosa.- 2021.
41 p.; 30 cm

Orientador: Osvaldo Bazzan Kaizer
Coorientador: Vinicíus Felipe Wandscher
Dissertação (mestrado) - Universidade Federal de Santa Maria, Centro de Ciências da Saúde, Programa de Pós Graduação em Ciências Odontológicas, RS, 2021

1. Retentores intrarradiculares 2. Pinos usinados 3. Tecnologia CAD/CAM 4. Resistência à fratura 5. Pinos pré fabricados I. Bazzan Kaizer, Osvaldo II. Wandscher, Vinicíus Felipe III. Título.

Sistema de geração automática de ficha catalográfica da UFSM. Dados fornecidos pelo autor(a). Sob supervisão da Direção da Divisão de Processos Técnicos da Biblioteca Central. Bibliotecária responsável Paula Schoenfeldt Patta CRB 10/1728.

Declaro, RAQUEL ROSA, para os devidos fins e sob as penas da lei, que a pesquisa constante neste trabalho de conclusão de curso (Dissertação) foi por mim elaborada e que as informações necessárias objeto de consulta em literatura e outras fontes estão devidamente referenciadas. Declaro, ainda, que este trabalho ou parte dele não foi apresentado anteriormente para obtenção de qualquer outro grau acadêmico, estando ciente de que a inveracidade da presente declaração poderá resultar na anulação da titulação pela Universidade, entre outras consequências legais.

Raquel Menezes da Rosa

ANÁLISE DE RESISTÊNCIA À FRATURA DOS DENTES TRATADOS ENDODONTICAMENTE RESTAURADOS COM PINOS USINADOS COMPARADOS A OUTROS RETENTORES INTRARRADICULARES

Dissertação apresentada ao Curso de Mestrado do Programa de Pós-Graduação em Ciências Odontológicas, área de concentração em Odontologia, ênfase em Prótese Dentária, da Universidade Federal de Santa Maria (UFSM, RS), como requisito parcial para a obtenção do grau de **Mestre em Ciências Odontológicas**

Aprovado em 23 de dezembro de 2021

Osvaldo Bazzan Kaizer

Osvaldo Bazzan Kaizer, Dr. (UFSM)
(Orientador / Presidente)

Marciano de Freitas Borges

Marciano de Freitas Borges, Dr. (UFN)

Andressa de Follak

Andressa Cargnelutti Follak Miotti, Drª. (UFSM)

Santa Maria, RS
2021

AGRADECIMENTOS

Ao longo desta trajetória tive a oportunidade desfrutar momentos especiais de grande alegria e de crescimento, assim como momentos difíceis, onde o medo e a insegurança se fizeram presentes, mas também pude encontrar pessoas incríveis as quais me estenderam a mão e caminharam ao meu lado para que eu pudesse concluir mais uma etapa em minha vida... Há vocês expresso minha sincera gratidão...

À Deus, por ter escutado as minhas preces e ter me fortalecido diante de momentos em que a dúvida se fez presente se esse era o caminho certo a percorrer, pois diante de toda a dor e saudade do meu amado pai, tu foste o meu amparo e a minha fortaleza, obrigada Senhor...

Aos meus pais, Wilson Menezes da Rosa *(in memoriam)* e Elsa Menezes da Rosa, por transmitirem os princípios mais genuínos do amor, dignidade e respeito, construindo a base da minha vida pessoal e profissional, principalmente demonstrando a cada dia toda a coragem para lutar diante das batalhas mais árduas, sem perder a doçura no olhar e o sorriso mais terno. Obrigada por serem o meu refúgio e apoio frente as minhas escolhas.

Ao meu irmão, e ao meu cunhado, obrigada pela cumplicidade e amizade, por sempre se fazerem presentes e compartilharem comigo todos os momentos de alegrias e tristezas.

Ao meu noivo, Valdem Junior, que sempre esteve ao meu lado, até quando a odontologia era apenas um sonho distante, tu me fizeste acreditar que seria possível e não mediste esforços para que eu pudesse chegar até aqui, saibas que essa conquista também é tua, pois compartilhaste comigo todos os momentos de alegria e de incertezas, obrigada meu amor, por ser tão especial.

Ao meu orientador, Prof. Dr. Osvaldo Bazzan Kaizer, agradeço a oportunidade de desenvolver esta dissertação, por compartilhares comigo todos os ensinamentos teóricos e práticos nas clínicas da graduação juntamente com os alunos e demais colegas, tornando as nossas aulas enriquecedoras.

Ao meu Co-orientador, Prof. Dr. Vinícius Felipe Wandscher por todo o apoio e contribuição no decorrer da minha formação acadêmica durante as aulas na graduação, bem como a experiência prática junto as monitorias agregando ao meu crescimento pessoal e profissional. Muito obrigada pela confiança desde o projeto e a realização do presente trabalho de dissertação.

Aos colegas de mestrado, por todo apoio, em especial ao Helder Callegaro Velho, que esteve presente durante todo o meu processo de aprendizado, sou muito grata por todo o apoio e grande amizade na construção do presente trabalho, pela parceria durante os seminários e apresentações, sempre disposto a ajudar, a escutar e compartilhar o conhecimento, saibas que tenho grande admiração pela pessoa que és e não tenho dúvidas que logo colherás os frutos merecidos do teu trabalho, obrigada por todos os momentos de descontração com um bom café no laboratório, pela tua sensibilidade e carinho.

Estendo a minha gratidão aos demais colegas: Eduardo Oliveira, por todas as caronas e os trabalhos em sala de aula, as meninas Anna Luiza Cruz e Rafaela Varallo, pelo nosso vínculo de amizade, ao colega Lucas Saldanha pela disponibilidade e atenção durante a fase laboratorial e revisão da presente dissertação, bem como a apresentação do trabalho, muito obrigada.

A Michele May e Carolina Druck, obrigada pelo incentivo desde a graduação, por todos os ensinamentos e principalmente por todo o carinho e amizade.

À Thaís Bohrer e Patrícia Fontana, pelo apoio durante esta trajetória bem como a doação dos materiais, estendo o meu carinho as colegas da Iniciação Científica pela disponibilidade junto ao laboratório na execução do presente trabalho, Ana Luísa Gauger e Andrieli Righi, muito obrigada.

À Simone Lima e a Jéssica Dalcin, pelo auxílio, disponibilidade e gentileza, na demanda burocrática e as atividades relacionadas ao laboratório de biomateriais e a PPGCO, muito obrigada.

Ao Prof. Dr. Luiz Felipe Valandro, pela gentileza e disponibilidade durante o agendamento da Instron para a execução do presente trabalho.

Aos professores da Pós-Graduação em Ciências Odontológicas (PPGCO) por todas as aulas e desafios propostos os quais colaboraram para o meu crescimento ministrando as aulas teóricas e práticas aos alunos da graduação ao lado dos professores da Disciplina de Prótese Total.

Em especial ao Prof. Dr. Claudio Figueiró, pela confiança em mim depositada para desenvolver a atividade voluntária profissional com os alunos da graduação, proporcionando grande crescimento na minha formação pessoal, profissional, e incentivo para ingressar no mestrado com a construção do presente trabalho e contribuição durante o Exame de Qualificação.

Agradeço também ao Professor Marciano Borges por todo apoio ao longo da minha formação acadêmica, saibas que tenho grande admiração e carinho, obrigada pela disponibilidade e apreciação durante o Exame de Qualificação e Defesa.

Aos membros que compõem a banca examinadora, Prof.ª Drª Andressa Follak Miotti e Prof.ª Drª Sara Fraga, pelo aceite, disponibilidade e apreciação do presente trabalho.

À Universidade Federal de Santa Maria, por me proporcionar um ensino público e de qualidade durante o mestrado.

À CAPES, por fomentar o presente trabalho durante o meu ingresso na pós-graduação como bolsista.

A empresa Angelus pela doação de material para o desenvolvimento da presente pesquisa.

Ao Laboratório Vitasul, pela parceria, muito obrigada.

À Universidade Franciscana, pela minha formação acadêmica com ensino superior de qualidade, bem como todos os professores do curso de Odontologia manifesto a minha imensa gratidão.

À Clarissa Montagner, pelo apoio e amizade na realização do presente trabalho, dividindo comigo a tarefa de cuidados durante a minha recuperação da Covid-19 e também com o meu pai no momento em que mais precisei me ausentar para a realização do presente trabalho na fase laboratorial, muito obrigada.

À Claudia Trindade pela sessão de fotos laboratoriais, na fase inicial do presente trabalho, muito obrigada.

À Rosecleia Machado, por todo o carinho e atenção, me acalmando nos momentos de maior fragilidade, se fazendo presente diariamente como um anjo em minha vida, muito obrigada.

Enfim, agradeço a todas as pessoas que estiveram comigo nesta jornada e de alguma forma se fizeram presentes, me ouvindo, aconselhando e torcendo por mim durante a execução desta pesquisa, mesmo que não citado, saibas da minha gratidão, pois sozinhos nada somos e nada realizamos. Muito Obrigada.

RESUMO

ANÁLISE DE RESISTÊNCIA À FRATURA DOS DENTES TRATADOS ENDODONTICAMENTE RESTAURADOS COM PINOS USINADOS COMPARADOS A OUTROS RETENTORES INTRARRADICULARES

AUTOR: Raquel Menezes da Rosa
ORIENTADOR: Osvaldo Bazzan Kaizer
COORIENTADOR: Vinícius Felipe Wandscher

A utilização de blocos/discos de compósitos a base de fibra de vidro e resina epóxi para fresagem para a tecnologia assistida por computador - CAD/CAM possibilita a confecção de retentores intrarradiculares usinados, altamente individualizados às paredes radiculares, visando suprir requisitos biológicos, funcionais e estéticos, otimizando o tempo clínico. No entanto, não há estudos consolidados comparando este material aos já existentes no mercado, justificando a necessidade desta pesquisa. A presente dissertação busca avaliar a resistência à fratura e o modo de falha do pino intrarradicular usinado pelo sistema CAD/CAM, comparando a outros retentores intrarradiculares, após ciclagem mecânica. Para o estudo, foram selecionados 75 incisivos bovinos hígidos, onde a porção coronária foi seccionada em 16mm, pradronizando assim as raízes. Todos os espécimes foram tratados endodonticamente e obturados com cimento endodôntico à base de resina epóxica, foram randomizados e distribuídos em cinco grupos (n=15) conforme o tipo de retentor intrarradicular: NMF - núcleo metálico fundido; PF – pino de fibra de vidro; PA – pino anatômico; PFA - pino de fibra de vidro associado a pinos acessórios e PFU - pino usinado CAD/CAM. Na sequência, o espaço para o pino foi preparado em 12mm de profundidade, com sonda reta aquecida e com a broca indicada para o pino utilizado em cada grupo. A seguir, os canais foram fragilizados com a ponta diamantada #4137, para simular raízes fragilizadas (com canais alargados e paredes finas). Os retentores foram cimentados com cimento resinoso autoadesivo, receberam coroas metálicas e o ligamento periodontal foi simulado com o uso de material elastomérico. Os corpos de prova foram submetidos à ciclagem mecânica em equipamento de fadiga (Instron Electropuls E3000, Instron, Norwood, MA - USA) com o seguinte protocolo: 15Hz de frequência, 80N de carga, 37°C de temperatura e 100.000 ciclos. Os espécimes que sobreviveram à ciclagem mecânica foram submetidos ao teste de resistência à fratura em máquina de ensaios universal (DL 2000, Emic, São José dos Pinhais, Brasil), à velocidade de 0,5mm/min e a 45° de inclinação até a falha. Verificada a normalidade dos dados, foram realizadas análise de variância de um fator (Oneway ANOVA) e teste post hoc de Tukey ($p=0,05$). O grupo com núcleo metálico fundido apresentou valores de resistência à fratura superiores aos demais grupo ($p<0,05$), que não apresentaram diferenças significativas entre si ($p>0,05$). Assim é possível concluir que pinos usinados CAD/CAM apresentam valores de resistência à fratura semelhante ao pino de fibra de vidro, pino anatômico e ao pino de fibra de vidro associado a pinos acessórios, sendo esses menos resistentes à fratura que núcleos metálicos fundidos. No entanto, todos os grupos apresentaram falhas desfavoráveis, com fraturas abaixo da linha cemento-esmalte na grande maioria dos espécimes.

Palavras-chave: Retentores intrarradiculares. Pinos usinados. Tecnologia CAD/CAM. Resistência à fratura. Pinos pré-fabricados.

ABSTRACT

FRACTURE RESISTANCE ANALYSIS OF ENDODONTICALLY TREATED TEETH RESTORED WITH MACHINED POSTS COMPARED TO OTHER INTRA-RADICULAR

AUTHOR: Raquel Menezes da Rosa
PROMOTER: Osvaldo Bazzan Kaizer
CO-PROMOTER: Vinícius Felipe Wandscher

The use of composite blocks/discs based on fiberglass and epoxy resin for milling for computer-assisted technology - CAD/CAM enables the manufacture of machined intraradicular retainers, highly individualized to the root walls, in order to meet biological, functional and aesthetics, optimizing clinical time. However, there are no consolidated studies comparing this material to those already on the market, justifying the need for this research. This dissertation seeks to evaluate the fracture resistance and failure mode of the intraradicular post machined by the CAD/CAM system, comparing it to other intraradicular retainers, after mechanical cycling. For the study, 75 healthy bovine incisors were selected, where the coronary portion was sectioned in 16mm, thus standardizing the roots. All specimens were endodontically treated and filled with epoxy resin-based endodontic cement, were randomized and distributed into five groups (n=15) according to the type of intraradicular retainer: CMP - cast metal post; PF – fiberglass post; PA – anatomical post; PFA - fiberglass post associated with accessory posts and MP - machined posts CAD/CAM. Next, the space for the post was prepared at 12mm in depth, with a heated straight probe and the drill indicated for the post used in each group. Then, the channels were embrittled with a #4137 diamond tip, to simulate embrittled roots (with widened channels and thin walls). The retainers were cemented with self-adhesive resin cement, received metallic crowns and the periodontal ligament was simulated using polyether. The specimens were subjected to mechanical cycling in fatigue equipment (Instron Electropuls E3000, Instron, Norwood, MA - USA) with the following protocol: 15Hz frequency, 80N load, 37°C temperature and 100,000 cycles. The specimens that survived mechanical cycling were submitted to fracture resistance test in a universal testing machine (DL 2000, Emic, São José dos Pinhais, Brazil), at a speed of 0.5mm/min and a 45° inclination to the failure. After verifying the normality of the data, one-way analysis of variance (Oneway ANOVA) and Tukey's post hoc test ($p=0.05$) were performed. The group with cast metal core showed higher fracture resistance values than the other groups ($p<0.05$), which did not present significant differences between them ($p>0.05$). Thus, it was observed that machined CAD/CAM posts have fracture resistance values similar to conventional fiberglass post, anatomical post and to fiberglass post associated with accessory post, which are less resistant to fracture than cast metal post. As for failures, all groups had unfavorable failures, with fractures below the cemento-enamel line in most specimens.

Keywords: Intra-radicular retentors. Machined posts. CAD / CAM technology. Fracture resistance. Prefabricated

SUMÁRIO

1 INTRODUÇÃO

Perdas estruturais extensas da porção coronária oriundas de lesões de cárie e traumas, podem determinar a necessidade de tratamento endodôntico associado a um retentor intrarradicular (GARCIA et al., 2018; VELHO et al., 2021).

Segundo Marchionatti et al (2017), para a reabilitação de dentes tratados endodonticamente com significativa perda de estrutura mineral, preconiza-se a indicação de um pino intrarradicular, o qual não irá fortalecer a estrutura dental, mas irá promover a retenção da restauração final e diminuir a transferência de tensões a estrutura dental.

Entretanto, o reestabelecimento biomecânico, funcional e estético de dentes despolpados com indicação de retentores intrarradiculares torna-se complexo, uma vez que a estrutura dentária enfraquecida pela perda mineral se apresenta mais suscetível a fraturas quando comparadas a dentes vitais (MARCHIONATTI et al., 2017; RUSCHEL et al., 2018; FONTANA et al., 2019).

É relativamente comum que dentes tratados endodonticamente possuam a configuração de canais radiculares muito alargados e paredes finas devido à excessiva remoção de dentina durante o preparo do canal, o que pode inviabilizar técnicas reabilitadoras diretas e elevar o risco de fratura durante a função (EID a et al.,2019; PANG et al., 2019).

Portanto, é de grande importância o uso de técnicas restauradoras utilizando retentores intrarradiculares que configurem uma melhor adaptação ao conduto radicular, diminuindo assim a espessura da linha de cimentação, proporcionando a necessária retenção mecânica dos materiais de reconstrução da estrutura coronária perdida (DEMIRYÜREK et al., 2010; MANICARDI et al., 2011; WANDSCHER et al., 2014).

Os núcleos metálicos fundidos foram a principal escolha como retentores intrarradiculares em dentes com pouco ou nenhum remanescente coronário durante muitas décadas (SANTOS et al., 2010; RUSCHEL et al., 2018). Porém, devido principalmente a aspectos biomecânicos como o alto módulo de elasticidade do metal em relação ao da dentina e a possibilidade de interferir na estética, especialmente em restaurações livres de metal, a utilização dos núcleos metálicos fundidos tem diminuído (WANDSCHER et al., 2014; MIORANDO et al., 2018).

A partir de meados dos anos 1990, houve grande crescimento na utilização de pinos pré-fabricados de fibra em relação aos outros tipos de retentores intrarradiculares (NAUMANN et al., 2012). Ao contrário dos retentores intrarradiculares metálicos, os pinos de fibra possuem módulo de elasticidade similar ao da dentina, distribuindo de forma mais homogênea as tensões na estrutura dentária, além de melhores propriedades estéticas, menor tempo clínico, dispensando assim a fase laboratorial e reduzindo o risco de fraturas radiculares irreparáveis (GIACHETTI et al., 2009; GARCIA et al., 2018; EID a et al.,2019).

Entretanto, os pinos de fibra pré-fabricados, assim denominados em escala industrial, possuem uma configuração geométrica cônica ou cilíndrica, onde a configuração cônica possui uma retenção menor, gerando estresse durante a função mastigatória, consequentemente aumentando o risco de fratura (PASQUALIN et.al, 2012). A configuração cilíndrica para ter retenção necessita maior remoção de estrutura durante o preparo, ou seja, os padrões não são personalizados, o que os torna contraindicado para elementos dentários com condutos excessivamente alargados, com pouca estrutura remanescente, podendo comprometer o sucesso clínico (SILVA et al., 2009; PASQUALIN et.al., 2012; EID a et al., 2019).

A técnica de pinos anatômicos (pinos reembasados) visa alcançar melhor adaptação aos canais amplos e evitando assim falhas decorrentes da quantidade excessiva de cimento necessária para preencher o espaço deixado entre pinos de diâmetro inferior ao de condutos alargados (OLIVEIRA et al., 2018; BORZANGY et al., 2019). Esta técnica consiste basicamente em reembasar o pino pré-fabricado de fibra, modelando o conduto radicular usualmente com um material polimérico (CLAVIJO et al., 2006; OWEN; BARBER, 2018).

Assim, obtém-se melhor adaptação do pino às paredes do canal e significativa diminuição da linha de cimentação, levando a um prognóstico mais favorável dos casos, bem como economia de tempo, custo-benefício e longevidade do tratamento (COELHO et al., 2009; OLIVEIRA et al.2018).

Ainda é possível utilizar pinos acessórios associados ao pino principal de fibra de vidro, com esse mesmo objetivo de diminuir a quantidade de cimento no interior do conduto, minimizando os prejuízos advindos de uma grande contração de polimerização na utilização de material polimérico (MARTELLI et al., 2008). Segundo Aggarwal et al. (2012), o método não aumentou a resistência à fratura, mas reduziu a ocorrência de fraturas irreparáveis quando comparado aos grupos com núcleos metálicos fundidos.

Recentemente, novos produtos e tecnologias têm sido propostos para reconstrução de dentes tratados endodonticamente, e dentre estes materiais é possível obter um de pino usinado através de tecnologia assistida por computador, descrita na literatura como CAD-CAM *(Computer-Aided-Design/Computer-Aided-Manufacturing)* (DAVIDOWITZ; KOTICK, 2011; GARCIA et al., 2018; BORZANGY et al., 2019).

Segundo Chen et al., (2015) através da análise de elementos finitos, a estrutura do pino de fibra de vidro e núcleo de resina composta configuram unidades separadas o que pode levar a falha da restauração através da interface de união, além do pino não ser totalmente adaptado ao espaço intrarradicular.

No entanto, o estudo mostra que um pino de fibra de vidro fabricado pela tecnologia CAD/CAM possui uma configuração em estrutura única, unindo a porção intrarradicular e a porção coronária, minimizando a interface entre o pino a resina e o cimento, adaptando o pino intrarradicular usinado ao conduto alargado e com paredes finas devido à excessiva remoção de dentina durante o preparo, sendo melhor que um pré-fabricado em escala comercial principalmente para dentes anteriores gravemente danificados (BERNARDES et al., 2012; PANG et al., 2019).

O FIBER CAD POSTE & Core (Fiber CAD, Post & Core, Angelus Indústria de Produtos Odontológicos S/A – Londrina, Paraná, Brasil) é um compósito de 75-80% fibras de vidro e 20-25% resina epóxi nos formatos de blocos para uso *charside* onde a confecção é realizada no ambiente clínico do próprio consultório através da aquisição da imagem/digitalização, desenho e produção, ou em discos para uso *lab-side,* ou seja, uso laboratorial pelo sistema CAD/CAM, indicado para a confecção de núcleo anatômico devidamente adaptado ao conduto, mecanicamente compatível com a estrutura radicular, estético, além de reduzir a interface de cimentação, o tempo clínico e variáveis dependentes do operador, segundo orientações do manual do fabricante (ALGHAZZAWI, 2016).

Diante da necessidade de um maior entendimento sobre o comportamento biomecânico dos pinos usinados pela tecnologia CAD/CAM quando comparado aos outros sistemas de retentores intrarradiculares já existentes, bem como a escassa literatura no que tange informações sobre esta nova opção para reconstrução de dentes tratados endodonticamente, norteou a realização da presente dissertação, que será apresentada em formato de artigo, intitulado **"Análise de resistência à fratura dos dentes tratados endodonticamente restaurados com pinos usinados comparados a outros retentores intrarradiculares"** que objetivou avaliar a resistência à fratura e padrão de falha dos dentes restaurados com pinos usinados pelo sistema CAD/CAM quando comparado a outros sistemas de retentores intrarradiculares após ciclagem mecânica.

2 ARTIGO: ANÁLISE DE RESISTÊNCIA À FRATURA DOS DENTES TRATADOS ENDODONTICAMENTE RESTAURADOS COM PINOS USINADOS COMPARADOS A OUTROS RETENTORES INTRARRADICULARES.

Este artigo será submetido ao periódico Operative Dentistry, ISSN: 0361-7734, Fator de impacto = 2.893; Qualis A1. As normas para publicação estão descritas no Anexo A.

ANÁLISE DE RESISTÊNCIA À FRATURA DOS DENTES TRATADOS ENDODONTICAMENTE RESTAURADOS COM PINOS USINADOS COMPARADOS A OUTROS RETENTORES INTRARRADICULARES

Rosa, RM; Bohrer, TC; Fontana PE; Velho, HC; Da Rosa, LS; Wandscher, VF; Kaizer OB;

Raquel Menezes da Rosa, DDS, MSD, graduate student in Oral Sciences (Prosthodontics) Faculty of Odontology, Federal University of Santa Maria, Santa Maria, Brazil.

Thaís Camponogara Bohrer, DDS, MSD, graduate student in Oral Sciences (Prosthodontics) Faculty of Odontology, Federal University of Santa Maria, Santa Maria, Brazil.

Patrícia Eliana Fontana, DDS, graduate student in Oral Sciences (Prosthodontics) Faculty of Odontology, Federal University of Santa Maria, Santa Maria, Brazil.

Helder Callegaro Velho, DDS, MSD, graduate student in Oral Sciences (Prosthodontics) Faculty of Odontology, Federal University of Santa Maria, Santa Maria, Brazil.

Lucas Saldanha da Rosa, DDS, MSD, graduate student in Oral Sciences (Prosthodontics) Faculty of Odontology, Federal University of Santa Maria, Santa Maria, Brazil.

Vinícius Felipe Wandscher, DDS, MSD, PhD, Adjunct Professor, Faculty of CNEC Santo Ângelo, Brasil.

Osvaldo Bazzan Kaizer MSD, PhD, Professor Adjunct, MDS Graduate Program in Oral Sciences (Prosthodontics Units), Faculty of Odontology, Federal University of Santa Maria, Santa Maria, Brazil.

Corresponding author:

Osvaldo Bazzan Kaizer
MSD, PhD, Adjunt Professor,
MDS Graduate Program in Oral Science (Prosthodontics Units)
Faculty of Odontology,
Federal University of Santa Maria, Santa Maria, Brazil.
Department of Restorative Dentistry
Floriano Peixoto Street, 1184, 97015-372, Santa Maria, Brazil.
Phone: +55-55-3222-3444
E-mail: obekaizer@terra.com.br

Authors' email adresses:

Raquel Menezes da Rosa (odontollegal@gmail.com)
Thaís Camponogara Bohrer (thaiscbohrer@hotmail.com)
Patrícia Eliana Fontana (patricia_fontana_@hotmail.com)
Helder Callegaro velho (heldercvelho@hotmail.com)
Lucas Saldanha da Rosa (lucas.saldanha.da.rosa @gmail.com)
Vinícius Felipe Wandscer (viniwan@hotmail.com)
Osvaldo Bazzan Kaizer (obekaizer@terra.com.br)

Short title: Machined pins and fracture resistance of endodontically treated teeth

Clinical Revelance: The use of a machined intraradicular retainer presents better adaptation to the wide root canal and a smaller cementation interface as it is a structure that joins the post to the coronary portion, minimizing failures resulting from cementation.

ABSTRACT

Purpose: Evaluate the fracture resistance and failure mode of intraradicular posts machined by the CAD/CAM system when compared to other intraradicular retainer systems after mechanical cycling.

Methods: 75 bovine incisors were selected, where the coronary portion was sectioned in 16mm, thus standardizing the roots. All specimens were endodontically treated and filled with epoxy resin-based endodontic cement and, were randomized and distributed into five groups (n=15) according to the type of intraradicular retainer: CMP – cast metal post; PF – fiberglass post; PA – anatomical post; PFA – fiberglass post associated with accessory posts; MP – machined post CAD/CAM. Next, the space for the post was prepared at 12mm in depth, with a heated straight probe and the drill indicated for the post used in each group. Then, the channels were embrittled with a #4137 diamond tip, to simulate embrittled roots (with widened channels and thin walls). The retainers were cemented with self-adhesive resin cement, received metallic crowns and the periodontal ligament was simulated using polyether. The specimens were subjected to mechanical cycling in fatigue equipment (Instron Electropuls E3000, Instron, Norwood, MA - USA) with the following protocol: 15Hz frequency, 80N load, 37°C temperature and 100,000 cycles. The specimens that survived mechanical cycling were submitted to fracture resistance test in a universal testing machine (DL 2000, Emic, São José dos Pinhais, Brazil), at a speed of 0.5mm/min and a 45° inclination to the failure.

Results: After verifying the normality of the data, one-way analysis of variance (Oneway ANOVA) and Tukey's post hoc test ($p=0.05$) were performed. The group with cast metal core showed higher fracture resistance values than the other groups ($p<0.05$), which did not present significant differences between them ($p>0.05$).

Conclusions: Thus, it was observed that machined CAD/CAM post have fracture resistance values similar to conventional fiberglass post, anatomical post and to fiberglass post associated with accessory post, which are less resistant to fracture than cast metal. As for failures, all groups had unfavorable failures, with fractures below the cemento-enamel line in most specimens.

Keywords: Intra-radicular retentors. Machined posts. CAD / CAM technology. Fracture resistance. Prefabricated posts.

INTRODUCTION

The endodontic treatment provided dentistry with the preservation of the tooth element and its rehabilitation[1,2]. However, it remains a complex task in large canals due to the significant loss of coronary structure and the preparation of the root canal for the restoration using an intraradicular retainer[3,4,5].

Due to the significant amount of mineral structure lost as a result of extensive cavitary preparations for prosthetic purposes, failures in restorations, extensive carious lesions and/or trauma to dental tissues, it is common for canals to present wider configurations increasing the risk of fracture during function when compared to vital teeth[6,7,8].

The rehabilitation of pulpless teeth aims to restore the biomechanical, functional, and aesthetic restoration, with restorative techniques that have better adaptation to the root canal, providing the necessary mechanical retention of the reconstruction materials and reducing the transfer of stresses to the tooth structure weakened by mineral loss[9,10,11,12].

Traditionally, cast metal were the choice for long decades for the rehabilitation of teeth with excessive loss of coronary structure[13,14]. However, in addition to interfering with esthetics, especially in metal free restorations, the use of cast metal has decreased due to the high modulus of elasticity, which can result in catastrophic failures, making the maintenance of the dental element difficult[9,3,15].

In this sense, in the search to preserve the tooth structure from catastrophic failures and materials with biomechanical properties, similar to dentin and aesthetic, there was a growth in the use of fiberglass posts[14,16]. Among the advantages of restoring with prefabricated fiberglass posts, in addition to better aesthetic properties, shorter clinical time, it does not require the laboratory phase and the lower risk of irreparable root fractures, distributing stresses evenly to the tooth structure[7,17].

However, depending on the configuration of the root canal, as very wide canals, the patterns are not personalized, which makes them contraindicated by increasing the thick cementation interface, generating a challenge in adhesion, which may compromise clinical success[18,19].

In this case, in excessively widened root canal with little remaining structure, it basically consists of relining the prefabricated fiber post, modeling the root canal with a polymeric material, that is, anatomical posts relined with composite resin, in order to fill the space between the smaller diameter post to root canal avoiding failures due to the amount of cement[20,21].

It is still possible to associate accessory posts to the main fiberglass post, in order to reduce the amount of cement inside the root canal, minimizing the damage caused by a large polymerization contraction [22,23].

Given the complexity of restoring excessively large root canal, the choice of intraradicular retainer becomes a challenging factor, since prefabricated fiber posts are not customized, limiting their use due to polymerization shrinkage factors, cementation failures and contributing to the reduction of fracture resistance[24,25].

Recently, advances through *Computer-Aided Design/Computer-Aided Manufacturing* (CAD-CAM) technology include the fabrication of intraradicular retainers, with materials of high aesthetic performance and allied to biomechanical properties for restorations of excessively enlarged root canal[26,27].

Through CAD/CAM technology, aided by virtual planning, an alternative emerges, which aims to overcome the limitations of the prefabricated fiberglass post in wide root canal, customizing the intraradicular retainer in a single structure, joining the intraradicular portion and the coronary portion, thus minimizing the interface between the post, resin and cement, better distributing forces to the remaining tooth due to mechanical properties similar to the tooth structure[28,8,29].

In view of the scarce literature on the subject, the present study aimed to evaluate the fracture resistance and failure pattern of posts machined by the CAD/CAM system when compared to other intraradicular retainer systems after mechanical cycling. The null hypothesis considered was that there would be no difference in the values of fracture resistance and failure mode between the groups.

METHODS AND MATERIALS

Selection of specimens

75 bovine incisor teeth were selected and analyzed for detection of possible fractures, cracks and fissures, with the aid of a magnifying glass (4x magnifying EyeMag® Pro, Carl Zeiss do Brasil Ltda, São Paulo, Brazil). Afterwards, they had the coronary portions sectioned to standardize the roots in 16mm the root apex, were randomized and randomly distributed using the website: random.org (Trinity College, Dublin, Ireland) into five groups (n=15), varying the type of intraradicular post used, as shown in Table 1. In order to reduce the variation in size between the root canals, they were measured with the aid of a digital caliper (Starrett 727, Starrett, Itu, São Paulo, Brazil), in the mesio-distal and vestibulo-lingual distances and the

measurements were tables, checked the normality of the data, one-way analysis of variance was performed (Oneway ANOVA), it was shown that there was no statistically significant difference ($\alpha < 0.5$) in the size of the teeth between the groups.

Endodontic treatment

The teeth were endodontically treated using the conventional step technique using second serie endodontic files (Dentsply Maillefer, Ballaigues, Switzerland) and Gates-Glidden drills (Dentsply Maillefer, Ballaigues, Switzerland) number 3, 4 and 5. The specimens were filled 1 mm below the root apex with endodontic cement based on AH Plus epoxy resin (Dentsply Maillefer, Petrópolis, Rio de Janeiro, Brazil) and gutta-percha cone (Tanari, Manacapuru, Amazonas, Brazil). The cold lateral condensation technique was used with R8 accessory cones (Tanari, Manacapuru, Amazonas, Brazil). For the compaction of the material, a digital scale was used in order to standardize the obturation force, not exceeding 2000g (BOHRER et al., 2018)31. After endodontic treatment, the specimens were stored for 24 hours at 37°C.

Periodontal ligament confection

The periodontal ligament was simulated using the protocol according to SOARES et al. (2005)[30], where the roots were coated with wax 7 (Lysanda, São Paulo, São Paulo, Brazil), liquefied in a container with a standard temperature of 70ºC at a thickness of 0.3mm measured with the aid of a digital calipers (Starrett 727, Itu, São Paulo, Brazil). Then, the roots were embedded in polyvinyl chloride rings with a height of 20mm and diameter of 25mm with chemically activated acrylic resin (VIPI Flash, VIPI, Pirassununga, São Paulo, Brazil) keeping 2mm of the root remnant out of the resin until the total polymerization.

After polymerization of the acrylic resin, the teeth were removed and the wax 7 removed, simulating the periodontal ligament space, which was filled with elastomeric material (Impregum F-3M-ESPE, Seefeld, Germany), manipulated according to the manufacturer's instructions, inserted into the Artificial alveolus and teeth were repositioned and excesses removed.

Preparation for post

The space for the post was prepared by partially opening the roots to 12mm in depth for all groups. For this, a heated instrument was used, keeping 4mm of gutta-percha in the apical third, followed by Largo drills of size 1, 2, 3 and 4 respectively (Dentsply Maillefer, Petrópolis, Rio de Janeiro, Brazil).

The weakening of the root canals (wide and thin-walled canals) was simulated with the number 4137 truncated-conical diamond drill (KG Sorensen, Cotia, São Paulo, Brazil), with a 2.6mm coronary diameter, adapted to a high-speed pen. and abundant irrigation (Extra Torque 605C; Kavo do Brasil Ind. Com. Ltda, Joinville, Santa Catarina, Brazil).

Production and cementation of posts and crowns

Group CMP

To obtain the patterns of the cast metal post and core, the root canal was insulated with a water-soluble gel (KY gel, Johnson & Johnson, São José dos Campos, São Paulo, Brazil) using a thin cylindrical microapplicator (Cavibrush – FGM Produtos Odontológico, Joinville, Santa Catarina, Brazil). Afterwards, the root canal was modeled using the fine brush technique (Marta's brush, Dencril, Pirassununga, São Paulo, Brazil) with increments of polymer (powder) and monomer (liquid) of chemically activated red acrylic resin (Reliance Dental Mfg. Co. Chicago, USA). After the technique, prefabricated plastic post (Pinjet, Angelus, Londrina, Paraná, Brazil) were inserted into the root canal in order to help modeling along its entire length.

For the coronal portion of the core, a standardized acetate matrix measuring 5mm in height and 4mm in width was made, which were used in all groups.

These acetate matrices were filled with chemically activated red acrylic resin and positioned on the tooth element. After polymerization, adjustments and removal of excess were carried out with conical tungsten cutters (America Burrs, Palhoça, Santa Catarina, Brazil).

Resin patterns were handed over to a commercial laboratory for the casting (Ni-Cr, Wironia Light, Bego, Germany).

Next, the cast posts and cores were evaluated for adaptation and, prior to cementation, received surface treatment by air-abrasion with aluminum oxide particles (110 µm, pressure 2.8 bars, 10 mm distance and 15 seconds) (Blue, São José do Rio Preto, Brazil).

Groups PA, PF e PFA

The prefabricated fiberglass posts followed the surface preparation protocol established by the manufacturer, using alcohol at 70° and treatment with a silane bonding agent (Angelus, Londrina, Paraná, Brazil) applying a layer awaiting solvent evaporation for 5 minutes and repeating the application. For group PA to obtain the anatomical posts, composite resin color

A1 Z250 (3M-ESPE, Seefeld, Germany) was photo-activated.Initially, a layer of insulating K-Y water-soluble gel was applied to the root canal in order to prevent the bonding of the composite resin to the walls using a disposable microapplicator. The composite was inserted in a single increment and the fiberglass post was positioned centrally in the root canal, the excesses being removed, the entire set was photoactivated (Radiical, SDI, Victoria, Australia) for 10 seconds through its occlusal surface. After photoactivation, the set was removed from the conduit and photoactivated for another 40 seconds (10 seconds on each face - buccal, mesial, distal and lingual).

For group PF and PFA, the fiberglass posts (main post) and the accessory fiberglass posts were cemented simultaneously.

Group PM CAD/CAM

The post machined by the CAD/CAM system followed the patterns of posts obtained with red acrylic resin chemically activated by the same technique described in the CMP group and then sent to a commercial laboratory for machining.

In the Laboratory, the red acrylic resin pattern received a non-aqueous spray layer of the Metal.Chekmart brand (Metal-Chek do Brasil Ind. e Comércio LTDA, Bragança Paulista, São Paulo, Brazil) which is specifically intended for the scanning phase, as per the manufacturer's note.

The scanning was performed on device (Model E1 3Shape Exocad software, Copenhagen, Denmark) thus making a digital model. The digital model was worked virtually in specific 3Shape Exocad software according to the necessary standards (cervical, mesio-distal and vestibular-lingual dimensions).

After calibrating the system and inserting the fiberglass disc (Fiber CAD, Post & Core LAB, Angelus Produtos Odontológico, Joinville, Santa Catarina, Brazil) in the machining machine (Motion 1 Amnngirrbach, Koblach - Austria), it performed the execution of the milling itself in 20 minutes to make one piece. The machined post received the same surface treatment protocol described for groups PF, PA and PFA.

All groups were cemented with self-adhesive resin cement RelyX U200 (3M – ESPE, Seefeld, Germany) manipulated according to the manufacturer's guidelines, the cement was applied to the walls of the root canal with Lentulo number 40 (Injecta, Diadema, São Paulo, Brazil). The posts were positioned in the root canal and excess cement was removed and light-activated for 40 seconds (on each side of the tooth for 10 seconds).

After the cementation of the posts, cores of the PA, PF and PFA groups were made: the coronary portion were prepared using 37% phosphoric acid (Angelus, Londrina, Paraná, Brazil), and the adhesive Ambar (FGM) was applied according to the manufacturer's guidelines.

For the core standardization, an acetic matrix (identical to that used for the CMP group) was used. The matrix was filled with increments of composite resin and adapted over the coronary portion of the post. Afterward, the matrices were sectioned, and the composite resin was photo-activated (1200 mW/cm^2, Radiical, SDI, Victoria, Australia) on each side of the tooth for 10 seconds.

For all groups, metallic full-crowns (Ni-Cr alloy, Wirona light, Bego, Goldschlagerei, Germany) were prepared with standard shape and dimensions, according to the anatomy of a superior canine. After that, the crowns were evaluated and air-abraded with aluminum oxide (110 µm, pressure: 2.8 bars, 10 mm distance and 15 seconds).

The total metal crowns were cemented with RelyX U200 (3M – ESPE, Seefeld, Germany) manipulated according to the manufacturer's guidelines, excess cement was removed. The samples were stored for 24 hours before testing.

Mechanical cycling

The specimens were subjected to mechanical cycling in fatigue equipment (Instron Electropuls E3000, Instron, Norwood, MA - USA) with the following protocol: 15Hz frequency, 80N load, immersion in water at ± 37°C temperature and 100,000 cycles, with the load 45° in relation to the horizontal plane, with the spherical piston of 6mm in diameter positioned in the lingual portion of the metallic total crown.

After cycling, the specimens were evaluated for the presence of damage with the aid of a magnifying glass and transillumination, then they were submitted to the fracture resistance test.

Fracture load test

To perform the fracture load test, a universal test machine (DL 2000, Emic, São José dos Pinhais, Brazil) was used. The specimens were subjected to the fracture load test, positioned on a fixed metal device, and aligned at a 45° angle with respect to the long axis of the tooth.

The spherical piston (diameter 0.6 mm) attached to the load cell (1000 kN) was applied to the lingual load (2 mm from the lingual incisal edge) at a speed of 0.5 mm/min until failure occurred.

Failure analysis

The roots were stained superficially with hydrographic pens (Blue overhead marker, Faber-Castell, São Carlos, Brazil). The excess ink was then removed with cotton and 70% alcohol, and the specimens were visualized with a stereomicroscope at 10x magnification (Stereomicroscope Discovery V20; Carl Zeiss, Germany). The failures were classified as favorable and unfavorable. The fractures were considered favorable when they were located above the limit of the inlaid acrylic resin (3 mm), which simulated the bone tissue. Fractures located below this limit (3 mm) were considered unfavorable (Figure 2).

Data analysis

The fracture resistance data for each group were analyzed using the SPSS 19.0 statistical software. Data were analyzed for normality and a one-way analysis of variance (ANOVA) and post hoc Tukey (α = 0,05) were performed.

Failures were categorized and analyzed qualitatively.

RESULTS

No restoration failures were found after mechanical cycling for 100,000 cycles, as well as crown displacement, decementation and/or root surface fractures.

Regarding fracture resistance values, the highest values were found for the CMP group, the other groups had statistically similar values (Table 2). As for the failure mode, most were unfavorable failures (n = 97.33%) and in relation to the fracture region, most occurred in the palatal, mesial and distal regions (Table 3; Figure 1).

DISCUSSION

The null hypothesis that there would be no difference in the values of fracture resistance and failure mode between the groups was partially rejected, since the CMP group had significantly higher fracture resistance values compared to the other groups, and on the other hand both the groups most failures were unfavorable (Table 2; Figure 1).

Several studies have shown that cast metal cores were the main choice as intraradicular retainers in teeth with little or no coronary remnant for many decades[33]. However, due to the large number of irreparable fractures, new materials have been proposed in order to preserve the root structure and combine characteristics similar to dentin[33, 34].

Studies established in the literature aim explain the higher values of fracture resistance presented to the CMP group. In one side, it has a high modulus of elasticity in relation to dentin, which associated with loss of remaining mineral structure, either by cavitated injury, trauma or even during preparation, contribute to the reduction of the element's resistance, making its maintenance difficult and consequently resulting in irreparable root fracture[3,4,5]. In the other, side fiber reinforced epoxy resin has a similar , through a material with modulus of elasticity similar to dentin associated with cement with the same properties[39,40, 41] According to the literature due to the dentin-like modulus of elasticity, transfer the occlusal loads more uniformly to the tooth structure combined with cement with the same properties as to the modulus of elasticity[36, 24, 27].

Another aspect brought up by the literature is the search for aesthetics combined with materials that enable the maintenance and longevity of the tooth structure, which does not occur with metallic alloys used as intraradicular retainers, which can directly interfere with the patient's gingival profile, directly affecting the aesthetics in addition to suffering corrosion, especially in metal free restorations, the use of cast metal cores has decreased[9,35].

One important aspect that leads the choice of a technique is its practicality of use, in this regard, fiber reinforced epoxy resin has lower cost and optimization of laboratory, different from the cast metal post technique, requiring several clinical and laboratory steps[14, 16].

The anatomical post technique aims to improve the adaptation to wide and/or irregular canals and, the adaptation of the intraradicular retainer to the canal walls can change due to the contraction of polymeric materials used in anatomical retainers, generating stress due to load during function, being a factor of great vulnerability at the post, cement and dentin interface, which can raise levels of failure[38, 20]. When using a fiber post associated to accessory posts, according to Aggarwal et al. (2012), the technique did not increase fracture resistance but reduced the occurrence of unfavorable fractures when compared to groups with cast metal cores, which is a contradictory finding when compared to the present study, which all groups presented the same predominance of failure types (Table 3).

The posts machined by CAD/CAM technology, aim at making personalized, aesthetic, lower cost retainers in a single structure, joining the root portion to the coronary portion, minimizing the cementation interface, distributing the stress generated in function throughout the entire structure[,40, 41]. A study carried out by Pang et al 2018, which evaluated the fracture resistance properties of maxillary incisors with widened channels using posts machined by the CAD/CAM system, showed positive results in protecting the dental element, reducing the occurrence of unfavorables fractures, also being contradictory to the present findings (Table 3).

The metal used in the CMP technique is less sensitive to adhesion with the cement used in this study once it has no chemical bonding to the metal, only counting on the mechanical retentions[24,27,36].

The epoxy resin has the advantage of interacting with silane, a bifunctional molecule that confers chemical bonding, which is a additional to the traditional mechanical micro retention used in conventional cements, according to Matinlinna et al (2018), improves bonding with resin and fiber matrix.

In a recent vitro study, EID et al., 2019 evaluated bond strength to root dentin by comparing prefabricated fiber posts and concluded that bond strength was significantly higher in the group using anatomic post milling using CAD/CAM, which proved better retention in the root canal.

In the present study, the cement application was made using lentulo, which, according to Skupien et al (2015), should not negatively affect the cement insertion into dental canals, then self-adhesive resin cements were found to be less technique-sensitive to luting procedures as compared with regular resin cements.

Taking this in consideration, CAD/CAM *Computer-Aided Design/Computer-Aided Manufacturing*, is a promising material that able to the clinician personalize even more the treatment for its patients with less clinical time and more predictability. Therefore, further research must be carried out in order to validate the results of the present study, requiring further investigations related to the mechanical properties of the machining of intraradicular retainers through CAD/CAM technology in the fracture resistance of endodontically treated teeth. More studies evaluating FEA scenarios are needed to elucidate different tension distribution between the elements of a post and core restoration and among the tested techniques observed in the present study.

CONCLUSION

The posts machined by the CAD/CAM system have a fracture resistance similar to other fiberglass post systems tested, which are inferior to CMP. All groups tested had a predominance of non-repairable failures.

CONFLICT OF INTEREST

Acknowledgements

This study was partly supported by: the Brazilian Federal Agency for Coordination of Improvement of Higher Education Personnel – CAPES, Brazil (Finance code 001, R.M.R.

Master's scholarship); This study is part of the Master's Dissertation by (R.M.R.). The authors declare no conflicts of interest.

REFERENCES

1. Garcia, Paula-Pontes et al. Effect of surface treatments on the bond strength of CAD/CAM fiberglass posts. *Journal of clinical and experimental dentistry,* v. 10, n. 6, p. e591, 2018.

2. Fontana, P.E. et al. Effect of Ferrule Thickness on Fracture Resistance of Teeth Restored With a Glass Fiber Post or Cast Post. *Operative Dentistry*, v. 44 n.6 p. 2019.

3. Ruschel, G. H. et al. Mechanical properties and superficial characterization of a milled CAD-CAM glass fiber post. *Journal of the mechanical behavior of biomedical materials,* v. 82, p. 187-192, 2018.

4. Bacchi, A. et al. Fracture strength and stress distribution in premolars restored with cast post-and-cores or glass-fiber posts considering the influence of ferule. *BioMed research international,* v. 2019, 2019.

5. Pinto,C.L. Bhering, C.L. de Oliveira, G.R. et al.,"The influence of post system design and material on the biomechanical behavior of teeth with little remaining coronal structure, *Journal of Prosthodontics,* 2018.

6. Marchionatti, A.M.E. et al. Clinical performance and failure modes of pulpless teeth restored with posts: a systematic review. *Brazilian Oral Reserarch,* v.31, 2017.

7. Eid, R. et al. Fracture Resistance and Failure Pattern of Endodontically Treated Teeth Restored with Computer-aided Design/ Computer-aided Manufacturing Post and Cores: A Pilot Study. *The Journal of Contemporary Dental Practice,* v. 20, n. 1, p. 56-63, Janeiro, 2019.

8. Pang J., Feng C., Zhu X., Liu, B. Fracture behaviors of maxillary central incisors with flared root canals restored with CAD/CAM integrated glass fiber postand-core. *Dental Materials Journal,* v. 38, p. 1, p. 114–119, 2019.

9. Wandscher, VF. et al. Preliminary results of the survival and fracture load of roots restored with intracanal posts: weakened vs nonweakened roots. *Operative Dentistry*, v. 39, n. 5, p. 541-55, 2014.

10. Güth, J. F. et al. CAD/CAM polymer vs direct composite resin core buildups for endodontically treated molars without ferrule. *Operative dentistry,* v. 41, n. 1, p. 53-63, 2016.

11. Pantaleón, Domingo Santos et al. Influence of remaining coronal tooth structure on fracture resistance and failure mode of restored endodontically treated maxillary incisors. *The Journal of prosthetic dentistry,* v. 119, n. 3, p. 390-396, 2018.

12. Sadykov, M. I. et al. Biomechanical evaluation of stress-strain condition of restorative ceramic pin structures and dental roots. *Archiv EuroMedica*, v. 10, n. 2, p. 115-120, 2020.

13. Ahmed, Sumitha N.; Donovan, Terry E.; Ghuman, Taneet. Survey of dentists to determine contemporary use of endodontic posts. *The Journal of prosthetic dentistry,* v. 117, n. 5, p. 642-645, 2017.

14. Teixeira, K. N. et al. Fracture Resistance and Failure Mode of Custom-made Post-and-cores of Polyetheretherketone and Nano-ceramic Composite. *Operative dentistry*, v. 45, n. 5, p. 506-515, 2020.

15. Savychuk, Anatolii et al. Stress generation in mandibular anterior teeth restored with different types of post-and-core at various levels of ferrule. *The Journal of prosthetic dentistry,* v. 119, n. 6, p. 965-974, 2018.

16. Conrado, Aiane Maria Ferreira et al. Substituição de núcleo metálico fundido por pino de fibra de vidro anatomizado: relato de caso. *Archives of health investigation,* v. 10, n. 4, p. 661-666, 2021.

17. Freitas, T. L. de et al. Effect of glass fiber post adaptation on push-out bond strength to root dentin. *Brazilian dental journal,* v. 30, n. 4, p. 350-355, 2019.

18. Bakaus, T. E. et al. Bond strength values of fiberglass post to flared root canals reinforced with different materials. Brazilian oral research, v. 32, 2018.

19. Pereira, Renata et al. Glass fiber posts. *Brazilian Journal of Oral Sciences,* v. 19, p. e207508-e207508, 2020.

20. Owen, T. A.; Barber, M. W. Direct or indirect post crowns to restore compromised teeth: a review of the literature. *British Dental Journal,* p. 413-418, 2018.

21. BRAZ, R. et al. Flared Roots Reinforced With Bulk-fill Flowable Composite—Case Report. *Operative dentistry*, v. 43, n. 3, p. 225-231, 2018.

22. Martelli, H. J. R. et al. Fracture resistance of structurally compromised root filled bovine teeth restored with accessory glass fiber posts. *International Endodontic Journal,* v. 41, p. 685-692, 2008.

23. Aggarwal, V. et al. Comparative evaluation of fracture resistance of structurally compromised canals restored with different dowel methods. *Journal of Prosthodontics,* v. 21, n. 4, p. 312-316, Jun, 2012.

24. Oliveira, R. R. et al. Resistência à fratura de dentes reforçados com pinos pré-fabricados: revisão de literatura. *Journal of Research in Destristry*, v. 6, n. 2, p 35-42, 2018.

25. Narayanan, Lalith et al. Stress analysis of maxillary central incisors endodontically treated with varying ferrule heights and three different post dowel materials a finite element analysis. *Journal of Oral Research,* v. 8, n. 2, p. 108-115, 2019.

26. Chen, A. et al. Finite element analysis to study the effects of using CAD/CAM glass-fiber post system in a severely damaged anterior tooth. *Bio-medical materials and engineering,* v. 26, n. s1, p. S519-S525, 2015.

27. Borzangy, S. S. et al. Effect of restoration technique on resistance to fracture of endodontically treated anterior teeth with flared root canals. *Journal of Biomedical Research,* v. 33, n. 2, p. 131, 2019.

28. Eid, R. et al. Effect of Fabrication Technique and Thermal Cycling on the Bond Strength of CAD/CAM Milled Custom Fit Anatomical Post and Cores: An In Vitro Study. *Journal of Prosthodontics,* v. 28, n. 8, p. 898-905, Ago, 2019.

29. Velho, H.C. et al. Fatigue failure load of prefabricated fiber reinforced post: The influence of the post diameter and fatigue test method. *International Journal of Adhesion and Adhesives,* v. 108, p. 102864, 2021.

30. Soares, C. J., et al. Influence of root embedment material and periodontal ligament simulation on fracture resistence tests. *Brazilian Oral Research*, v. 19, p. 11-16, 2005.

31. Bohrer, T.C. et al. Endodontic Sealers affect the bond strength of fiber posts and the degree of conversion of two resin cements. The Journal of Adhesive Dentistry, v. 20, n. 2, p. 1-8, 2018.

32. Skupien, Jovito Adiel et al. A systematic review of factors associated with the retention of glass fiber posts. *Brazilian oral research,* v. 29, p. 1-8, 2015.

33. Santos, A. F. et al. Can fiber posts increase root stresses and reduce fracture? *Journal of Dental Research,* v. 89, p. 587-591, 2010.

34. Figueiredo, F. E. D. et al. Do metal post–retained restorations result in more root fractures than fiber post–retained restorations? A systematic review and meta-analysis. *Journal of endodontics,* v. 41, n. 3, p. 309-316, 2015.

35. Miorando, B. et al. Utilização de pinos intra-radiculares. *Journal of Research in Dentistry,* v. 6, n. 1, p. 16-22, 2018.

36. May, L. G.; Kelly, J. R. Influence of resin cement polymerization shrinkage on stresses in porcelain crowns. *Dental Materials,* 29, n. 10, p. 1073-1079, Oct 2013.

37. Coelho, C. S. et al. Finite element analysis of weakened roots restored with composite resin and posts. *Dental Materials Journal,* v. 28, p. 671-678, 2009.

38. Clavijo, V. G. R. et al. Pinos anatômicos – uma nova perspectiva clínica. *Dental Press Estética,* v. 3, p. 100-121, 2006.

39. Davidowitz, G.; Kotick, P. G. The use of CAD/CAM in dentistry. *Dental Clinics of North America,* v. 55, n. 3, p. 559-570, 2011.

40. Bernardes, S. R. et al. Tecnologia CAD/CAM aplicada a prótese dentária e sobre implantes: o que é, como funciona, vantagens e limitações. *Jornal ILAPEO,* v. 6, n. 1, p. 08-13, Jan/Mar, 2012.

41. Alghazzawi, T. F. Advancements in CAD/CAM technology: Options for practical implementation. *Journal of Prosthodontic Research,* v. 60, n. 2, p. 72-84, April, 2016.

42. Matinlinna, Jukka Pekka; Lung, Christie Ying Kei; Tsoi, James Kit Hon. Silane adhesion mechanism in dental applications and surface treatments: *A review. Dental materials,* v. 34, n. 1, p. 13-28, 2018.

TABLES

Tabela 1- Study design

Group	Description	Material
CMP	Cast metal post	Chromium nickel alloy (Ni-Cr, Wironia Light, Bego, Germany).
PF	Post fiberglass	Reforpost number 2 (Angelus, Londrina, Paraná, Brazil).
PA	Post anatomical	Reforpost number 2 (Angelus, Londrina, Paraná, Brazil) + light curing composite resin color A1 Z250 (3M-ESPE, Seefeld, Germany).
PFA	Fiberglass post associated with acessory post	Reforpost number 2 (Angelus, Londrina, Paraná, Brazil) + fiberglass post acessory post Reforpin Universal (Reforpin, Angelus, Londrina, Paraná, Brazil).
PM	Machined post CAD/CAM	(Fiber CAD, Post & Core LAB, Angelus Produtos Odontológico, Joinville, Santa Catarina, Brazil).

Table 2 - Mean (± standard deviation) of the results of fracture load (N) and Tukey's test.

	Mean (± standard deviation)
Cast metal post	622.02 ± 186.96 A
Fiberglass post	435.80 ± 78.42 B
Anatomical post	361.81 ± 143.50 B
Acessory post	374.35 ± 89.08 B
Machined post CAD/CAM	390.02 ± 102.07 B

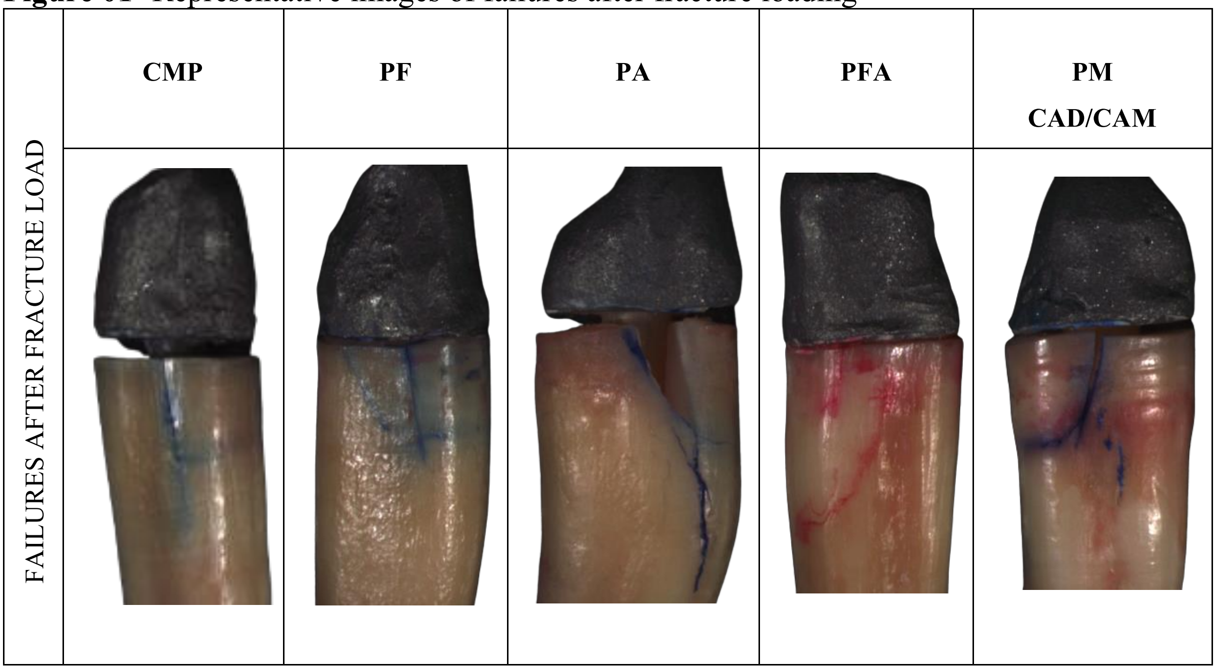
Similar upper-case letters indicate absence of difference between groups ($p<0.05$).

Table 03 - Qualitative evaluation of failures fracture loading

			CMP	PF	PA	PFA	PM CAD/CAM	TOTAL
FAILURES AFTER FRACTURE LOAD	Pattern of Failure	Favorable	0(0%)	0(0%)	1(6,67%)	1(6,67%)	0(0%)	2(2,67%)
		Unfavorable	15(100%)	15(100%)	14(93%)	14(93%)	15(100%)	73(97,33%)
	Failure Place	Crown Displacement (lingual)	14	9	12	4	13	52
		Mesial crack	14	11	12	11	15	63
		Buccal crack	3	1	4	1	2	11
		Distal crack	11	11	12	10	10	54
		Lingual crack	1	2	1	-	2	6
		Fracture in the post	-	-	-	-	-	-
		Crown, core, post pull out	5	-	2	1	2	10

FIGURES

Figure 01- Representative images of failures after fracture loading



CMP: Specimen of the group with cast post and core. PF: Specimen of the group with post fiberglass. PA: Specimen of the group with post anatomical. PFA: Specimen of the group with Fiberglass post associated with acessory post. PM CAD/CAM: Specimen of the group with Machined post CAD/CAM.

Figure 02 - Representative images of failures after fracture loading.

	CMP	PF	PA	PFA	PM CAD/CAM
FAILURES EVALUATED UNDER STEREOMICROSCOPE					

CMP: Specimen of the group with cast post and core. PF: Specimen of the group with post fiberglass. PA: Specimen of the group with post anatomical. PFA: Specimen of the group with Fiberglass post associated with acessory post. PM CAD/CAM: Specimen of the group with Machined post CAD/CAM.

3 CONCLUSÃO

Assim, observou-se que os retentores usinados pelo sistema CAD/CAM apresentaram valores de resistência à fratura semelhante aos pinos convencionais de fibra de vidro, pinos anatômicos e pinos de fibra de vidro associados a pinos acessórios, que são inferiores aos núcleos metálicos fundidos.

Quanto às falhas, todos os grupos testados apresentaram predominância de falhas desfavoráveis, com fraturas abaixo da linha cemento-esmalte na maioria dos espécimes.

REFERÊNCIAS

GARCIA, P. P. et al. Effect of surface treatments on the bond strength of CAD/CAM fiberglass posts. **Journal of clinical and experimental dentistry**, v. 10, n. 6, p. e591, 2018.

VELHO, H.C. et al. Fatigue failure load of prefabricated fiber reinforced post: The influence of the post diameter and fatigue test method. **International Journal of Adhesion and Adhesives**, v. 108, p. 102864, 2021.

MARCHIONATTI, A.M.E. et al. Clinical performance and failure modes of pulpless teeth restored with posts: a systematic review. **Brazilian Oral Reserarch,** v.31, 2017.

RUSCHEL, G. H. et al. Mechanical properties and superficial characterization of a milled CAD-CAM glass fiber post. **Journal of the mechanical behavior of biomedical materials,** v. 82, p. 187-192, 2018.

FONTANA, P.E. et al. Effect of Ferrule Thickness on Fracture Resistance of Teeth Restored With a Glass Fiber Post or Cast Post. **Operative Dentistry,** v. 44 n.6 p. 2019.

EID, R. et al. Fracture Resistance and Failure Pattern of Endodontically Treated Teeth Restored with Computer-aided Design/ Computer-aided Manufacturing Post and Cores: A Pilot Study. **The Journal of Contemporary Dental Practice,** v. 20, n. 1, p. 56-63, Janeiro, 2019.

PANG J., FENG C., ZHU X., LIU, B. Fracture behaviors of maxillary central incisors with flared root canals restored with CAD/CAM integrated glass fiber postand-core. **Dental Materials Journal,** v. 38, p. 1, p. 114–119, 2019.

DEMIRYÜREK, E. O. et al. Effects of three canal sealers on bond strength of a fiber post. **Journal of Endodontics,** v. 36, n. 3, p. 497-501, 2010.

MANICARDI, C. A. et al. Influence of filling materials on the bonding interface os thin-walled roots reinforced with resin and quartz fiber posts. **Journal of Endodontics,** v. 37, n. 4, p. 531-537, 2011.

WANDSCHER, V. F. et al. Preliminary results of the survival and fracture load of roots restored with intracanal posts: weakened vs nonweakened roots. **Operative Dentistry,** v. 39, n. 5, p. 541-55, 2014.

SANTOS A. F. et al. Can fiber posts increase root stresses and reduce fracture? **Journal of Dental Research,** v. 89, p. 587-591, 2010.

MIORANDO, B. et al. Utilização de pinos intra-radiculares. **Journal of Research in Dentistry,** v. 6, n. 1, p. 16-22, 2018.

NAUMANN, M. et al. 10-year survival evaluation for glass-fiber-supported post endodontic restoration: A prospective observational clinical study. **Journal of Endodontics,** v. 38, n. 4, p. 432-435, 2012.

GIACHETTI, L. et al. Translucent fiber post cementation using light and dual-curing adhesive techniques and a self-adhesive material: push-out test. **Journal of Dentistry,** v. 37, n. 8, p. 638-642, 2009.

EID, R. et al. Effect of Fabrication Technique and Thermal Cycling on the Bond Strength of CAD/CAM Milled Custom Fit Anatomical Post and Cores: An In Vitro Study. **Journal of Prosthodontics,** v. 28, n. 8, p. 898-905, Ago, 2019.

PASQUALIN, F. H. et al. In vitro fracture resistance of glass-fiber and cast metal posts with different designs. **Revista Odonto Ciência,** v. 27, n. 1, p. 52-57, 2012.

SILVA, N. R. et al. Influence of different post design and composition on stress distribution in maxillary central incisor: Finite elemento analysis. **Indian Journal of Dental Research,** v. 20, n. 2, p. 153-158, 2009.

OLIVEIRA, R. R. et al. Resistência à fratura de dentes reforçados com pinos pré-fabricados: revisão de literatura. **Journal of Research in Destristry,** v. 6, n. 2, p 35-42, 2018.

BORZANGY, S. S. et al. Effect of restoration technique on resistance to fracture of endodontically treated anterior teeth with flared root canals. **Journal of Biomedical Research,** v. 33, n. 2, p. 131-138, 2019.

CLAVIJO, V. G. R. et al. Pinos anatômicos – uma nova perspectiva clínica. **Dental Press Estética,** v. 3, p. 100-121, 2006.

OWEN, T. A.; BARBER, M. W. Direct or indirect post crowns to restore compromised teeth: a review of the literature. **British Dental Journal,** p. 413-418, 2018.

COELHO, C. S. et al. Finite element analysis of weakened roots restored with composite resin and posts. **Dental Materials Journal,** v. 28, p. 671-678, 2009.

MARTELLI H. J. R. et al. Fracture resistance of structurally compromised root filled bovine teeth restored with accessory glass fiber posts. **International Endodontic Journal,** v. 41, p. 685-692, 2008.

AGGARWAL, V. et al. Comparative evaluation of fracture resistance of structurally compromised canals restored with different dowel methods. **Journal of Prosthodontics,** v. 21, n. 4, p. 312-316, Jun, 2012.

DAVIDOWITZ, G.; KOTICK, P. G. The use of CAD/CAM in dentistry. Dental Clinics of North America, v. 55, n. 3, p. 559-570, 2011.

BORZANGY, S. S. et al. Effect of restoration technique on resistance to fracture of endodontically treated anterior teeth with flared root canals. **Journal of Biomedical Research,** v. 33, n. 2, p. 131-138, 2019.

CHEN, A. et al. Finite element analysis to study the effects of using CAD/CAM glass-fiber post system in a severely damaged anterior tooth. **Bio-medical materials and engineering,** v. 26, n. s1, p. S519-S525, 2015.

BERNARDES, S. R. et al. Tecnologia CAD/CAM aplicada a prótese dentária e sobre implantes: o que é, como funciona, vantagens e limitações. **Jornal ILAPEO,** v. 6, n. 1, p. 08-13, Jan/Mar, 2012.

ALGHAZZAWI, T. F. Advancements in CAD/CAM technology: Options for practical implementation. **Journal of Prosthodontic Research,** v. 60, n. 2, p. 72-84, April, 2016.

ANEXO A – NORMAS PARA A PUBLICAÇÃO NO PERIÓDICO OPERATIVE DENTISTRY

Authors Guide for publication on Operative Dentistry:

Manuscript submission General Requirements

Operative Dentistry requires electronic submission of all manuscripts. All submissions must be sent to Operative Dentistry using the Allen Track upload site. A mandatory and nonrefundable $25.00 fee is required at submission. Your manuscript will only be considered officially submitted after it has been approved through our initial quality control check, and any quality problems have been resolved. You will have 6 days from when you start the process to submit and approve the manuscript. After the 6 day limit, if you have not finished the submission, your submission may be removed from the server. You are still able to submit the manuscript, but you must start from the beginning. Be prepared to submit the following manuscript files in your upload:

• A Laboratory or Clinical Research Manuscript file must include: a title; a running (short) title; a clinical relevance statement; a concise summary (abstract); Current as of: introduction, methods & materials, results, discussion and conclusion; references (see Below).

• The manuscript body MUST NOT include any: o Author identifying information such as: ♣ Authors names or titles ♣ Acknowledgements ♣ Correspondence information ♣ Response to reviewer files should also NOT include any author identifying information, such as a signature at the end, etc. Figures, Graphs, Tables.

• An acknowledgement, disclaimer and/or recognition of support (if applicable) must in a separate file and uploaded as supplemental material.

• All figures, illustrations, graphs and tables must also be provided as individual files. These should be high-resolution images, which are used by the editor in the actual typesetting of your manuscript. Please refer to the instructions below for acceptable formats and sizes.

• All other manuscript types use this template, with the appropriate changes as listed below.

Complete the online form (which includes complete author information, copyright release and conflict of interest), and select the files you would like to send to Operative Dentistry. Manuscripts that do not meet our formatting and data requirements listed below will be sent back to the corresponding author for correction.

Important Information

• All materials submitted for publication must be submitted exclusively to Operative Dentistry.

• The editor reserves the right to make literary corrections.

• Currently, color will be provided at no cost to the author if the editor deems it essential to the manuscript. However, we reserve the right to convert to gray scale if color does not contribute significantly to the quality and/or information content of the paper.

• The author(s) retain(s) the right to formally withdraw the paper from consideration and/or publication if they disagree with editorial decisions.

• International authors whose native language is not English must have their work reviewed by a native English speaker prior to submission. Manuscripts that are rejected before peer-review for English correction should be entered as a new manuscript upon resubmission. In the manuscript comments box the comment, "this is a resubmission of manuscript number XX-XXX" should be noted. Manuscripts that are rejected after peer-review are not eligible for resubmission. Manuscripts that have major revisions requested (i.e. For English correction) are entered as a resubmission of the original article.

• Spelling must conform to the American Heritage Dictionary of the English Language, and SI units for scientific measurement are preferred.

• While we do not currently have limitations on the length of manuscripts, we expect papers to be concise; authors are also encouraged to be selective in their use of figures and tables, using only those that contribute significantly to the understanding of the research.

• Acknowledgement of receipt is sent automatically upon acceptance through quality control. This may take up to 7 days. If you do not receive such an acknowledgement, please check your author homepage at http://jopdent.allentrack.net if the paper does not appear there please resend your paper.

IMPORTANT: Please add our e-mail address to your address book on your server to prevent transmission problems from spam and other filters. Also make sure that your server will accept larger file sizes. This is particularly important since we send page-proofs for review and correction as .pdf and/or .doc(x) files.

Manuscript Type Requirements

All Manuscripts

CORRESPONDING AUTHOR must provide a WORKING / VALID e-mail address which will be used for all communication with the journal.

NOTE: Corresponding authors MUST update their profile if their e-mail or postal address changes. If we cannot contact authors within seven days, their manuscript will be removed from our publication queue.

AUTHOR INFORMATION must include:

• full name of all authors

• complete mailing address for each author

• valid email address for each author

• degrees (e.g. DDS, DMD, PhD)

• affiliation (e.g. Department of Dental Materials, School of Dentistry, University of Michigan)

MENTION OF COMMERCIAL PRODUCTS/EQUIPMENT must include:

• full name of product

• full name of manufacturer

• city, state and country of manufacturer

MANUSCRIPTS must be provided as Word for Windows files. Files with the .doc and .docx extensions are accepted.

TABLES may be submitted as either Word (.doc and .docx) or Excel (.xls and .xlsx) files. All tables must be legible, with fonts being no smaller than 7 points. Tables have the following size limitations: In profile view a table must be no larger than 7 x 9 inches; landscape tables should be no wider than 7 inches. It is the Editor's preference that tables not need to be rotated in order to be printed, as it interrupts the reader's flow.

ILLUSTRATIONS, GRAPHS AND FIGURES must be provided as TIFF or high resolution JPEG files with the following parameters:

• line art (and tables that are submitted as a graphic) must be sized with the short edge being no shorter than 5 inches. It should have a minimum resolution of 600 dpi and a maximum resolution of 17 Current as of: 1200 dpi. This means the shortest side should be no smaller than 3000 pixels.

• gray scale/black & white figures must be sized with the short edge being no shorter than 5 inches. It should have a minimum resolution of 300 dpi and a maximum of 400 dpi. This means the shortest side should be no smaller than 1500 pixels.

• color figures and photographs must be sized with the short edge being no shorter than 3.5 inches. It should have a minimum resolution of 300 dpi and a maximum of 400 dpi. This means that the shortest side should be no smaller than 1050 pixels.

Other Manuscript Type – Additional Requirements

CLINICAL TECHNIQUE/CASE STUDY MANUSCRIPTS must include as part of the narrative:

• a running (short) title

• purpose

• description of technique

• list of materials used

• potential problems

• summary of advantages and disadvantages

• references (see below)

LITERATURE AND BOOK REVIEW MANUSCRIPTS must include as part of the narrative:

• a running (short) title

• a clinical relevance statement based on the conclusions of the review

• conclusions based on the literature review…without this, the review is just an exercise and will not be published

• references (see below). References must be numbered (superscripted numbers) consecutively as they appear in the text and, where applicable, they should appear after punctuation. The reference list should be arranged in numeric sequence at the end of the manuscript and should include:

1. Author(s) last name(s) and initial (ALL AUTHORS must be listed) followed by the date of publication in parentheses.

2. Full article title.

3. Full journal name in italics (no abbreviations), volume and issue numbers and first and last page numbers complete (i.e. 163-168 NOT attenuated 163-68).

4. Abstracts should be avoided when possible but, if used, must include the above plus the abstract number and page number.

5. Book chapters must include chapter title, book title in italics, editors' names (if appropriate), name of publisher and publishing address.

6. Websites may be used as references, but must include the date (day, month and year) accessed for the information.

7. Papers in the course of publication should only be entered in the references if they have been accepted for publication by a journal and then given in the standard manner with "In press" following the journal name.

8. DO NOT include unpublished data or personal communications in the reference list. Cite such references parenthetically in the text and include a date.

9. References that contain Crossref.org's DOIs (Digital Object Identifiers) should always be displayed at the end of the reference as permanent URLs. The prefix http://dx.doi.org/ can be appended to the listed DOI to create this URL. i.e. http://dx.doi.org/10.1006/jmbi.1995.0238

Reference Style Guide

• Journal article-two authors: Evans DB & Neme AM (1999) Shear bond strength of composite resin and amalgam adhesive systems to dentin American Journal of Dentistry 12(1) 19-25.

• Journal article-multiple authors: Eick JD, Gwinnett AJ, Pashley DH & 19 Current as of: 3-Sep-14 Robinson SJ (1997) Current concepts on adhesion to dentin Critical Review of Oral and Biological Medicine 8(3) 306-335.

• Journal article: special issue/supplement: Van Meerbeek B, Vargas M, Inoue S, Yoshida Y, Peumans M, Lambrechts P & Vanherle G (2001) Adhesives and cements to promote preservation dentistry Operative Dentistry (Supplement 6) 119-144.

• Abstract: Yoshida Y, Van Meerbeek B, Okazaki M, Shintani H & Suzuki K (2003) Comparative study on adhesive performance of functional monomers Journal of Dental Research 82(Special Issue B) Abstract #0051 p B-19.

• Corporate publication: ISO-Standards (1997) ISO 4287 Geometrical Product Specifications Surface texture: Profile method – Terms, definitions and surface texture parameters Geneve: International Organization for Standardization 1st edition 1-25.

• Book-single author: Mount GJ (1990) An Atlas of Glass-ionomer Cements Martin Duntz Ltd, London.

• Book-two authors: Nakabayashi N & Pashley DH (1998) Hybridization of Dental Hard Tissues Quintessence Publishing, Tokyo.

• Book-chapter: Hilton TJ (1996) Direct posterior composite restorations In: Schwarts RS, Summitt JB, Robbins JW (eds) Fundamentals of Operative Dentistry Quintessence, Chicago 207-228.

• Website-single author: Carlson L (2003) Web site evolution; Retrieved online July 23, 2003 from: http://www.d.umn.edu/~lcarlson/cms/evolution.html

• Website-corporate publication: National Association of Social Workers (2000) NASW Practice research survey 2000. NASW Practice Research Network, 1. 3. Retrieved online September 8, 2003 from: http://www.socialworkers.org/naswprn/default

• Journal Article with DOI: SA Feierabend, J Matt & B Klaiber (2011) A Comparison of Conventional and New Rubber Dam Systems in Dental Practice. Operative Dentistry 36(3) 243-250, http://dx.doi.org/10.2341/09-283-C 20.

Author Rights

Authors of accepted manuscripts will be given access to a .pdf of their published version. Author acceptance letters give the right to the author to make unlimited prints of the manuscript. Authors may not share the electronic file. Those authors who are required to post a copy of their manuscript to a University, or Government repository due to professional or funding contract stipulations, may do so after receipt of the article as stated above; and after notifying Operative Dentistry, Inc. (at editor@jopdent.org) of their intent to post, and to what repository it will be posted, as well as the URL at which it will appear. Authors may post their articles to their own professional website as well. Any electronic postings should contain the appropriate copyright statements as listed in this manual (under “copyright”).