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**ESCOLA DE CIÊNCIAS DA VIDA
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ÁREA DE CONCENTRAÇÃO RADIOLOGIA**

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**RADIOGRAFIA PANORÂMICA 3D (P3D) UMA NOVA ESTRATÉGIA
NO ENSINO DA RADIOLOGIA ODONTOLÓGICA**

Curitiba

2017

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Dissertação apresentada ao Programa de Pós-Graduação em Odontologia da Pontifícia Universidade Católica do Paraná, como parte dos requisitos para obtenção do título de Mestre em Odontologia, Área de Concentração em Radiologia.

Orientadora: Profa. Dra. Vânia Portela Ditzel Westphalen.

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**Dedico esta dissertação às minhas
ancoras no céu e na terra, meu Pai e
minha Mãe. Dois exemplos de
perseverança, dedicação e amor na
família e na profissão.**

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ARTIGO EM PORTUGUÊS

Página título

Radiografia Panorâmica 3D (P3D) uma nova estratégia no ensino da Radiologia Odontológica

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1 **Resumo**

2 Os estudantes de Odontologia do milênio exigem do professor novas estratégias
3 de comunicação. Situação que deve ser aprimorada no ensino das estruturas
4 anatômicas em radiografias panorâmicas. Em consequência surgiu a proposta de
5 criar-se um aplicativo que estimule o interesse do estudante e desenvolva sua
6 habilidade espaço-visual, que seja atrativo e de fácil interação. Assim, o objetivo
7 deste estudo foi criar uma imagem panorâmica tridimensional. Para tanto,
8 utilizou-se 10 pares de imagens constituídas da projeção panorâmica
9 convencional e da imagem volumétrica por tomografia computadorizada de feixe
10 cônico (TCFC), sendo cada par oriundo de um mesmo indivíduo. Utilizaram-se o
11 *software* livre Invesalius®, o qual permitiu a reconstrução volumétrica a partir dos
12 arquivos DICOM; e o Matlab®, pela função cp2tform, para a realização da
13 interpolação polinomial da TCFC 3D e sua posterior correlação com uma
14 radiografia convencional. Foi obtida uma reformatação panorâmica, seccionada
15 por três planos de reconstrução, o que dificultou sua correlação com a
16 panorâmica convencional. Por essa razão, sugere-se o reinício do processo com
17 uma equação polinomial que permita a realização de uma varredura contínua
18 visando uma mínima distorção e objetivando uma radiografia panorâmica
19 reconstruída em 3D, ininterrupta, para ser implementada como uma nova
20 ferramenta de ensino na Radiologia Odontológica.

21
22 Palavras Chaves: Educação em Odontologia, Radiografia panorâmica, Imagem
23 Tridimensional, Multimídia

1 **Introdução**

2 No processo de aprendizagem, o armazenamento das informações
3 recebidas depende das operações mentais realizadas, existindo uma
4 probabilidade de esquecimento de 75% das informações, já nas 48 horas
5 seguintes ao ensinamento recebido (1).

6 Essa informação, gera preocupação por parte dos educadores e pode ser
7 constatada nas Faculdades, uma vez que os estudantes recebem informações
8 teóricas nas disciplinas antes de colocá-las em prática. Nos estudos realizados
9 por Corton *et al.* (2006), Jack *et al.* (2012) e Arya *et al.* (2013), observou-se que
10 conhecimentos de Anatomia oferecidos para os alunos do primeiro ano de
11 Medicina são esquecidos no decorrer do tempo. Aproximadamente no terceiro
12 ano, quando recebem as aulas de Radiologia, aqueles conhecimentos tornaram-
13 se vagos (2–4).

14 Essa situação é preocupante para o professor de Radiologia, obrigando-o
15 a procurar novas estratégias que ajudem no fortalecimento do conhecimento de
16 Anatomia para o entendimento da imagem radiográfica.

17 O papel do radiologista como educador é ressaltado pela sua
18 interdisciplinaridade, o que permite a ele interagir com as diferentes áreas da
19 Odontologia. Fornecendo assim um vasto campo de conhecimentos e uma
20 generosa quantidade de material, para ministrar aulas atrativas e interessantes
21 para o estudante, o que propicia melhor entendimento da disciplina (5).

22 Tradicionalmente, o método socrático vem sendo aplicado nas disciplinas
23 de Radiologia Odontológica, com o acréscimo de apresentações feitas em *Power*
24 *Point®* (6). Mas será que esta metodologia continua sendo apropriada para a
25 “geração do milênio”? Geração essa descrita por Slanetz *et al.* (2013) como uma
26 geração que se caracteriza por ser visual e influenciada pelas novas tecnologias
27 da comunicação da informação (TCI). Esta situação exige do “professor do
28 milênio” a aplicação de modernas estratégias de ensino e a conformação de uma
29 nova linguagem que lhe permita interagir com maior eficácia e eficiência com o
30 estudante (7).

31 A radiografia panorâmica é considerada uma ferramenta essencial no
32 diagnóstico e no planejamento do tratamento Odontológico, porque com uma
33 baixa dose de radiação, observa-se o complexo maxilofacial numa imagem única

1 e bidimensional. Porém, o grau de distorção e magnificação das estruturas
2 dificultam sua interpretação (8). Nesse sentido, o professor de Radiologia tem a
3 responsabilidade de desenvolver no estudante de Odontologia competências
4 para a interpretação radiográfica, sendo preciso conhecimentos teóricos e
5 topográficos da anatomia da cabeça e da face, para a compreensão da
6 redistribuição espacial das estruturas anatômicas nas imagens (9).

7 Tendo em vista a necessidade de gerar um diálogo mais fluente com os
8 estudantes, que permita uma maior e mais efetiva compreensão das estruturas
9 anatômicas observadas nas radiografias panorâmicas. Surgiu a proposta de criar
10 um aplicativo para o estudo das estruturas anatômicas nas radiografias
11 panorâmicas, associando o volume obtido pela tomografia computadorizada de
12 feixe cônico (TCFC). No intuito de facilitar ao estudante, o entendimento da
13 estruturação da imagem e desenvolver suas habilidades espaço-visuais, por meio
14 de uma imagem panorâmica redimensionada. A qual permitirá navegar dentro
15 das estruturas, reconhecer sua configuração por meio de cores, apoiando-se
16 sempre de um diálogo interativo que vai descrever o que estudante esta
17 observando. Para assim, viabilizar uma maior compreensão e não só a
18 memorização da anatomia da imagem.

19 Desta forma, o objetivo deste estudo, foi criar uma imagem panorâmica em
20 três dimensões (3D).

21 **Material e Método**

22 Este estudo foi aprovado pelo Comitê de Ética em Pesquisa local, sob o
23 parecer de número CAAE - 50963015.6.0000.0020.

24 **Amostra**

25 Utilizou-se um total de 10 pares de imagens (10 panorâmicas
26 convencionas e 10 imagens volumétricas da TCFC, tamanho do fov: 16 cm x 13
27 cm), sendo cada par de um mesmo indivíduo (figura 1), todas as imagens
28 pertencem a um banco de imagens de uma clínica particular de Radiologia
29 Odontológica, localizada na cidade de Curitiba-Pr.

Fase 1 do processamento da Imagem

Inicialmente, para a criação da reconstrução panorâmica fez-se um registro ou pareamento das imagens (radiografia panorâmica e TCFC do mesmo paciente), utilizando-se o *software* livre ImageJ[®]. Este mesmo tem uma interface própria para a análise de imagens e duas ferramentas para realizar o pareamento ou registro das mesmas, dependendo de pontos selecionados manualmente ou automaticamente pela presença de estruturas semelhantes. Mas, não houve êxito no registro devido ao grau de distorção na correlação final entre as imagens.

Fase 2 do processamento da Imagem

Após as dificuldades encontradas no registro com o ImageJ[®], utilizou-se o *software* livre Invesalius[®], o qual permite a reconstrução volumétrica a partir de arquivos DICOM ou renderização 3D da tomografia facial, para a posterior obtenção de projeções de máxima intensidade, para o entendimento do processo de criação das imagens panorâmicas a partir de volumes.

Para fazer a correspondência das duas imagens adotou-se o *software* Matlab[®], pela função *cp2tform*, que realiza a interpolação polinomial de duas imagens. Para a realização da interpolação polinomial da TCFC 3D e sua radiografia convencional, foram selecionados 3 pontos como parâmetros: ponto 1 (espinha nasal posterior), ponto 2 (face distal do incisivo lateral esquerdo), ponto 3 (face distal do incisivo lateral direito). Estes pontos permitiram a criação de planos de orientação (PO), os quais posteriormente se converteram em planos de reconstrução (PR). O primeiro ponto delimita o plano de orientação 1 (PO1), no final da dentição; plano de orientação 2 (PO2), perpendicular ao PO1, simulando o plano médio sagital do paciente e os dois pontos restantes conformaram o PR2, paralelo ao PO1 (figura 2).

Após divisão do corte axial pelos planos antes mencionados, se delimitaram os limites de reconstrução, o primeiro plano de reconstrução 1 (PR 1) está delimitado por PO1 e PR2; o PR2 está delimitado pelos pontos 2 e 3 e o plano de reconstrução 3 (PR3), está delimitado por PO1 e PR2.



Figura 1- Imagem volumétrica da TCFC e imagem panorâmica do mesmo paciente.
 Fonte: o autor.

O foco nessas divisões foi realizar a projeção 2D do modelo 3D por pré-seleção dos 3 planos (PR1, PR2 e PR3) para posterior junção, obtendo um “loop” de verificação por máxima intensidade por varredura intrabucal para extrabucal e armazenamento de suas coordenadas no espaço 3D, de modo a obter uma imagem radiográfica projetada que relaciona por meio de registro com a radiografia panorâmica original do mesmo paciente.

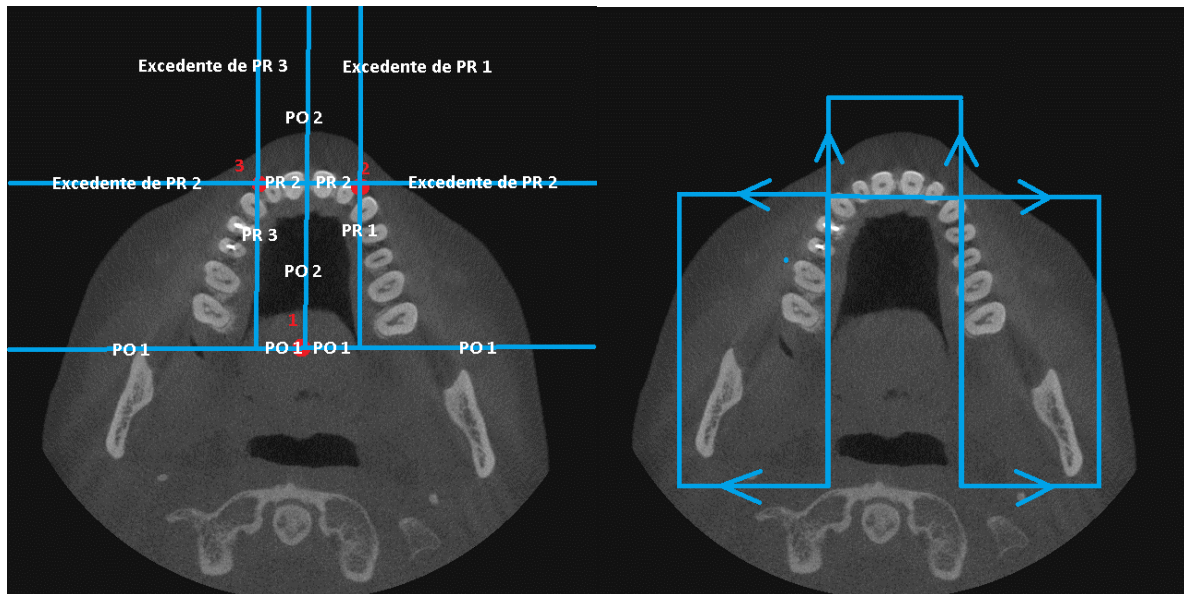
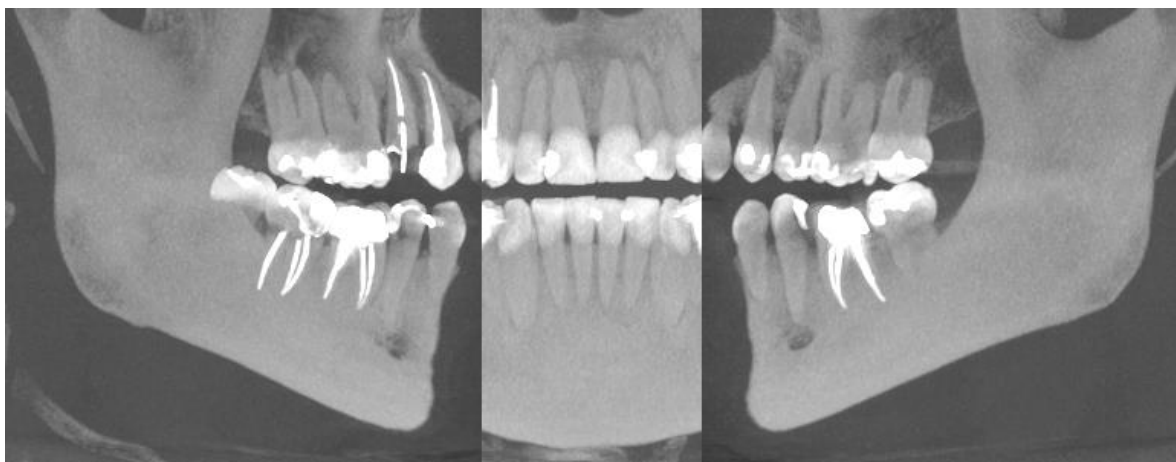


Figura 2 – Ilustração do processo de obtenção dos planos de projeção radiográfica a partir de cortes tomográficos. Fonte: o autor.

Resultados

Obteve-se uma reconstrução panorâmica 3D, constituída por três planos de reconstrução, que demonstram a redistribuição espacial das estruturas anatômicas no formato panorâmico. Porém, sua configuração dificulta o registro com a panorâmica convencional, porque gera distorção na imagem final, pelo fato de existir espaços em branco entre os planos e repetição dos dentes nas extremidades dos planos, os quais apresentam diferentes angulações. (figura 3)

Figura 3- Reconstrução panorâmica a partir dos planos de reconstrução.



Fonte: o autor.

Discussão

Com os avanços tecnológicos surgiram os novos formatos digitais dos estudos radiográficos, os quais facilitam o gerenciamento das bases de dados radiográficos dentro dos sistemas de comunicação – *pictures archiving and communication system*, PACS (2). Escolas na Alemanha, Inglaterra, Turquia, Irlanda, Estados Unidos e Brasil, têm implementado os PACS nas Escolas de Medicina para criar ferramentas de ensino de anatomia por meio de radiografias, observando-se excelentes resultados (4,10). Entretanto a radiografia panorâmica tem sido pouco considerada, no momento de gerar novas ferramentas de estudo, pelo fato de ser uma ferramenta quase exclusiva para o Cirurgião Dentista.

Nos trabalhos desenvolvidos por Khalil *et al.* (2005) e Corton *et al.* (2006) buscou-se observar a influência da implementação de ferramentas tecnológicas no processo de ensino-aprendizagem da anatomia, comparando dois grupos de estudantes: o primeiro usando a metodologia convencional e o segundo usando um aplicativo para computador. Naqueles estudos, não foi encontrada diferença significativa em relação ao processo de retenção da informação (3,11).

Em contrapartida, nos estudos realizados por Cook e Triola (2009), Ellaway (2014) e Jin *et al.* (2014) os quais avaliaram a implementação de pacientes virtuais nas aulas convencionais, concluiu-se que as ferramentas tecnológicas permitem a simplificação de conteúdos complexos, facilitam a observação das estruturas, promovem o raciocínio lógico na atividade clínica e geram um maior comprometimento do estudante com o material, por ser mais atrativo e dinâmico (12–14).

Rizzolo *et al.* (2006) afirmaram que a implementação de diferentes formatos para o ensino de anatomia, assim como o uso de ferramentas tecnológicas como a imagem radiográfica, ajudam na fixação dos conhecimentos tornando-se mais efetivos do que os informativos (15). Situação que estimula o “professor do milênio” a buscar ou criar novas estratégias e ferramentas tecnológicas que se adaptem a seus cursos.

A radiografia panorâmica digital vem se implementando nos cursos de Odontologia. Ela conserva as mesmas características do formato analógico, mantendo a observação do complexo maxilofacial em uma imagem só, com sua respectiva redistribuição espacial das estruturas em um único plano (16). Quando

se equipara esta imagem com uma fotografia, pode-se entender que por mais que seja um conjunto de imagens radiolúcidas e radiopacas, nelas existem detalhes, sombras, pontos ou sinais pictóricos que permitem compreender que aquela imagem originou-se de uma estrutura 3D curva (17), elementos que são facilmente observados na reconstrução panorâmica (figura 3).

A TCFC é uma ferramenta de estudo e planejamento cirúrgico, comumente utilizada pelo Cirurgião-Dentista, nas diferentes especialidades. Fornecendo maior campo de observação, maior precisão na mensuração linear e uma reconstrução volumétrica com menor dose de radiação (18). A maioria dos *softwares* que trabalha com a TCFC, tem a habilidade de formatar uma reconstrução panorâmica a partir da tomografia, mas ela se caracteriza por ser corte tomográfico que vai depender da posição do corte e de sua espessura. A qual perde parcialmente informações anatômicas comparando-a com a panorâmica convencional (19,20). Essa situação é desfavorável quando o objetivo é avaliar o complexo maxilofacial. Dificuldade que busca ser resolvida com esta nova formatação da imagem.

Estes estudos radiográficos apresentam vantagens e desvantagens na sua configuração. No intuito de resgatar as melhores qualidades de ambos os estudos e aproveitar que as duas imagens são compostas por *pixels* e *voxels* que permitem sua inter-relação, objetivou-se criar a panorâmica 3D a partir de sua correlação. Como ferramenta didática, para melhorar a habilidade espaço-visual do estudante, na avaliação da anatomia na radiografia panorâmica. Porque esta vai fornecer os detalhes pictóricos necessários para ressaltar os detalhes anatômicos. Uma vez desenvolvido o aplicativo, o estudante poderá navegar entre as estruturas para sua maior compreensão anatômica e espacial.

A habilidade espaço-visual foi definida como a habilidade de gerar, manter e manipular representações mentais dos objetos reais (21). Autores como Garg *et al.* (2001) e Guillot *et al.* (2007) descreveram a relação existente entre a habilidade espaço-visual dos estudantes e sua capacidade para interpretar e identificar as estruturas anatômicas nas radiografias (22,23).

Em 2011, Vuchkova *et al.* (25), partiram das conclusões de Garg *et al.* e Guillot *et al.*, e estudaram o potencial das imagens 3D TCFC para desenvolver a habilidade espaço-visual na interpretação de imagens 2D. Observaram que a utilização das imagens 3D não melhorou significativamente o desempenho dos

estudantes, concluíram que tal fato devia-se a uma minúscula relação entre a habilidade espaço-visual e a interpretação radiográfica. Porém, os autores verificaram que os resultados também demonstraram que a correta observação da imagem em 3D afetou positivamente o processo de ensino-aprendizagem em 93% (n=55) dos casos e, em 91% (n=54), o processo de interpretação da imagem radiográfica. Fato que estimula o professor de Radiologia a desenvolver esta habilidade para atingir as competências dos estudantes da Odontologia e Medicina. Dos estudantes avaliados, 88% (n=52) preferiram a utilização da imagem 3D, dos quais 84% (n=43) acharam que foi mais fácil entender e 70% (n=36) consideraram mais rápida a interpretação (24).

Após o análise do estudo anterior, sugere-se que não foi encontrada uma diferença significativa, porque eles utilizaram uma imagem 3D e uma imagem convencional separadamente. Similar ao que acontece nas aulas tradicionais com os modelos ou crânios secos. Razão pela qual esta proposta de imagem panorâmica em 3D, cruzando a imagem volumétrica da TCFC e a panorâmica convencional, irá fazer uma diferença importante, pois possibilitará a observação direta da posição relativa das estruturas anatômicas em uma representação pictórica 2D, melhorando a habilidade espaço-visual dos estudantes como sugeriram Rodt *et al.* (2002), Nilson *et al.* (2007) e Luffler *et al.* (2012) em seus estudos (17,25,26).

Tem sido relatadas muitas complicações na formatação da panorâmica 3D. A principal é que a panorâmica convencional origina-se a partir de três eixos de rotação, para dar origem a um corredor focal que se adapte parcialmente ao arco dentário, explicando o apagamento, magnificação e distorção das estruturas anatômicas que ficam fora desse corredor. Enquanto que a TCFC se estrutura a partir de um só eixo de rotação, permitindo uma mínima distorção na formatação da imagem (8,27,28). Para gerar novamente aquela configuração panorâmica seria preciso reproduzir aqueles três eixos de rotação na reconstrução volumétrica. Eixos que são particulares para cada equipamento, pelo qual se decidiu realizar o seccionamento da tomografia com os três planos de reconstrução, junção dos mesmos e posterior registro com a imagem panorâmica original. Porém, o resultado não foi atingido em sua totalidade.

Em virtude de tal fato, sugere-se realizar novamente o processo com 25 pontos, de modo a permitir gerar um arco similar ao arco dentário realizando

1 assim uma varredura contínua, para posterior registro com a panorâmica original,
2 buscando uma mínima distorção e objetivando a criação de uma radiografia
3 panorâmica reconstruída em 3D, para sua implementação no aplicativo de
4 ensino-aprendizagem das estruturas anatômicas na Radiologia Odontológica.

5 **Consideração Final**

6 Trabalhar com a “geração do milênio”, tal como se apresenta e levá-la a se
7 interessar pelos conhecimentos que posteriormente necessitará é um grande
8 desafio. O professor atualmente precisa estar preparado para tal, pelo simples
9 fato de que a linguagem, ou seja, o primeiro elemento de comunicação tem que
10 ser mudado. Nesse ponto, acredita-se que essa ferramenta venha auxiliar no
11 desenvolvimento de competências interpretativas na Radiologia Odontológica.
12 Futuros estudos aprimorarão a imagem atual e os testes da ferramenta irão
13 demonstrar a sua efetividade no desempenho do processo ensino-aprendizagem.

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ARTIGO EM INGLÊS

Title Page

Panoramic Radiography 3D (P3D) a new strategy in the teaching process of Dental Radiology

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Abstract

The new millennium students of Dentistry are demanding to their professors, new communication strategies, prioritizing this need in teaching of anatomy structures in panoramic radiographies (PR), it was proposed the creation of an app to stimulate them and to develop their visual-spatial ability. Based in a revolutionary tool, that has to be easy to manipulate, attractive and explained in an easy way a spatial redistribution of the anatomy structures in PR. For that, the objective of this study was to create a panoramic radiography image in three dimensions (3D). Were used 10 pair of images, 10 conventional PR and 10 volumetric images from a Cone Beam Computed Tomography (CBCT), each pair of images from the same patient. Were used Invesalius[®], a free software, to reconstruct the volume from DICOM images of the CBCT, and Matlab[®] software, for performing a polynomial interpolation in the CBCT, by the function cp2tform, and its posterior correlation with their conventional PR. Reaching a new 3D panoramic format, sectioned by three reconstruction plans, that was difficult to correlate with their conventional PR. For that reason it was suggested to restart the process with a new polynomial equation that will allow a continue projection of the scanning, for minimum distortion and generating a reconstructed 3D panoramic continued. That will be used like a new tool for teaching in Dental Radiology.

Key words: Education in Dentistry, Panoramic Radiography, Tridimensional images, Multimedia.

1 **Introduction**

2 The information acquired during the process of teaching and learning
3 depends on mental operations. Most people lose 75% of the information in just 48
4 hours after receiving it (1). This process can be verified in all Faculties and it is a
5 fact that worries many teachers because students forget the knowledge acquired
6 by the moment they need put them into practice. As evidenced in studies of
7 Corton et al. (2006), Jack et al. (2012) and Arya et al. (2013), they observed that
8 knowledge of Anatomy that received the first year students had been forgotten
9 with the passage of time. In approximately the third year of the carrier, when they
10 need it in the Radiology practice, those knowledges became vague (2–4). This led
11 the professors of Radiology to search for new strategies to secure better
12 knowledge of Anatomy, specifically in radiographic images.

13 Thanks to its interdisciplinary understanding, the role of Radiologists as
14 teachers has many advantages because they can interact in different areas of
15 Dentistry, providing them a vast field of knowledge and a generous amount of
16 practical material for attractive and interesting classes, and providing a better
17 understanding of the discipline for the student (5).

18 Traditionally the Socratic method had been applied in the discipline of
19 Radiology by the students of Dentistry through the addition of Power Point® slides
20 (6). However, is this Methodology still appropriate for the “millennial generation”?
21 Generation explained for Slanetz et al. (2013), like “digital native” totally
22 influenced by the new telecommunication information technologies and tend to be
23 visual learners. Forcing the “millennial teacher” to use moderns` strategies and
24 new methods of communication with their students to interact with more
25 effectiveness and efficiency with them (7).

26 A panoramic radiograph (PR) is an essential tool in diagnosing and
27 planning treatment in Dentistry. Since with a small amount of radiation you can
28 see the maxillofacial region in one single and unique two-dimensional (2D)
29 image, although the distortion and significant magnification of anatomic structures
30 make them difficult to be interpreted (8). For that reason, Professor of Radiology
31 has the responsibility for developing the competence for the interpretation of the
32 image in the students of Dentistry, by offering precise theories and topographic

knowledge of the face and the head anatomy, aiming to understand the spatial redistribution of anatomical structures in the PR (9).

Given the need to generate a more fluid dialogue with the millennial students, for even better and more effective understanding of the anatomical structures observed in PR, the creation of an app was proposed to teach these anatomical structures associated with volumetric images of Cone Beam Computed Tomography (CBCT), in order to facilitate the correct understanding of the image structure and the development of spatial visual ability of students in a resized panoramic view. all this with the possibility to navigate in the interior of the anatomy structures, allowing a greater understanding and not only memorization of the anatomy of the image.

In this sense, the objective of this study was to create a three-dimensional (3D) panoramic image.

Material and Methods

This study was approved for a local Research Ethic Committee under the number CAAE - 50963015.6.0000.0020.

Sample:

10 pairs of images (10 digital PR and 10 volumetric images of CBCT, fof size: 16 cm x 13 cm) were used for this study, each pair from the same patient (figure 1), for correlation between each pair of images. Those images are from a data base from a private Radiology Clinic of Dentistry in the city of Curitiba-Pr.

Phase 1 of Images processing

In the first phase, a registration or paring of images (RP and volumetric CBCT of the same patient) were done for a panoramic reconstruction, using an ImageJ®, a free software that has its own interface for analyzing images and two different tools to registrate or paring of the images. It could be made by different points: manually selection or automatically correlation by the same structures in both images. However, there was not success in the final recording because it had an important distortion in the final image.



Figure 1- Volumetric image of CBCT and conventional panoramic radiography from the same patient.

Phase 2 of Image Processing

After difficulties with the registration using ImageJ®, Invesalius® was used, which is a free software to do a volumetric reconstruction from DICOM images or 3D renderization of the patient, to subsequently obtain maximum intensity projections, to understand the PR reconstruction process starting from the volume.

For both images correlation, Matlab® software was used, by the function `cp2tform`. A polynomial interpolation of both images can be done with this software. For the polynomial interpolation of volume of CBCT, 3 parameter points were selected: point 1 (posterior nasal spine), point 2 (distal face of left lateral incisor) and point 3 (distal face of right lateral incisor). Each point let created guidance planes (PO), than later would be reconstruction planes (PR). The first point was used to limit the guidance plane 1 (PO1), in the final dentition arc. The guidance plane 2 (PO2) is perpendicular to PO1 simulating the patient's sagittal mean plane and the last plane created by PO2 and PO3, created PR2, which is parallel to PO1 (figure 2).

After axial cut division by several PO mentioned before, the PR were delimited: the first one (PR1) was delimited by PO1 and PR2, the second one (PR2,) was delimited by points 2 and 3. The last one, (PR3), was delimited by PO1 and PR2.

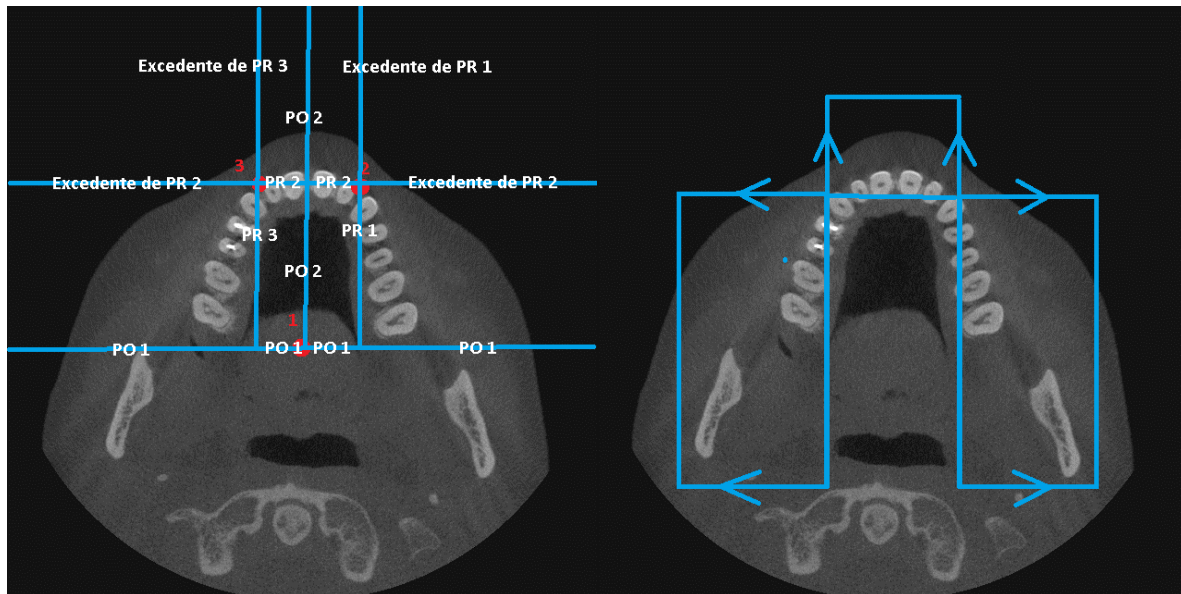


Figure 2- Axial cut of CBCT illustrating the preselected points, the guidance planes and the reconstruction planes.

The main of these divisions to obtain a 2D projected radiographie from a 3D model was created by preselected plans (PR1, PR2 and PR3) for final junction of those three plans, having a “loop” of verification by highest intensity by intraoral for extrabuccal sweep. This allows to archive spatial coordinates and to obtain a projected 3D panoramic radiograph image that would be related by registration process with the original PR of the same patient.

Results

There was a 3D reconstructed panoramic radiograph made by three different reconstructed planes that presented anatomical redistribution in the space of the panoramic format. However their constitution did not allow registration with their original patient PR because of the black spaces between the planes and the deferent angulation of the same teeth on the edge of the planes that prohibited their junction (figure 3).

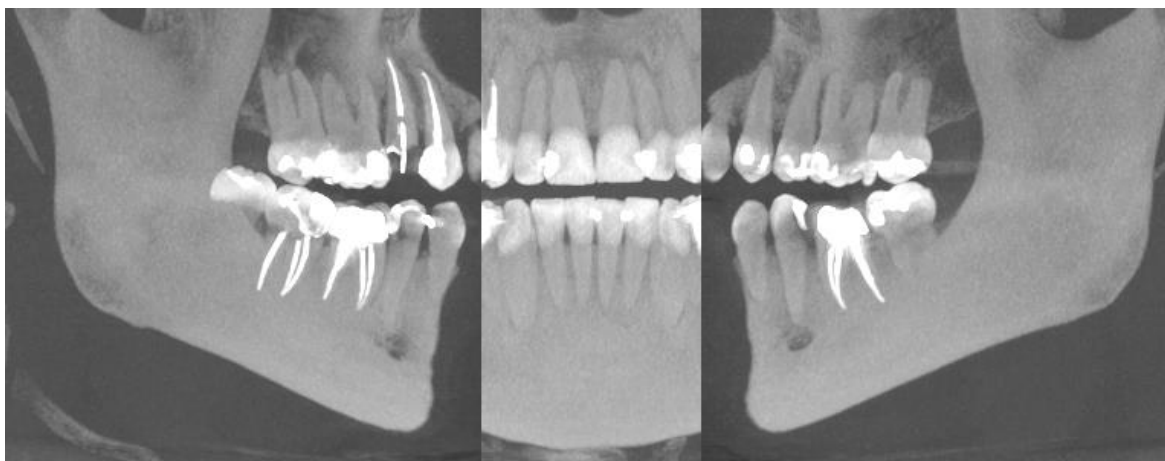


Figure-3 Reconstructed 3D panoramic radiography divided by three different planes.

Discussion

Thanks to the advancement of technology, formats of radiologic studies have appeared, which facilitate the process of archiving and managing the data base of pictures archiving and communication system (PACS) (2). Schools in Germany, England, Turkey, Ireland, USA and Brazil had implemented the PACS in the Medicine Schools to create several tools for anatomy's teaching by radiographies, observing excellent results (4,10).

Khalil et al. (2005) and Corton et al. (2006) studied the influence of technological tools in the teaching and learning process of anatomy, comparing two different groups of students: the first one which used a conventional methodology, and the second one which used a computer app. They showed that there wasn't a significant difference between both groups in relation to the retention of the information process (3, 11). In contrast, studies of Cook and Triola (2009), Ellaway (2014) and Jin et al. (2014) concluded that technological tools help, simplifying complex content, simplifying the assessment of anatomical structures, promoting the logical reasoning in the clinical practice and generating more commitment from the student with the class material, because it is more friendly and dynamic (12–14).

Rizzolo et al. (2006) affirmed that the implementation of different strategies in the anatomy teaching benefits the fixing of the knowledge, becoming more effective than the informative ones (15).

This would force A digital PR was implemented in the Dentistry course and it conserved the characteristics of analog format to preserve the maxillofacial

1 complex in one and unique image, with the same spatial distribution of anatomical
2 structures in one unique plan (16). When they are related with a photography, it
3 could be understood that the radiolucents and radiopaques images had the same
4 details, shadows and pictorial signs that permitted their 3D curve structure origin
5 (17), real important elements to easily observation of PR conformation (figure
6 3).the millennial teachers to search or create new strategies and technological
7 tools for the millennial learners.

8 The CBCT is an important study tool in the dentistry surgical planning and
9 other specialties, bringing more camp of vision, precise linear measurement and
10 volume reconstruction with low radiation dose (18). The majority of CBCT
11 software formatted a panoramic view, but it principal characteristic is being slice of
12 tomography that depend of the position and thickness cut losing part of the
13 anatomic information, if it is compared with conventional PR (19,20). Unfavorable
14 situation when the objective is asses a maxillofacial complex. Difficulty that try to
15 be solved que this new proposal.

16 Both radiography studies had their advantages and disadvantages. Trying
17 to rescue their best qualities, taking advantage of the fact that both images are
18 composed by pixels and voxels that allow their interrelationship, by the degree of
19 the highest intensity pixel and being of the same patient. Aim was to create 3D
20 panoramic for a didactic tool, for increase the visual-spatial ability of the student
21 for the better assessment of PR. Because this new format is offering the
22 necessary pictorial signs, that a student need to recognize the deferent structures
23 and once the app is functioning with this image, the millennia learners could travel
24 inside the maxillofacial complex for a better spatial comprehension.

25 The visual-spatial ability was defined as the ability to generate, maintain
26 and manipulate mental representations of real objects (21). Authors like Garg et
27 al. (2001) and Guillot et al. (2007) described the relationship existing between the
28 student visual-spatial ability and their capacity to identify the anatomical structures
29 in radiography images (22,23).

30 In 2011, Vuchkova et al. (25), based in Garg et al. and Guillot et al.
31 conclusions, studied the 3D CBCT image value to develop the interpretative ability
32 in 2D images. They observed that the utilization of 3D images did not increase in
33 a significant way the student performance. Justifying the fact, affirming that exist a
34 minimum relationship between a visual –spatial ability and radiography

1 interpretation. However, their results demonstrated that the correct observation of
2 3D images affected in a positively way the teaching and learning process in 93%
3 of the cases and the radiographic interpretation process in 91% of the cases.
4 Facts that stimulate the Radiology teacher to develop this ability to reach the
5 competence in Dentistry or Medicine student. 88% of the student assessed, they
6 preferred use 3D images, 84% of them found it easier to understand and 70% of
7 the same group considered faster to interpret (24).

8 After having analyzed the previous study, no significant differences were
9 found due to the fact that 2D and 3D images had been used separately, which
10 is similar to the the mehod used with models or dry skulls given in conventional
11 classes. For this reason, the proposal to join together both images becoming a 3D
12 panoramic image would come out as an important difference. This is because
13 it allows for observing the relative position of the anatomic structures in the
14 original 2D image, which increases the visual-spatial ability, as suggested by Rodt
15 et al. (2002), Nilson et al. (2007) and Luffler et al. (2012), in their studies
16 (17,25,26).

17 Several difficulties had been reported in the formatting process of the panoramic
18 in 3D. The principal difficulty is the fact that the conventional PR acquisition origin
19 is from three rotation axes, to create a focal truogh adapted to the dental arc.
20 Explaining the deletion, magnification and distortion of the anatomical structures
21 that are outside this focal trough. In a different way, the CBCT structure their
22 image from one rotation axe, allowing a better projection of the image without
23 distortion of it (8,27,28). To generate the same panoramic distribution it would be
24 necessary to reproduce the ortophantomographic process in the volumetric
25 image, reproduce the three axes in the same position and this information is
26 particular and secret for each equipment. For that reason, sectioning the CBCT in
27 three plans was decided for later junction of them and for last a registration with
28 the original PR. However, the final objective was notenterely achieved.

29 Restarting the processing image with 25 point in the space is suggested to
30 generate continues arc that will be an uninterrupted projection plan.It will be
31 registered with the original PR with less distortion that could be implemented in
32 the final app. This will create an innovative tool for the teaching and learning
33 process of anatomy structures in Radiology for Dentistry.

Final Consideration

Working with the “millennia generation”, the way they are presented and make that they are interested in the knowledge they will need in the future is a big challenge for the millennial teachers, who have to prepare for the simple fact that the way to communicate with students is changing. In this regard, we believe that this new tool came to help develop interpretative skills in the new era of dental radiology. In future studies, these 3D images will be improved and tested to demonstrate its effectiveness in the teaching and learning process.

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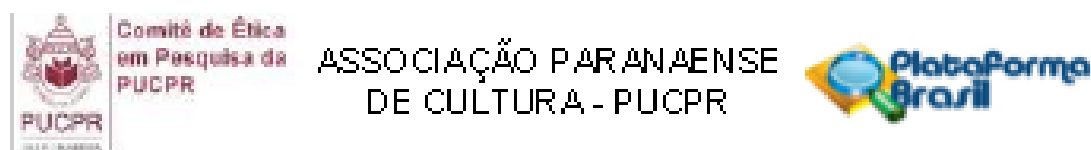
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28 [BR&lr=&id=m91B8zm_1qqC&oi=fnd&pg=PA121&dq=Hegarty+M,+Waller+](https://books.google.com.br/books?hl=pt-BR&lr=&id=m91B8zm_1qqC&oi=fnd&pg=PA121&dq=Hegarty+M,+Waller+D.+Individual+differences+in+spatial+abilities.+In:+Shah+P,+Miyake+A,+eds.+The+Cambridge+handbook+of+visuospatial+thinking.+New+York:+Cambridge+University+Press,+2005:121–69&ots=knqjRpmzpm&sig=Z3_iRjDDJHtRk-ssYm01rX1PaPU&redir_esc=y#v=onepage&q&f=false)
29 [D.+Individual+differences+in+spatial+abilities.+In:+Shah+P,+Miyake+A,+ed](https://books.google.com.br/books?hl=pt-BR&lr=&id=m91B8zm_1qqC&oi=fnd&pg=PA121&dq=Hegarty+M,+Waller+D.+Individual+differences+in+spatial+abilities.+In:+Shah+P,+Miyake+A,+eds.+The+Cambridge+handbook+of+visuospatial+thinking.+New+York:+Cambridge+University+Press,+2005:121–69&ots=knqjRpmzpm&sig=Z3_iRjDDJHtRk-ssYm01rX1PaPU&redir_esc=y#v=onepage&q&f=false)
30 [s.+The+Cambridge+handbook+of+visuospatial+thinking.+New+York:+Cam](https://books.google.com.br/books?hl=pt-BR&lr=&id=m91B8zm_1qqC&oi=fnd&pg=PA121&dq=Hegarty+M,+Waller+D.+Individual+differences+in+spatial+abilities.+In:+Shah+P,+Miyake+A,+eds.+The+Cambridge+handbook+of+visuospatial+thinking.+New+York:+Cambridge+University+Press,+2005:121–69&ots=knqjRpmzpm&sig=Z3_iRjDDJHtRk-ssYm01rX1PaPU&redir_esc=y#v=onepage&q&f=false)
31 [bridge+University+Press,+2005:121–](https://books.google.com.br/books?hl=pt-BR&lr=&id=m91B8zm_1qqC&oi=fnd&pg=PA121&dq=Hegarty+M,+Waller+D.+Individual+differences+in+spatial+abilities.+In:+Shah+P,+Miyake+A,+eds.+The+Cambridge+handbook+of+visuospatial+thinking.+New+York:+Cambridge+University+Press,+2005:121–69&ots=knqjRpmzpm&sig=Z3_iRjDDJHtRk-ssYm01rX1PaPU&redir_esc=y#v=onepage&q&f=false)
32 [69&ots=knqjRpmzpm&sig=Z3_iRjDDJHtRk-](https://books.google.com.br/books?hl=pt-BR&lr=&id=m91B8zm_1qqC&oi=fnd&pg=PA121&dq=Hegarty+M,+Waller+D.+Individual+differences+in+spatial+abilities.+In:+Shah+P,+Miyake+A,+eds.+The+Cambridge+handbook+of+visuospatial+thinking.+New+York:+Cambridge+University+Press,+2005:121–69&ots=knqjRpmzpm&sig=Z3_iRjDDJHtRk-ssYm01rX1PaPU&redir_esc=y#v=onepage&q&f=false)
33 [ssYm01rX1PaPU&redir_esc=y#v=onepage&q&f=false](https://books.google.com.br/books?hl=pt-BR&lr=&id=m91B8zm_1qqC&oi=fnd&pg=PA121&dq=Hegarty+M,+Waller+D.+Individual+differences+in+spatial+abilities.+In:+Shah+P,+Miyake+A,+eds.+The+Cambridge+handbook+of+visuospatial+thinking.+New+York:+Cambridge+University+Press,+2005:121–69&ots=knqjRpmzpm&sig=Z3_iRjDDJHtRk-ssYm01rX1PaPU&redir_esc=y#v=onepage&q&f=false)
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1 ANEXO

2 Parecer de comitê de ética



PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: FERRAMENTA DE ENSINO-APRENDIZAGEM DAS ESTRUTURAS ANATÔMICAS EM RADIOGRAFIAS PANORÂMICAS EM 3D.

Pesquisador: Aaron Bersaul Trullio Lopez

Área Temática:

Versão: 1

CAAE: 50563015.6.0000.0020

Instituição - Proponente: Pontifícia Universidade Católica do Paraná - PUCPR

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 1.337.613

Apresentação do Projeto:

A Radiologia é uma ferramenta essencial para a avaliação das condições normais e alterações patológicas dos pacientes, na qual o Cirurgião-Dentista (CD) precisa desenvolver a habilidade espacial-visual, que lhe permitam entender as características da imagem radiográfica. Na atualidade, algumas escolas de Medicina na Alemanha, usam a comparação de reconstruções volumétricas das estruturas anatômicas, obtidas por meio de tomografia computadorizada (TC), e radiografias digitais para o ensino de anatomia nos cursos de graduação com o objetivo de que o aluno consiga aqueles pontos ou sinais que lhe ajudem no desenvolvimento das habilidades espaciais-visuais. Frente a isso, o objetivo principal deste estudo é desenvolver um software de ensino-aprendizado, utilizando imagens panorâmicas e tomografias computadorizadas de telas cônicas (TC-FC), com o objetivo de que o aluno possa comparar uma radiografia panorâmica, uma reconstrução volumétrica de uma TC-FC e a criação de uma panorâmica 3D telar a partir das duas imagens anteriores, de forma interativa, para facilitar o ensino das estruturas anatômicas na graduação.

Objetivo da Pesquisa:

Criar uma ferramenta digital e didática que facilite o ensino da telar das estruturas anatômicas na radiografia panorâmica usando a reconstrução volumétrica da TC-FC como ferramenta de apoio.

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Carta de aprovação: UJF.61

para a interpretação da imagem.

• Objetivos específicos:

- Coletar imagens panorâmicas digitais e reconstruções volumétricas em bancos de imagens da PUC, da UFPR e Centros Radiológicos.
- Realizar comparações morfológicas e estabelecer uma relação anatômica entre as duas imagens.
- Fazer uma panorâmica em 3D, a partir das panorâmicas e TCFCs.
- Desenvolver um software que permita a utilização destas três imagens para o ensino das estruturas anatômicas e seja aplicado na sala de aula e a distância.
- Desenvolver uma metodologia de avaliação dos conhecimentos adquiridos pelo aluno a partir deste software didático.

Avaliação dos Riscos e Benefícios:

Conforme apresentados pelo pesquisador:

Riscos:

Não apresenta risco, porque serão trabalhadas imagens arquivadas num banco de imagens.

Benefícios:

Será feita uma ferramenta tecnológica para as salas de aula que facilitará o ensino das estruturas anatômicas em radiografias.

Comentário do Considerações sobre a Pesquisa:

Projeto condão e objetivo. Apresenta hipótese de que a elaboração de um software interativo para uso didático, donde o aluno irá a comparar a radiografia panorâmica, uma reconstrução volumétrica de uma TCFC e uma panorâmica 3D feita a partir das imagens anteriores. Com o objetivo de facilitar o processo de ensino-aprendizagem, das estruturas anatômicas em radiografias panorâmicas.

Considerações sobre os Termos de apresentação obrigatória:

Foram apresentados adequadamente.

Recomendações:

Conclusão ou Pendência e Ucla de Inadequações:

Projeto aprovado.

Considerações e Análise crítica do CEP:

Lembramos aos senhores pesquisadores que, no cumprimento da Resolução 466/12, o Comitê de

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Ética em Pesquisa (CEP) deverá receber relatórios anuais sobre o andamento do estudo, bem como a qualquer tempo e a critério do pesquisador nos casos de reavaliação, além do envio dos relatos de eventos adversos, para conhecimento deste Comitê.

Solicitamos ainda, a necessidade de relatório completo ao final do estudo. Eventuais modificações ou emendas ao protocolo devem ser apresentadas ao CEP PUCPR de forma clara e sucinta, identificando a parte do protocolo a ser modificado e as suas justificativas.

Este parecer foi elaborado baseado no documento cabalio relacionado:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PR_INFORMAÇÕES_BÁSICAS_DO_PROJETO_556135.pdf	13/11/2015 15:17:34		Acelo
TCLE / Termos de Assentimento / Justificativa de Ausência	tcle.pdf	13/11/2015 15:17:10	Aaron Benesaul Thullio Lopez	Acelo
Declaração de Instituição e Intersetividade	pucpr.pdf	13/11/2015 15:15:53	Aaron Benesaul Thullio Lopez	Acelo
Declaração de Instituição e Intersetividade	unpr.pdf	13/11/2015 15:15:28	Aaron Benesaul Thullio Lopez	Acelo
Protocolo Detalhado / Brochura Investigador	Protocolo_plataforma.docx	23/10/2015 18:16:06	Aaron Benesaul Thullio Lopez	Acelo
Declaração de Instituição e Intersetividade	declaração.pdf	23/10/2015 18:10:58	Aaron Benesaul Thullio Lopez	Acelo
Folheto Resumo	folheto_resumo.pdf	23/10/2015 18:04:02	Aaron Benesaul Thullio Lopez	Acelo

Situação do Parecer:

Aprovado

Nome e data Apresentação da COMEP:

Não

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Página 10 de 14



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Carta de Apreciação LUT-61

CURITIBA, 25 de Novembro de 2015

Agradado por:
MAIM AKEL FILHO
(Coordenador)

Endereço: Rua Imaculada Conceição 1155
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Original investigations, preliminary investigations, and technical reports should contain discrete **Introduction, Materials and Methods, Results, and Discussion** sections and should not exceed 15 manuscript pages (excluding references, tables, and figure legends). The journal permits flexibility in the format of all other sections. Rapid Communications are shorter than Original Investigations and are timely and describe new techniques or observations that have the potential of having a major impact on the science of biomedical imaging. Authors must select "Rapid Communication" as the Article Type at time of submission via the Elsevier Editorial System. Only manuscripts with little to no revisions qualify for this submission type. Manuscripts not accepted as Rapid Communications can be expanded and re-submitted as regular Original Investigations. Rapid Communication submissions require the following manuscript format:

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2. All manuscript text and tables should be Word format.
3. Rapid Communication manuscripts must also be submitted with a concise summary page succinctly describing the type and novelty of the contribution and comparison to existing state-of-the-art techniques or observations. This summary page is not included in the word count.

Subdivision - *unnumbered* *sections*

Divide your article into clearly defined sections. Each subsection is given a brief heading. Each heading should appear on its own separate line. Subsections should be used as much as possible when cross-referencing text: refer to the subsection by heading as opposed to simply 'the text'.

Introduction

State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.

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Results

Results should be clear and concise.

Discussion

This should explore the significance of the results of the work, not repeat them. A combined Results and Discussion section is often appropriate. Avoid extensive citations and discussion of published literature.

Conclusions

The main conclusions of the study may be presented in a short Conclusions section, which may stand alone or form a subsection of a Discussion or Results and Discussion section.

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If there is more than one appendix, they should be identified as A, B, etc. Formulae and equations in appendices should be given separate numbering: Eq. (A.1), Eq. (A.2), etc.; in a subsequent appendix, Eq. (B.1) and so on. Similarly for tables and figures: Table A.1; Fig. A.1, etc.

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and formulae where possible.

• **Author names and affiliations.** Please clearly indicate the given name(s) and family name(s) of each author and check that all names are accurately spelled. Present the authors' affiliation addresses (where the actual work was done) below the names. Indicate all affiliations with a lower-case superscript letter immediately after the author's name and in front of the appropriate address. Provide the full postal address of each affiliation, including the country name and, if available, the e-mail address of each author.

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A structured abstract, by means of appropriate headings, should provide the context or background for the research and should state its purpose, basic procedures (selection of study subjects or laboratory animals, observational and analytical methods), main findings (giving specific effect sizes and their statistical significance, if possible), and principal conclusions. It should emphasize new and important aspects of the study or observations.

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Please submit a list of abbreviations used in your article, to appear in a callout box alongside the text. All abbreviations and acronyms must be defined at first mention in the text and should be used a minimum of three times throughout the article text. Write out the full term for each abbreviation, followed by its definition in parentheses. Abbreviations appearing in figures and in table text should be defined in their respective figure captions and table footnotes in alphabetical order.

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Journal article

1. Valle JPM, Hiltbrand E, Zimmermann H, et al. Dynamic phosphorus-31 spectroscopy after fructose load in experimental biliary liver cirrhosis. Acad Radiol 1997; 4:26-34.

Book

2. Poritsky R. Neuroanatomy: functional atlas of parts and pathways. Philadelphia, Pa: Hanley & Belfus, 1992.

Chapter in a book

3. Heaton EB. Fibromuscular dysplasia. In: Barnett HJM, Stein BM, Mohr JP, Yatsu FM, eds. Stroke: pathophysiology, diagnosis, and management. New York, NY: Churchill Livingstone, 1986; 201-233.

Website

4. The Four Dimensions of Learning at ACR. Available at:

<http://www.acr.org/SecondaryMainMenuCategories/FourDimensions.aspx>. Accessed January 18, 2008.

Journal

abbreviations

source

Journal names should be abbreviated according to the [List of Title Word Abbreviations](#).

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