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System Applied to Bleached Dentin

Influence of Piperine on Collagen Color

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Dr. Han-Xiang Deng

MD., Ph.D

Associate Professor and Research Department

Division of Neuromuscular Medicine

Davee Department of Neurology and Clinical Neurosciences

Northwestern University Feinberg School of Medicine

Web: neurology.northwestern.edu/faculty/deng.html

Dr. Pina C. Sanelli

Associate Professor of Radiology

Associate Professor of Public Health

Weill Cornell Medical College

Associate Attending Radiologist

NewYork-Presbyterian Hospital

MRI, MRA, CT, and CTA

Neuroradiology and Diagnostic Radiology

M.D., State University of New York at Buffalo,

School of Medicine and Biomedical Sciences

Web: weillcornell.org/pinasanelli/

Dr. Roberto Sanchez

Associate Professor

Department of Structural and Chemical Biology

Mount Sinai School of Medicine

Ph.D., The Rockefeller University

Web: mountsinai.org/

Dr. Michael R. Rudnick

M.D., FACP

Associate Professor of Medicine

Chief, Renal Electrolyte and Hypertension Division (PMC)

Penn Medicine, University of Pennsylvania

Presbyterian Medical Center, Philadelphia

Nephrology and Internal Medicine

Certified by the American Board of Internal Medicine

Web: uphs.upenn.edu/

Dr. Feng Feng

Boston University

Microbiology

72 East Concord Street R702

Duke University

United States of America

Dr. Seung-Yup Ku

M.D., Ph.D., Seoul National University Medical College, Seoul, Korea Department of Obstetrics and Gynecology Seoul National University Hospital, Seoul, Korea

Dr. Hrushikesh Aphale

MDS- Orthodontics and Dentofacial Orthopedics.

Fellow- World Federation of Orthodontist, USA.

Santhosh Kumar

Reader, Department of Periodontology,

Manipal University, Manipal

Gaurav Singhal

Master of Tropical Veterinary Sciences, currently pursuing Ph.D in Medicine

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Bachelor of Dental Surgery (B.D.S.) M.D.S. in Pedodontics and Preventive Dentistr Pursuing Phd in Dentistry

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Getahun Asebe

Veterinary medicine, Infectious diseases, Veterinary Public health, Animal Science

Dr. Suraj Agarwal

Bachelor of dental Surgery Master of dental Surgery in Oromaxillofacial Radiology.

Diploma in Forensic Science & Oodntology

Osama Alali

PhD in Orthodontics, Department of Orthodontics, School of Dentistry, University of Damascus. Damascus, Syria. 2013 Masters Degree in Orthodontics.

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MCh (Pediatric Surgery, Gold Medalist), FISPU, FICS-IS

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Influence of Piperine on Collagen Color and Degree of Conversion of a Universal Adhesive System Applied to Bleached Dentin

By Flávia Maria Noronha Nigri, Lara Rabelo Aragão, Wildson Max Barbosa da Silva, Guida Hellen Mota do Nascimento, Solange de Oliveira Pinheiro, Juliana Paiva Marques Lima Rolim, Diana Araújo Cunha, Paulo Goberlânio de Barros Silva, Phillipe Nogueira Barbosa Alencar & Jiovanne Rabelo Neri

Centro Universitário rio Christus (Unichristus)

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Methods: The piperine extraction process was carried out using a water reflux system and confirmed by UV-Vis spectrophotometry. For collagen staining analysis, dentin collagen disk were analyzed with a spectrophotometer. Regarding the collagen color evaluation, there was no statistically significant difference between the groups regarding ΔL, Δa, Δb e ΔE (p>0,05).

Keywords: tooth whitening. antioxindant. pipper nigrum.

GJMR-J Classification: LCC: RK309

INFLUENCEOFPIPERINEONCOLLAGENCOLORANDDEGREEOFCONVERSIONOFAUNIVERSALADHESIVESYSTEMAPPLIEDTOBLEACHEDDENTIN

Strictly as per the compliance and regulations of:

Influence of Piperine on Collagen Color and Degree of Conversion of a Universal Adhesive System Applied to Bleached Dentin

Flávia Maria Noronha Nigri [α], Lara Rabelo Aragão [σ], Wildson Max Barbosa da Silva [ρ], Guida Hellen Mota do Nascimento [ω], Solange de Oliveira Pinheiro [¥], Juliana Paiva Marques Lima Rolim [§], Diana Araújo Cunha [χ], Paulo Goberlânio de Barros Silva [ν], Phillipe Nogueira Barbosa Alencar [θ] & Jiovanne Rabelo Neri [ζ]

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Methods: The piperine extraction process was carried out using a water reflux system and confirmed by UV-Vis spectrophotometry. For collagen staining analysis, dentin collagen disk were analyzed with a spectrophotometer. Regarding the collagen color evaluation, there was no statistically significant difference between the groups regarding ΔL, Δa, Δb e ΔE (p>0,05).

Results: Regarding the degree of conversion, there was no statistically significant difference between without hydrogen peroxide, PH + 0,001% piperine, PH + 0,002% piperine and PH + 0,004% piperine (p>0,05).

Conclusions: It is possible to conclude that piperine, did not change the color of the dentin collagen and avoided the reduction in the degree of conversion of a universal adhesive system applied immediately after bleaching with 35% hydrogen peroxide.

Keywords: tooth whitening. antioxindant. pipper nigrum.

I. Introdução

Atualmente, a buscacada vez maiorpelos padrões de beleza tem influenciado diretamente na estética do sorriso. Muitos são os tratamentos dentários que envolvem a estética, tais como: restaurações imperceptíveis com resina compostas e os diversos métodos de clareamento dental (1).

O clareamento dental é o procedimento mais procurado pelos pacientes (2), existindo três técnicas conhecidas que são usadas rotineiramente pelos que buscam uma tonalidade diferente dos dentes, sendo elas: clareamento a base de peróxido de carbamida na concentração de 10% (técnica caseira), clareamento a base de peróxido de hidrogênio na concentração de 35% (técnica no consultório) e clareamento misto (caseiro + consultório) (3).

O mecanismo de ação desses agentes usados como clareador está diretamente relacionado com a liberação do oxigênio, chamados radicais livres, na estrutura do dente (4). Devido ao baixo peso molecular do peróxido, o clareamento ocorre por meio da penetração facilitada dessas moléculas na estrutura dental, que quando associada à permeabilidade dentária consegue difundir o oxigênio pelo esmalte e pela dentina, agindo nas estruturas mecânicas e, assim, clareá-las (5).

Contudo, estudos mostram que tanto o peróxido de carbamida quanto o peróxido de hidrogênio demonstram efeitos deletérios nas características mecânicas das interfaces adesivas dos dentes clareados, alterando os valores de resistência de união e na ligação entre o sistema adesivo e a dentina clareada, quando essa união é feita imediatamente após o processo de clareamento dental (6, 7, 8). Esses efeitos contrários da união imediata do sistema adesivo e a dentina clareadapodem estar ligados pela presença de oxigênio residual que vai afetar a reação de polimerização dos sistemas adesivos, afetando na resistência de união dos materiais restauradores e os substratos dentários (9).

Sendo assim, inúmeras pesquisas vêm estudando o poder antioxidante do ácido ascórbico, bem como suas características químicas e biológicas (10). Estudos demonstram um efeito protetor do ácido ascórbico quando se tem indução do peróxido de hidrogênio sobre os sistemas biológicos (11).

Estudos utilizando a piperina, proveniente da *Piper nigrum,* como material de pós tratamento clareador para remover os radicais livres deixados pelo peróxido de hidrogênio, foram eficazes demonstrando um menor índice de microinfiltração, quando comparados a tratamentos pós clareadores sem o uso de antioxidantes (12,13). A *Piper nigrum* possui em sua composição: piperina, ferro, retinol, ácido ascórbico, entre outros componentes. Suas principais funções

Author α σ § χ ν θ: Mestrado em Ciências Odontológicas, Centro Universitário Christus (Unichristus), Fortaleza, Ceará, Brasil.

Author ρ: Programa de Pós-graduação em Ciências Naturais, Universidade Estadual do Ceará (UECE), Fortaleza, Ceará, Brasil.

Author ω ¥: Curso de graduação em Química, Centro de Ciências e Tecnologia (CCT), Universidade Estadual do Ceará (UECE), Fortaleza, Ceará, Brasil.

Corresponding Author ζ: Mestrado em Ciências Odontológicas, Centro Universitário Christus (Unichristus), Fortaleza, Ceará, Brasil.
e-mail: jiovanne@hotmail.com

biológicas são alto poder anti-inflamatório, antioxidante e antibactericida (14).

A literatura traz bons resultados para o uso de antioxidantes como pré tratamentos para dentes submetidos a clareamentos dentais por serem agentes neutralizantes de radicais livres (13). Por outro lado, alguns estudos ainda demonstram que alguns desses antioxidantes possuem compostos que podem manchar o substrato dental. Como exemplo, temos os flavonoides, que são compostos dos polifenóis que podem promover uma alteração de cor na interface dente-restauração quando o mesmo se encontra com um pH ácido, pois eles se tornam ativos e acabam liberando endopeptídeos (15, 16).

O mesmo acontece com antioxidantes a base de polifenóis, como a epigalocatequina-galato (EGCG), encontrada no chá verde, e as proantocianidinas, presentes no extrato de semente, que pigmentam o colágeno dentinário com tons rosados e amarronzados, respectivamente (17).

A piperina tem sido muito estudada em várias áreas das ciências, demonstrando efeito antioxidante, o que tem chamado a atenção da indústria farmacêutica e médica. Porém, não existem estudos abordando o uso da piperina como antioxidante na Odontologia. As propriedades da piperina podem ser de interesses para algumas especialidades da Odontologia como, periodontia, prótese e dentística. Portanto, há a necessidade de conduzir pesquisas com esta molécula, para que novas possibilidades terapêuticas sejam vislumbradas dentro da clínica odontológica.

Desta forma, o objetivo desse estudo é avaliar a influência da piperina, extraída da *Pippernigrum*, na coloração do colágeno e no grau de conversão de sistema adesivo universal à dentina clareada. Como hipótese, espera-se que a piperina extraída da *piper nigrum*, independente da concentração apresentada, exercerá influência positiva no grau de conversão de união de sistema adesivo universal aplicado em dentina clareada.

II. Materiais e Métodos

O processo de extração e caracterização da piperina utilizada no presente estudo seguiu o protocolo adotado por Albuquerque *et al.,* 2021 (dados não publicados). Foram utilizados 50 g de pimenta do reino (*Piper nigrum*) e, por meio do processo de extração utilizando um sistema em refluxo em água, foi obtido 78 mg de um sólido cristalino e amarelado, que foi devidamente caracterizado como piperina, com 99,9% de pureza.

Posteriormente, a piperina foi pesada em balança digital analítica (AUX-220, Shimadzu, Tóquio, Japão) e diluída em água destilada (pH= 7,55) com o auxílio de vórtex (QL-901, Biomixer, São Paulo, SP, Brasil), a fim de obter soluções aquosas de piperina a

0,001% (pH= 6,01), 0,002% (pH= 5,99) e 0,004% (pH= 5,87) peso/volume. O pH de cada solução foi aferido no momento de sua preparação através de um pHmetro digital (QUIMIS, modelo Q400AS, Diadema, SP, Brasil).

Para a realização da avaliação de cor do colágeno e grau de conversão *in situ*, foi obtida aprovação no Comitê de Ética de Pesquisa em Humanos sob o protocolo Nº 2.006.679. Trinta e dois terceiros molares humanos recém extraídos tiveram os ligamentos periodontais removidos com cureta periodontal Gracey 5-6 (Golgran, São Caetano do Sul, SP, Brasil) e limpos com escova de Robinson e pasta de pedra pomes e água. Em seguida, foram armazenados em água destilada a 4°C até o momento de sua utilização, com renovação periódica da solução a cada 15 dias, para evitar proliferação bacteriana. Foram excluídos da amostra dentes careados, com fraturas ou desgastados.

a) Avaliação de cor do colágeno dentinário

Vinte dentes humanos foram aleatoriamente divididos pelo software Excel (Excel 2020, Microsoft Corporation, Redmond, WA, EUA) em 4 grupos, de acordo com a soluçãoutilizada: Água destilada (grupo controle), piperina a 0,001%, 0,002% e 0,004%.

Um disco de dentina (espessura de 1 mm ± 0,08 mm) foi obtido da porção coronária média de cada dente, atravésde um disco de diamante, em baixa velocidade, (Extec modelo 12205; ExtecCorp., Enfield, CT, EUA) montado em uma máquina de corte (Labcut 1010; Extec, Enfield, CT, EUA), sob refrigeração abundante.

Todos os discos de dentina foram imersos, individualmente, em 5 mL de ácido fosfórico a 10%, durante 10 horas, para que fossem completamente desmineralizados e restassem a matriz orgânica do colágeno dentinário. Em seguida, os espécimes desmineralizados foram lavados, abundantemente, com água destilada, secos com jato de ar durante 10 s e a cor inicial de cada espécime foi avaliada (*baseline*), com o auxílio de espectrofotômetro (VITA Easyshade Advance 4.0, Vident, Brea, CA, EUA).

Posteriomente, os espécimes foram reumidecidos com 20 μL da solução designada para o seu grupo. As soluções permaneceram em contato com as superfícies desmineralizadas durante 60 segundos sob agitação, com auxílio de um microbrush. Os discos de dentina desmineralizados foramsecos com jatos de ar por 10s e foi realizada uma avaliação finalcom um espectrofotômetro que realizou a mensuração da cor por meio de valores correspondentes à escala CIE L* a*b*. Nesse sistema, L* indica a luminosidade, e o a*e b*, o matiz, sendo que o a* representa a saturação no eixo vermelho-verde e o b* no eixo azul-amarelo.

$$\Delta E^*ab = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{0.5}$$

Todas as leituras dos espectros de cor dos espécimes ocorreram de forma padronizada quanto a localização do espécime avaliada, luminosidade, temperatura e umidade do ambiente. A ponteira de medição foi apoiada e assentada completamente, de forma perpendicular aos discos de dentina. Quando o valor de ΔE foi maior que 3,7, considerou-se uma variação de cor facilmente visível clinicamente. Valores entre 3,7 e 1, foram considerados como uma diferença de cor clinicamente aceitável. Por outro lado, valores de ΔE menores que 1 foram considerados como clinicamente não perceptíveis (Reis *et al.,* 1996).

b) Grau de conversão in situ

Para o teste de grau de conversão, 12 terceiros molares humanos foram aleatoriamente divididos pelo software Excel (Excel 2020, Microsoft Corporation, Redmond, WA, EUA) em 6 grupos, de acordo com os tratamentos utilizados (Tabela 1). Todos os dentes, exceto do grupo sem peróxido de hidrogênio (PH), foram submetidos ao clareamento com peróxido de hidrogênio a 35% (WhitenessHP Blue, FGM Produtos Odontológicos, Ltda., Joinville, SC, Brasil – Lote 1152211).

Tabela 1: Distribuição dos grupos experimentais.

Grupo	Descrição
Sem peróxido de hidrogênio (PH) (controle)	Sem clareamento, sem aplicação de agente antioxidante (aplicação de água destilada) e restauração imediata com resina composta.
PH + restauração imediata	Clareamento com peróxido de hidrogênio a 35%, sem aplicação de agente antioxidante (aplicação de água destilada) e restauração imediata com resina composta.
PH + restauração após 7 dias	Clareamento com peróxido de hidrogênio a 35%, sem aplicação de agente antioxidante (aplicação de água destilada) e restauração com resina composta após 7 dias.
PH + 0,001% piperina	Clareamento com peróxido de hidrogênio a 35%, aplicação de solução aquosa de piperina a 0,001% p/v, durante 60 s e restauração imediata com resina composta.
PH + 0,002% piperina	Clareamento com peróxido de hidrogênio a 35%, aplicação de solução aquosa de piperina a 0,002% p/v, durante 60 s e restauração imediata com resina composta.
PH + 0,004% piperina	Clareamento com peróxido de hidrogênio a 35%, aplicação de solução aquosa de piperina a 0,004% p/v, durante 60 s e restauração imediata com resina composta.

Todos os dentes, exceto do grupo sem peróxido de hidrogênio (PH), foram submetidos ao clareamento com peróxido de hidrogênio a 35% (Whiteness HP Blue, FGM Produtos Odontológicos, Ltda., Joinville, SC, Brasil- Lote 1152211), que foi aplicado sobre o esmalte da superfície coronal, em uma camada de aproximadamente 1,0 mm de espessura (0,06 mL). O produto permaneceu em contato com a superfície de esmalte dos fragmentos por 45 minutos, em seguida, lavados com jatos de água durante 60 segundos e secos com jatos de arpor 10 segundos.

Após o clareamento, os dentes foram fixados em placas de acrílico com seu longo eixo paralelo à superfície da placa com o auxílio de godiva em bastão (Kerr, Joinville, SC, Brasil) e foram removidas as superfícies oclusais de todos os espécimes com auxílio da máquina de corte Isomet (Buehler, Lake Bluff, IL, EUA) e de um disco diamantado, sob irrigação abundante. Logo após, as superfícies foram desgastadas com lixa de carbeto de silício de granulação #280 e #600 acoplada a uma máquina politriz elétrica (APL, 4, Arotec, Cotia, SP) sob irrigação abundanteaté a exposição da dentina. As superfícies de dentina foram condicionadas com ácido fosfórico à 37% (FGM Produtos Odontológicos Ltda., Joinville, SC, Brasil) durante 15 segundos, em seguida, foram lavadas com água destilada durante 30 segundos e secas com jato de ar livre de água e óleo durante 10 segundos. Os dentes foramreumidecidos com 20 μL da solução destinada para o seu grupo com auxílio de uma micropipeta (Tabela 1). As soluções permaneceram em contato com as superfícies dentinárias durante 60 segundos e foram agitadas com auxílio de um microbrush. Em todos os grupos foram aplicados o sistema adesivo Single Bond Universal (3M ESPE, St. Paul, MN, EUA – Lote 1910000745) de acordo com as orientações do fabricante (Tabela 2). Posteriormente, foram aplicados 5 incrementos de resina composta Z350 XT (3M ESPE, St. Paul, MN, EUA – Lote 270617), onde cada incremento teve espessura de 1 mm e foi fotoativado individualmente durante 20s. Os dentes foram armazenados durante 24h em água destilada à 37°C.

Tabela 2: Sistema adesivo utilizado e modo de aplicação.

Produto	Composição	Fabricante (Lote 1910000745)	Modo de aplicação
Single Bond Universal	MDP, BIS-GMA HEMA, DMA, Polímero functional de metacrilato, enchimento, etanol, água, iniciadores, silano.	3M ESPE, St.Paul, MN, USA	1. Aplicar o adesivo 2. Deixar agir por 20s 3. Seque suavemente ao ar por 5s.

Abrevições: MDP: 10di-hidrogenofosfato de metacriloiloxidecilBIS-GMA: metacrilato de diglicidil bisfenol A; HEMA: metacrilato de 2-hidroxietil; DMA, dimetacrilato.

Após os procedimentos, foram removidas as raízes dos dentes e as coroas foram fixadas com cera pegajosa em um dispositivo para serem cortadas com auxílio da máquina de corte Isomet (Buehler, Lake Bluff, IL, EUA) e de disco diamantado, sob irrigação abundante. A coroa de cada dente foi seccionada longitudinalmentea fim de se obter 3 espécimes em forma de fatia de cada dente, com 2 mm de espessura. Para a determinação do grau de conversão, foi realizada 1 leitura em cada espécime através de um espectrômetro micro-Raman (Xplora; HoribaScientifc, Kyota, Japão). O espectro foi excitado a partir do uso de um laser com comprimento de onda em 532 nm através de uma objetiva (100 X). O espectro foi obtidode acordo com as seguintes condições: tempo de irradiação: 60s; número de acumulações: 10 e grade: 1200 linhas/mm. O grau de conversão foi calculado com base na redução da intensidade do pico correspondente aos grupos metacrilatos C=C em 1.636 cm^{-1} e 1.608 cm^{-1} polimerizada (P) comparado com o espécime não polimerizado (U), de acordo com a seguinte equação:

$$\text{Grau de conversão} = \left(1 - \frac{P}{U}\right) \times 100$$

As análises estatísticas dos resultados foram realizadas com o programa SigmaStat 4.0 (Systat Software Inc., San Jose, CA, EUA). Os testes de Shapiro-Wilk e Brown-Forsythe foram aplicados em todos os grupos para analisar a distribuição normal dos dados e a igualdade de variância, respectivamente. Para a análise dos dados de grau de conversão e variação de cor do colágeno foi usado o teste de Análise de Variância e o nível de significância adotado foi de $p<0,05$.

III. Resultados

a) Extração da Piperina

Através do processo de extração utilizando um sistema em refluxo em água foi obtido um sólido cristalino e amarelado, cujo ponto de fusão foi de 125°C.Após a extração, foram obtidos 78mg de piperina, com um rendimento de 92,86% e com a pureza de 99,9%.

b) Avaliação de cor do colágeno dentinário

Os dados referentes a avaliação de cor do colágeno estão representados na Tabela 3. Os resultados demonstraram que não houve diferença estatisticamente significante entre os grupos quanto ao ΔL, Δa, Δb e ΔE ($p>0,05$).

Tabela 3: Valores médios de coordenadas de cor (ΔL, Δa, Δb e ΔE) de esmalte após exposição a diferentes agentes antioxidantes.

Grupos (n=6)	ΔL	Δa	Δb	ΔE
Água destilada	0,2±1,4[A]	-0,1±1,1[A]	0,2±1,1[A]	1,9±0,4[A]
Piperina 0,001%	0,4±0,8[A]	0,2±0,7[A]	0,1±1,1[A]	1,1±0,8[A]
Piperina 0,002%	1,3±0,6[A]	0,5±0,8[A]	0,5±0,4[A]	1,6±0,7[A]
Piperina 0,004%	0,3±1,0[A]	0,4±0,4[A]	0,3±1,4[A]	1,5±1,0[A]

* Letras maiúsculas semelhantes indicam que não houve diferença estatística nas colunas.

c) Grau de conversão in situ

Os dados referentes ao grau de conversão de cada grupo avaliado estão representados na Tabela 4. Não houve diferença estatisticamente significante entre os grupos sem peróxido de hidrogênio, PH + 0,001% piperina, PH + 0,002% piperina e PH + 0,004% piperina ($p>0,05$). O grupo PH + restauração imediata apresentou o menor grau de conversão quando comparado aos demais ($p<0,05$).

Tabela 4: Grau de conversão de valores *in situ* (mean ± SD (*), de acordo com o tratamento utilizado.

Grupos (*n*=6)	Grau de conversão *in situ*
Sem peróxido de hidrogênio (PH) (controle)	88,17±4,39[A]
PH + restauração imediata	75,05±1,21[B]
PH + restauração imediata após 7 dias	92,11±3,02[C]
PH + 0,001% piperina	86,13±3,85[A]
PH + 0,002% piperina	89,53±3,57[AC]
PH + 0,004% piperina	87,01±4,77[AC]

* *Letras maiúsculas semelhantes indicam que não houve diferença estatística nas colunas.*

IV. Discussão

Após o uso de géis clareadores, os radicais livres gerados durante o tratamento continuam presentes nos túbulos dentinários provocando um efeito oxidativo que resulta em reações microestruturais no esmalte dentário, diminuição do tamanho, número e qualidade dos *tags* resinosos e na inibição da polimerização dos materiais resinosos(14).

Carr *et al.*(1999) (15)foi um dos pioneiros a utilizar antioxidantes para neutralizar os óxidos do peróxido de hidrogênio, aumentando a força de adesão das restaurações em resina composta no elemento clareado, tanto em dentina, como em esmalte. No presente estudo observa-se que o uso da piperina elevou o grau de conversão da resina composta, quando se analisa o resultado do substrato restaurado imediatamente e o substrato restaurado utilizando a menor concentração de piperina.

Jordão *et al.*(2016) (16) demonstrou em seu estudo que o uso de géis de clareamento dental reduz a resistência de união do material restaurador com a dentina, sendo assim, diminuindo as propriedades de adesão do materialdevido à altas concentrações de radicais livres presentes no substrato. No presente estudo, percebemos que o uso do antioxidante diminuiu esses radicais livres, contribuindo para uma adequada reação de adesão entre os materiais restauradores e o dente.

De acordo com os resultados anteriores, observou-se que o valor do grau de conversão do primeiro grupo teste, na interface de união entre agente restaurador e dente mostrou-se o mais baixo, isso se explica devido a esse corpo de prova receber o material imediatamente após o clareamento, não havendo nenhum preparo com antioxidante. O que se confirma nos estudos de Turkmen*et al.*(2016) (17) e Ozelin*et al* (2014) (18).

De acordo com a literatura, a piperina age contra danos oxidativos, inibindo os radicais livres e espécies reativas do oxigênio, através da enzima 5-LO que participa da biossíntese dos leucotrienos, sendo efetiva como antioxidante (19). Estes achados corroboram com os resultados do presente estudo em que a utilização da piperina como agente antioxidante impediu a redução do grau de conversão de um sistema adesivo aplicado em dentina após clareamento dental. Desta forma, a hipótese do estudo falhou em ser rejeitada.

A aplicação da solução antioxidante de piperina foi testada por 60 segundos por ser um tempo clinicamente viável para o paciente e para o cirurgião-dentista, demonstrando que mesmo sendo aplicada em baixas concentrações e em tempo moderado, esta solução demonstra ser eficiente. Outros achados na literatura, que utilizaram outros agentes antioxidante como o ascorbato de sódio, demonstraram que para que ocorra um efeito antioxidante, o seu uso deve ser de pelo menos 5 minutos (20, 21).

No presente estudo, o uso de um espectrofotômetro foi utilizado para análise de cor dos substratos estudados antes e após a aplicação da piperina. De acordo com a literatura, o uso desses espectrofotômetros deve ser sempre utilizado para fazer leitura de cor, pois possuem uma técnica que demonstra precisão e rapidez nos resultados (22).

Para estudos que avaliem estabilidade de cor é recomendado utilizar o sistema CIE L*, a* e b, onde o L vai fazer referência às coordenadas relacionadas com a cor nas axiais vermelho-verde e amarelo-azul, respectivamente (23).

As proantocianidinas, uma categoria de flavonóides, apresentam coloração marrom escuro e alguns estudos apontam que após a sua aplicação sobre o colágeno dentinário, acabam resultando em pigmentação do mesmo, sendo referida como um obstáculo para a estética (24, 25). Da mesma maneira, estudos mostram que a epigalocatequina-3-galato que possuem na sua composição os flavonóides que derivam dos polifenóis, também apresenta essa desvantagem e pigmentam o colágeno dentinário com rons rosados(26). Contudo, no presente estudo podemos destacar que a aplicação da piperina no colágeno dentinário não promoveu mudanças de cor (27). A não alteração de cor do colágeno após aplicação da piperina pode ser devido ao seu uso em baixas concentrações e devido à cor amarela pálida, que se assemelha muito a cor da dentina.

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Innovative Strategies for Dental Anatomy Education: A Qualitative Exploration of Online Learning Perceptions

By Suveer Sachdeva & Susha Rajadurai

Abstract- Purpose: COVID-19 mandated emergency remote (online) teaching of dental anatomy at King's College London. To overcome the challenges of online learning in practical subjects such as dental anatomy, novel approaches to teaching were employed in an attempt to maintain learning quality. Online tutorials were tailored to incorporate technology enhanced learning using digitised lecture slides that emphasised 3-dimensional tooth structures and case-based problem solving along with a key, in-hand, visual aid, namely 1:1 acrylic teeth which were given to each student as a learning accessory. This contemporary online learning format has remained to date. Thus, this work set out to assess the effectiveness of these innovative efforts in online dental anatomy learning and elucidate the key elements that drive learning success. Through this, valuable strategies for improved future course delivery were gained.

Keywords: online dental anatomy learning, tooth morphology education, medical anatomy e-learning, blended learning, practical subject education, thematic analysis, phenomenology, pedagogy.

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INNOVATIVESTRATEGIESFORDENTALANATOMYEDUCATIONAQUALITATIVEEXPLORATIONOFONLINELEARNINGPERCEPTIONS

Strictly as per the compliance and regulations of:

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Suveer Sachdeva [α] & Susha Rajadurai [σ]

Abstract- Purpose: COVID-19 mandated emergency remote (online) teaching of dental anatomy at King's College London. To overcome the challenges of online learning in practical subjects such as dental anatomy, novel approaches to teaching were employed in an attempt to maintain learning quality. Online tutorials were tailored to incorporate technology enhanced learning using digitised lecture slides that emphasised 3-dimensional tooth structures and case-based problem solving along with a key, in-hand, visual aid, namely 1:1 acrylic teeth which were given to each student as a learning accessory. This contemporary online learning format has remained to date. Thus, this work set out to assess the effectiveness of these innovative efforts in online dental anatomy learning and elucidate the key elements that drive learning success. Through this, valuable strategies for improved future course delivery were gained.

Methodology: Upon gaining informed consent, semi-structured qualitative interviews, thematic analysis and interpretive phenomenological analysis on lived experience of participants was performed. This approach to research design uniquely revealed the unquantifiable realities of the social phenomena that underpin the human experience when learning dental anatomy.

Results and conclusions: Findings suggest that participants preferred the online format to a face-to-face format citing improved engagement, interaction, technology enhanced learning (TEL) and visual aided learning (VAL) as key advantages, and therefore, themes. A positive learning environment appeared to be gained and maintained owing to these themes. Findings further suggest it may be instrumental for the success of future online dental anatomy learning strategies to place engagement and interaction as prime strategic teaching objectives and to use elements of TEL and VAL to enable these objectives. Perhaps most interesting was that participants suggest a desire for a blended learning approach with online and face-to-face lectures that would gain the pros while mitigating the cons of either format if applied individually.

Keywords: online dental anatomy learning, tooth morphology education, medical anatomy e-learning, blended learning, practical subject education, thematic analysis, phenomenology, pedagogy.

Author α: Centre for Craniofacial and Regenerative Biology, Faculty of Dentistry, Oral & Craniofacial Sciences, Guy's Hospital, King's College London, London, SE1 9RT, UK.
Orcid: 0009-0004-9929-2556
Corresponding Author σ: Faculty of Dentistry, Oral & Craniofacial Sciences, Guy's Hospital, King's College London, SE1 9RT, UK.
e-mail: susha.rajadurai@kcl.ac.uk

I. Introduction

The onset of the COVID-19 pandemic caused unprecedented disruptions to lifestyles of dental staff and students in dental schools globally (Alwan et al. 2020; Farrokhi et al. 2021). In the United Kingdom, national lockdowns were imposed that resulted in the suspension of dental school face-to-face lessons (Bashir et al. 2021). This mandated staff to creatively employ innovative techniques to facilitate Emergency Remote Teaching (ERT), *i.e.* the use of remote teaching solutions for education that would otherwise be delivered face-to-face. Online and electronic learning (e-learning) rose to prominence at this time (Allen and Seaman 2014; Ahmed et al. 2020; Ferrel and Ryan 2020; Wasfy et al. 2021; Dyrek et al. 2022).

While online learning involves tutor interaction, e-learning is defined as self-directed learning based on the use of electronic media and devices and can be entirely technology driven without face-to-face contact. If online or e-learning involve a mix of traditional and digital learning methodologies, they are then known as blended learning (Rowe et al. 2012; Duque et al. 2013; Makhdoom et al. 2013). Across disciplines, data suggests that well designed online and e-learning can lead to student enhanced motivation, satisfaction, and learning (Zheng et al. 2021). Some work has gone on to show that medical students prefer the online learning format to face-to-face formats due to advantages such as greater accessibility, resource scalability, self-paced learning, and cost effectiveness. However, notable disadvantages with online learning are known to exist particularly regarding the lack of peer-to-peer and peer-to-teacher contact, along with learning inefficiency. This is perhaps particularly so in more practical medical subjects such as dental anatomy because these subjects involve more complex visual-dependent learning, and learning institutions have raised concerns about the possibility of lowered academic integrity (Mukhtar et al. 2020; Stecuła and Wolniak 2022). While research pertaining to the efficacy of learning dental anatomy is lacking, in other fields, a growing body of evidence suggests online learning, may produce better if not the same learning outcomes in comparison to face-to-face learning (Means et al., 2012; Pei & Wu,

2019). Alongside this, contemporary work across higher education institutions suggests that blended learning systems may achieve better learning outcomes for more practical subjects (Fermozelli et al. 2017; Chin et al. 2020; Vallee et al. 2020; Kumar et al. 2021; Sarkar et al. 2021; Atwa et al. 2022).

Tooth morphology or dental anatomy is a good example of such a practical subject and it is a year-spanning course offered to first-year dental and hygiene therapy students at King's College London. Upon the onset of the COVID-19, dental anatomy teaching moved purely online. Although this format was conceived as an ERT format, it has since remained in an online learning format. Learning efficacy is imperative in this online learning dental anatomy component as upon completion, students are expected to enter the dental labs and complete wax ups of teeth, thus gaining invaluable foundational clinical skills, a pre-requisite to clinical dental restorative work.

Anatomy is known to be challenging even in face-to-face formats (Peirce et al. 2014; Bączek et al. 2021; Byrnes et al. 2021). In an attempt to overcome some of the anticipated challenges of online learning dental anatomy, high quality digital modelling resources, visually stimulating 3-D lecture slides, and acrylic 1:1 primary and secondary teeth per student were provided. Conscious attempts to generate student to teacher feedback, student motivation, and student self-discipline were also made as these are established limiting factors to online learning (Mukhtar et al. 2020; Bączek et al. 2021; Yang et al. 2021). Given that online learning is a novel approach to dental anatomy, a crucial question remained, 'How effective is online learning for dental anatomy?'

This study was carried out by direct formal assessment of student lived experience and student perception using inductive thematic phenomenology, an established assay in qualitative research of this nature. The aim of this study was to gauge efficacy of the innovative strategies in this online learning approach, to elucidate the key elements that drive learning success, and thus identify areas for growth to improve course delivery and, in turn, produce better dental clinicians. The online learning format here offers a cost-effective teaching strategy for practical subjects in a rapidly digitising world, therefore, it is important that such benefits do not come at the expense of learning quality.

II. Methodology

a) Background

Semi-structured qualitative interviews were conducted and thematic analysis was performed to assess lived experience of participants. Interpretive phenomenological analysis allowed identification of common themes. This approach to research design

uniquely revealed the unquantifiable realities of the social phenomena that underpin the human experience when learning dental anatomy.

Informed consent was gained from each participant via a detailed information sheet, verbal conversations, and a consent form signed by each participant. Interviews were conducted until thematic saturation was reached, this was evident at n=10 participants. Since several students volunteered to participate in this study, participants were chosen at random.

At the time of interview, students had completed the online module, and subsequent in-person dental wax-up labs. Since they were required to put into practice what was learnt in the online modules in the laboratory sessions, it is inferred that participants were better able to effectively feedback on the quality of the online module and if it sufficiently prepared them.

b) Data collection

Participants were asked to attend an online recorded interview and to respond genuinely to standardised open ended semi-structured questions conducted by one researcher. A potential influence on the results collected may have occurred due to the researcher conducting the interview having been part of the teaching staff. However, an attempt to minimise this was made by motivating the participant to be as candid and critical as possible to improve course delivery. Data gained suggests this was achieved.

Following the interviews, verbal responses were transcribed and anonymised to maintain participant confidentiality prior to analysis by the researcher that was not involved in the interview process.

c) Standardised interview questions

1. How do you feel your dental anatomy online sessions went this year?
2. Was there anything you liked about the online tutorials?
3. Was there anything you disliked about the online tutorials?
4. What did you think about the acrylic teeth visual aids provided?
5. Did the online tutorials prepare you for your dental lab tooth wax up sessions? Please elaborate.
6. How would you do things differently to have better aided your learning?
7. Do you prefer an online or a face-to-face format? Please elaborate.

d) Data analysis

Interpretive phenomenological analysis on the anonymised data and an inductive and semantic approach of thematic analysis (Braun and Clarke 2006; Maguire and Delahunt 2017) was performed using Microsoft Excel on data gained. Themes were flagged based on the frequent mentioning of key words or

meanings in statements by different participants. Thematic analysis was independently verified by both researchers involved in the study.

Abbreviations

PLE – Positive Learning Environment

ERT – Emergency Remote Teaching

TEL – Technology Enhanced Learning

VAL – Visual Aided Learning

VLE – Virtual Learning Environment

III. Results

Six themes emerged from interviews of 10 participants by using thematic analysis using an inductive approach. The identified semantic themes, based on explicit and surface meanings, are strongly related, and linked to the data collected. Analysis did not include anything beyond what was said by the participants. The emergent themes gained were:

1. *A positive learning environment*– a measure of teaching success
2. *Interaction*– learning necessitates interaction
3. *Engagement*– engagement generates interaction
4. *Visual aided learning* – aid complex system learning beyond verbal explanations alone
5. *Technology enhanced learning (TEL)*– offers on-demand, portable and convenient learning
6. *Classroom format (Online vs. Face-to-face vs. Hybrid)*– a hybrid approach emphasises the pros and limits the cons of online and face-to-face individually

1) Positive learning environment

Studies show that student perception of instruction quality, including the learning environment, enhances the quality of learning (Cohen 1980). Thus, an overall positive learning experience (PLE) can serve as a measure of teaching success making it one of the most critical components of a skills-based health education classroom (Rusticus et al. 2023). A PLE is thought to be achieved in a learning environment where all students feel valued, safe, and supported (Allen et al. 2021; Amerstorfer and Freiin von Münster-Kistner 2021).

In this study, analysis of the data gained suggested that all participants in this study had an overall positive learning experience with the online tutorials. In support of this, two participants said:

'The online tutorials were fun, I gained quite a bit and heard good things from others.'

'The online tutorials were really good and insightful, before them I did not feel like I had a good grasp of tooth morphology, following them, things were much clearer.'

At the time of interview, students had completed the dental wax up lab modules where they were expected to put into practice what they had learnt in the online learning component suggesting more insightful responses. The findings suggest that the online learning format was overall effective at achieving a PLE.

2) Interaction

Interaction was the most frequent theme among participants, most commended it and requested more opportunities for it.

'I liked the images of skulls and their features and using them to determine age, it was interactive and fired participation.'

'Lectures were engaging and interactive, when we were asked questions, I chatted answers. I liked it, but more interaction maybe.'

'Interaction helped learn.'

Some comments suggested that teaching styles varied affecting interaction.

'I questioned even coming to the lectures because things were so similar to the pre-recorded lectures. I wish the tutorials were more question based and interactive.'

'I wish they had more questions throughout them, there's a lot of info so it would help to recap regularly.'

'I did not like the speaker reading the slides to us.'

These findings suggest that learning in the online learning setting may not exist without interaction. According to the literature, this idea is not novel. Interaction is known to play a critical role in contemporary learning system effectiveness, particularly so in online learning (Billings et al. 2001; Boyle and Wambach 2001; Bernard et al. 2009). In online learning courses, interaction is known to occur synchronously or asynchronously (Smith and Dillon 1999) and further to this, interaction occurs in three ways: learner-content interaction, learner-instructor interaction, and learner-learner interaction (Moore, M. G. ve Kearsley 2012). A fourth, novel but influential type of interaction, is learner-interface interaction (Hillman et al. 1994; Ehrlich 2002; Thurmond and Wambach 2004). Since most participants commended interaction, our findings suggest that interaction was a well-accepted feature of the dental anatomy online learning environment. Furthermore, useful comments offered ideas as to how interaction in the online learning format could be improved.

'Better quality of interaction through smaller breakout groups, maybe setting a task like skull age determination then letting us solve it and get back with an answer, instead of asking the whole class.'

'More quizzing in smaller groups to interact with other students.'

3) Engagement

Learning engagement has been described as 'constructive, enthusiastic, willing, emotionally positive,

and cognitively focused participation with learning activities' (Christenson et al. 2012). Engagement is known to predict academic achievement (Lei et al. 2018) and retention (Álvarez-Pérez et al. 2021). Interestingly, some teaching practise suggests that learner engagement generates interaction (Gherghel et al. 2023). These findings infer an intimate relationship between interaction, engagement, and learning.

Participants expressed positive sentiments toward engagement further inferring that interaction was a critical theme supporting the acceptance of the online learning format.

'The content was engaging and the lectures covered useful information.'

Some remarked positively to methods used to prompt engagement.

'Polls in chat is a really nice way to get people involved.'

However, comments also indicated issues with engagement online that are useful to build future strategies on.

'People like me may be reluctant to answer in big groups, it would be less intimidating in smaller groups. Sometimes the Teams sessions felt isolating and I felt like I was alone in the classroom although it was a big class, it may be better to have seen the people doing this with me and it could encourage discussions and different thinking. Maybe having the very first workshop session in person so everyone can meet and find comfort in the presence of one another, then it can move online and everyone kind of knows who they are sharing the virtual room with. People may feel more confident presenting answers.'

'Maybe smaller groups online would make me feel more comfortable asking questions about the tooth models.'

'I wish they had more questions throughout them.'

'It wasn't the most engaging because on Teams it can feel awkward because everyone is hesitant to answer questions.'

The findings thus suggest that learners found the content engaging and suggested better targeted opportunities to generate learner engagement are needed. This may foster a learning environment where students feel safe to share and participate thus improving interaction further.

4) Visual aided learning

Visual explanations and accessories have been shown to aid learning of complex systems beyond verbal explanations alone, this is particularly so for participants of low spatial ability (Azer and Azer 2016). The known benefits gained from visual aided learning are plentiful (Zacks and Tversky 1999; Hegarty et al.

2003; Tversky and Suwa 2009; Kessell and Tversky 2011; Bobek and Tversky 2016; Leung et al. 2020).

Tooth morphology is a critical foundational course for the dental professional (Eid et al. 2013; Kellesarian 2018). This means it is imperative that students gain proficiency in the 3D structure of teeth. Prior to COVID-19, students could attend in person lectures where they had opportunities to interact with extracted teeth to consolidate anatomical learning. Following this, these pre-laboratory tutorials were migrated wholly online, thus there was a need for innovative visual aid use. Lecture delivery using a virtual learning environment had to be re-invented to place emphasis on gaining a 3-dimensional understanding via 2-dimensional verbal teaching. Clinical photographs, skull/tooth images, and interactive exercises, helped orientate students, however, this alone lacked any 3-dimensional student accessory. An aseptic solution to aid a 3-dimensional understanding was gained using acrylic primary and secondary teeth sets at 1:1 scale. The importance of this aid has been documented in other teaching designs (Eid et al. 2013; Azer and Azer 2016; Lone et al. 2018; Kirkup et al. 2019; Risnes et al. 2019; Wang et al. 2020). Each student received their own set.

We assessed the efficacy of the acrylic teeth visual aids based on participants experience. It appeared that participants reacted overall positively to the acrylic teeth sets.

'It's one thing being told about features on a screen and another thing being able to see it in place 3-dimensionally. So, it was helpful to have something physical, I could really see differences between primary and secondary teeth.'

'Really helpful to just have and like look at as we were going through the lectures.'

'I am a very visual person and would like to see things up close, really helped.'

Participants also remarked positively to other visual aids employed:

'I liked the images of skulls and their features and using them to determine age.'

'I liked the 3D approach in presentations and the mouse pointer so we could follow along.'

Useful critical comments were also gained offering valuable feedback that can aid future visual aided learning delivery.

'It may be better to view the models in person because I think my tutor didn't have good lighting so I missed things in the camera.'

Our results suggest that visual aided learning using acrylic teeth and detailed 3-D images in presentations were useful techniques that must be further developed.

5) Technology enhanced learning (TEL)

The virtual learning environment developed for this online learning course was possible due to TEL. TEL is often used to describe the use of digital technology to support and offer educational activities (Goodyear and Retalis 2010) and its use in higher education has markedly grown in recent years (Kirkwood and Price 2014; Trelease 2016; Clunie et al. 2018). TEL's utility is increasingly recognised for its transformative approach to education even where barriers, such as those posed by COVID-19, exist (Nicoll et al. 2018). Literature also indicates that mobile devices increasingly play a role in student learning (Ozdalga et al. 2012).

Comments from participants in this study indicated that TEL overall aided the learning experience. These comments cited either TEL directly or referred to TEL resources that were recommended in course content.

'I really liked the prompts on how to learn dates on Youtube.'

'I especially liked the summary slide, could carry them on my phone.'

'Having the slides to refer to on my phone was really helpful in revision and wax ups.'

Challenges raised with TEL, were not new to online learning:

'Sometimes the internet connection was poor and it created confusion.'

Participants also offered useful feedback on ways to improve delivery.

'Would be nice to have 3D moveable images in the lectures so we can see the tooth move around and follow with the models - more similar to a patient.'

'I would have 3D animations to see model teeth details over using a live camera.'

'Good idea to recommend more online website quizzes or visual activities instead of books because it's a very visual thing rather than actually reading, in my opinion.'

Overall, TEL was well accepted by students suggesting online learning as an effective way to learn dental anatomy.

6) Classroom format (Online vs. Face-to-face vs. Hybrid)

Since online learning was an ERT approach to tooth morphology, it was necessary to determine whether participants preferred the purely online learning format to a face-to-face approach.

Most comments suggested that participants preferred the online learning format.

'I did not mind online sessions, I revise at home anyway so did not make a difference to me.'

'Online did work well and was encouraged to meet peers to go over things together in our own time.'

'Online is useful and flexible but I think that I could have really benefitted from having someone in person to ask things to at least once, the classes were too big.'

'I liked the ability to ask the lecturer anything online by chatting and to recap things I didn't understand.'

However, some participants highlighted key problems with a purely online learning approach.

'I often shy away from the camera too, so it's easy to think you're alone in the room, isolated.'

'I like answering questions more in person, it's a lot less awkward.'

'Sometimes the teams sessions felt isolating and I felt like I was alone in there although it was a big class.'

'I would prefer if the sessions were in person so I can understand details better.'

'Maybe having the very first workshop session in person so everyone can meet and find comfort in the presence of one another, then it can move online and everyone kind of knows who they are sharing the virtual room with. People may feel more confident presenting answers.'

Interestingly, the students suggested that several of these issues could be resolved through employing a hybrid learning format.

'I liked the format but a final extra session in person to recap everything and show us the models close up would be better.'

'Online is useful and flexible but I think that I could have really benefitted from having someone to in person ask things to at least once, the classes were too big.'

'If I was forced to choose, I think a hybrid between the two would be more beneficial.'

'I do like it in online as well because I can go back and look at the recordings if I'm unsure and actually like hear him speak again rather than just like working through my own. In my opinion, I think like a mix of both.'

The findings here identify that students prefer the purely online learning format of dental anatomy to a purely face-to-face format. However, student perceptions strongly suggest that a blended learning or hybrid approach (online learning with face-to-face) to dental anatomy may offer the most effective learning.

IV. DISCUSSION

The online learning format here offers a cost-effective teaching strategy for practical subjects in a rapidly digitising world, therefore, it is important that such benefits do not come at the expense of learning quality. The aim of this qualitative study was to gauge

efficacy of the innovative strategies in learning dental anatomy, a complex practical subject, online, based on student perceptions. Further aims were to understand the key elements that drive learning success, and thus identify areas for growth to improve course delivery. It is worth noting that the participants had completed the online learning module and subsequent in-person practical dental anatomy laboratory module where they put into practice what was learnt in the online learning module. Thus, having conducted interviews at this time suggested more insightful responses were gained from the students as they would be more aware of knowledge deficiencies and quality of learning. Data analysis revealed six themes through thematic analysis; 1) positive learning environment (PLE), 2) interaction, 3) engagement, 4) visual aided learning, 5) technology enhanced learning, 6) classroom format. The delineation of each of this themes offered orderly identification of areas of success and weakness thus generating valuable data that is likely to be of value to those coordinating online learning classrooms that teach practical subjects. Furthermore, through this work, findings strongly suggest a composable interplay between each of the themes with engagement and interaction featuring as indispensable elements that drive success accessorising the TEL and VLE resulting in a PLE.

The first success of this dental anatomy online learning approach was well demonstrated by students' unanimous comments in favour of a PLE having been gained through online learning dental anatomy. This finding is important because a PLE is achieved in a learning environment where students feel valued, safe, and supported. A PLE is also linked to student perception of instruction quality and the quality of learning. Thus, an overall PLE is suggested to serve as a measure of teaching success and has been referred to as a critical component of the skills-based health education classroom inferring success of the approaches used in dental anatomy online learning.

Interaction was the most apparent theme regarding what students valued most about the online learning classroom. The comments gained regarding interaction showed that students valued efforts made to nurture interaction within them appreciating the periodic recapitulatory quiz slides, and the opportunity to chat answers and questions. On the other hand, some critical comments gained insightfully indicate that a more uniform effort to nurture interaction by all teaching staff would be better received. Additionally, a student suggested the use of smaller problem-solving breakout rooms to enable interaction, this would offer an opportunity to generate progressive comfort with interacting in the larger online learning classroom. Perhaps the most important feature of the data gained was that students believed interaction would improve if

they felt safer sharing as they seemed to find the online classroom 'intimidating', 'isolating' and 'awkward'.

Engagement has been suggested to generate interaction, predict academic achievement and knowledge retention. This highlights the importance of this theme. Several comments by students described the lessons as engaging and their explanations eventually tied into interaction. This suggests that the strategies used to generate interaction generated engagement as well. Notably, a few comments praised the use of 'polls in the chat' to answer questions. The periodic use of polls may have served as a low stake engagement prompt that generated engagement from students that may not have otherwise participated, thus, the use of polls in the chat is a valuable tool for engagement and interaction in future course development that may lead to increased engagement. All together these findings suggest that engagement and interaction do appear linked and are critical themes of the online learning dental classroom that can influence success or failure of learning. The interaction strategies employed in this dental anatomy online learning course were sufficient but further opportunities to interact and efforts to make students feel safe to share and participate would likely add marked value.

Visually heavy explanations and accessories are known to aid learning of complex material and these constituted the theme visual aided learning (VAL). Dental anatomy requires future dental professionals to gain proficiency in the 3D structure of teeth. Clinical photographs, 3-D digitised skull/tooth images, and in-hand acrylic primary and secondary teeth were availed to students. Comments from students suggested each of these elements to be a resounding success in aiding learning 3-dimensionally. Notably, students appreciated the instructors mouse pointer as a guide when navigating through slide images during lectures, a small but apparently crucial element. While the acrylic teeth were highly beneficial, a key issue raised suggested a limitation based on the resolution of the instructors camera when placing the acrylic teeth in camera focus to instruct the students on how to navigate these visual aids. Thus, it may be of importance to provide high resolution orientation videos about the acrylic teeth for access by the students on the virtual learning platform, this will ensure unincumbered clarity. All in all, the findings suggest that the VAL elements employed were a success and can offer inspiration to other instructors that teach complex subjects via online learning.

Students also received technology enhanced learning (TEL) well. Comments suggested that students enjoyed learning from the convenience and flexibility offered by TEL, saving time they would ordinarily require to prepare for the day and commute. Students also enjoyed use of other digital platforms (YouTube and tooth morphology apps) and their mobile phones to learn on the go. Suggestions to improve TEL centred

around increasing opportunities to learn this way with more prompts to other resources that could aid learning, thus it may be worthwhile to research and compile a list of quality resources that are available on the market and incorporate or recommend them during the course in future years.

Finally, directly determining whether students preferred the online learning format to face-to-face learning was necessary to guiding future strategies. Comments suggested students were mostly in favour of online learning over face-to-face learning citing several advantages previously mentioned. However, many of the same students claimed to feel unable to share and participate due to feeling isolated and awkward in an online room. Interestingly, students also went on to suggest that a hybrid format that involved online learning and face-to-face classes would solve the challenges of pure online learning due to the opportunity to bond with their peers and feel more comfortable participating. The ability to interact between peers was markedly limited due to COVID-19 and perhaps most deleterious for first-year university students. Based on this valuable feedback, a blended learning or hybrid approach (online learning with face-to-face) to dental anatomy may indeed offer the most effective learning as it may balance the pros and cons of each if employed individually. Through this, students are crucially enabled to bond and interact on a human level while they pursue their formal education. Interestingly, blended learning is gaining recognition as an optimal format for learning when compared to pure online learning and pure face-to-face strategies.

It is worth mentioning that there are author-perceived limitations to this study that may be of value to the reader. Firstly, the participants lacked a direct comparison of a concurrent module that was solely face-to-face since most of the first-year learning was primarily digitised. However, it is worth noting that the participants had attended face-to-face subsequent modules such as the dental laboratory wax up module that may still offer a solid retrospective comparison of learning quality. With this in mind, the timing of interviews may present with a limitation given the order of class formats when comparing learning quality along with the time elapsed (approximately 3 months) between the online module and the completion of the dental labs, when the interviews were performed. Lastly, the n=10 sample size may serve as a limiting factor.

Nonetheless, this work has identified online learning dental anatomy to be a successful teaching strategy. This work has also offered a unique feedback mechanism from students to dental anatomy course coordinators likely improving course delivery in the future, in turn improving the quality of dental professionals produced at King's College London. Notably, the data gained here-in is also of value to other practical subject course coordinators as the ideas and

approaches can inspire improved approaches to teaching.

Disclosure of interest

The authors report no conflict of interest.

Ethical approval

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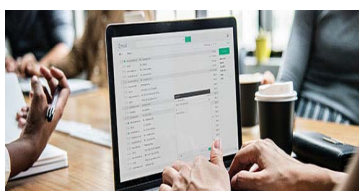
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Gradation of Research	**Gradation** of Research	**Gradation** of Research	
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GJ Community Access	**Online Presense** Assistance	**Online Presense** Assistance	
	GJ Community Access	GJ Community Access	

Preferred Author Guidelines

We accept the manuscript submissions in any standard (generic) format.

We typeset manuscripts using advanced typesetting tools like Adobe In Design, CorelDraw, TeXnicCenter, and TeXStudio. We usually recommend authors submit their research using any standard format they are comfortable with, and let Global Journals do the rest.

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Authors must ensure the information provided during the submission of a paper is authentic. Please go through the following checklist before submitting:

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3. Ensure corresponding author's email address and postal address are accurate and reachable.
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- Writings
- Diagrams
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- Printed material
- Graphic representations
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- Electronic material
- Any other original work

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2. Drafting the paper and revising it critically regarding important academic content.
3. Final approval of the version of the paper to be published.

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The corresponding author should mention the name and complete details of all co-authors during submission and in manuscript. We support addition, rearrangement, manipulation, and deletions in authors list till the early view publication of the journal. We expect that corresponding author will notify all co-authors of submission. We follow COPE guidelines for changes in authorship.

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Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

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PREPARING YOUR MANUSCRIPT

Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

FORMAT STRUCTURE

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in a research paper?" Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

PREPARATION OF ELETRONIC FIGURES FOR PUBLICATION

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

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TIPS FOR WRITING A GOOD QUALITY MEDICAL RESEARCH PAPER

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of medical research then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

INFORMAL GUIDELINES OF RESEARCH PAPER WRITING

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- o Explain the value (significance) of the study.
- o Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- o Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- o Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- o Report the method and not the particulars of each process that engaged the same methodology.
- o Describe the method entirely.
- o To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- o Simplify—detail how procedures were completed, not how they were performed on a particular day.
- o If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- o Resources and methods are not a set of information.
- o Skip all descriptive information and surroundings—save it for the argument.
- o Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- o Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- o In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- o Present a background, such as by describing the question that was addressed by creation of an exacting study.
- o Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- o Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- o Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- o Do not include raw data or intermediate calculations in a research manuscript.
- o Do not present similar data more than once.
- o A manuscript should complement any figures or tables, not duplicate information.
- o Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

o   You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
o   Give details of all of your remarks as much as possible, focusing on mechanisms.
o   Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
o   One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
o   Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

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Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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