Project Title

An Evaluation of Different Dental Materials in the Fabrication of Oral Positioning Stents for Head and Neck Radiotherapy

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Organisation(s) Involved

Department of Radiation Oncology, NCIS

Healthcare Family Group Involved in this Project

Medical

Applicable Specialty or Discipline

Radiology, Medical & Laboratory Technology

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Aims

To evaluate each material's clinical suitability by evaluating the radiodensity variation and the presence of image distortion.

Background

See poster appended/ below

Methods

See poster appended/ below

Results

See poster appended/ below

Conclusion

See poster appended/ below

Project Category

Technology

Product Development, Product Evaluation

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Oral Positional Aid, Material Evalution, Material Density, Radiology, Radiodensity, Image Distortion, Houndsfield Unit, HU

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ABSTRACT

An Evaluation of Different Dental Materials in the Fabrication of Oral Positioning Stents for Head and Neck Radiotherapy

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INTRODUCTION

An oral positioning stent (OPS) is a removable positioning aid for the maxilla-mandibular complex, tongue and swallowing structures. It is worn like a removable denture during head and neck (HnN) radiotherapy (RT). The gross tumour volume and adjacent organs at risk share a close positional relationship in the HnN region. An OPS reduces toxicity by the physical displacement of the adjacent uninvolved tissues away from the tumour thereby facilitating dose reduction [1,2]. The ideal OPS material should present good quality under irradiation with material density close to 0 Hounsfield unit (HU), so it does not create image distortion, interfere with dosimetric accuracy or dose delivery. Our Centre currently fabricates custom OPS using clear self-cured acrylic resin by hand. With access to a range of different dental materials, we aim to evaluate each material's clinical suitability by evaluating the radiodensity variation and the presence of image distortion.

METHODOLOGIES

6 different types of commonly available dental materials were evaluated: (1) light-cured acrylic resin, (2) heat-cured acrylic resin, (3) self-cured acrylic resin, (4) 3D-printed acrylic resin, (5) dental silicone, and (6) dental wax (Figure 1). In total, 12 individual samples (one clear and one coloured) were fabricated to a size of 3 x 2 x 1 cm (H x W x D). A computer tomography scan using Toshiba Aquillon LB Scanner was performed for each sample suspended in a water tank with slice thickness of 3mm at 120kV. We did not use the artifact reduction or image enhancement function. Radiodensity measurements of the samples in HU were taken using the Eclipse Treatment Planning System (Varian Medical Systems, Palo Alto, CA). The average HU value was derived from measuring 5 random points in the scanned sample. The presence or absence of image distortion for each material was recorded.

RESULTS

5 out of the 12 samples (light-cured, self-cured, heat-cured, wax and clear silicone) had HU value similar to that of human tissues (bone, cartilage, cartilage, adipose and skeletal muscle, respectively) (Table 1). The coloured silicone sample had HU value similar to that of polyvinylchloride (PVC) and both 3D-printed samples had HU value similar to polymethyl methacrylate (PMMA). The coloured dental silicone material, and both clear and coloured lightcured materials had high mean HU values (525 HU, 1240 HU and 1432 HU respectively). Image distortion was also present in these 3 samples (Figure 2).

Recommendations for Future Research

The samples in our study were fabricated in blocks instead of actual-size models. Hence the actual fabrication time could not be established. The clear self-cured resin, which is our currently used material, requires a fabrication time of 2 weeks, so it is preferable for any future alternative material used to have a fabrication time of 2 weeks or less. Given that a course of RT ranges from 3-7 weeks, any OPS material used needs to maintain dimensional stability for a minimum of 7 weeks. We recommend fabricating actual-size samples to measure fabrication time and dimensional stability.

No.	Assigned Material	CT Value (HU)	Similarity	Distortion (Y/N)
1	Light-cured - clear	1240	Bone	Y
2	Light-cured – coloured	1432	Bone	Y
3	Self-cured – clear	88	Cartilage	N
4	Self-cured – coloured	69	Cartilage	N
5	Heat-cured – clear	110	Cartilage	N
6	Heat-cured – coloured	139	Cartilage	N
7	3D Printed – clear	160	PMMA	N
8	3D Printed – coloured	120	PMMA	N
9	Dental silicone – clear	55	Muscle	N
10	Dental silicone – coloured	525	PVC	Y
11	Dental wax – clear	-120	Adipose	N
12	Dental wax – coloured	-116	Adipose	N

Table 1. CT value, known material equivalence and presence of image distortion by type of sample material.

CONCLUSION

From our study, materials with a high HU value (≥ 525 HU) resulted in image distortion. This can affect the accuracy of organ delineation and has the propensity to interfere with dosimetric accuracy or dose delivery. While this feasibility study demonstrated image distortion in 3 samples with HU value ≥ 525, there is still insufficient evidence to determine if any material is superior or inferior to the currently used material. D

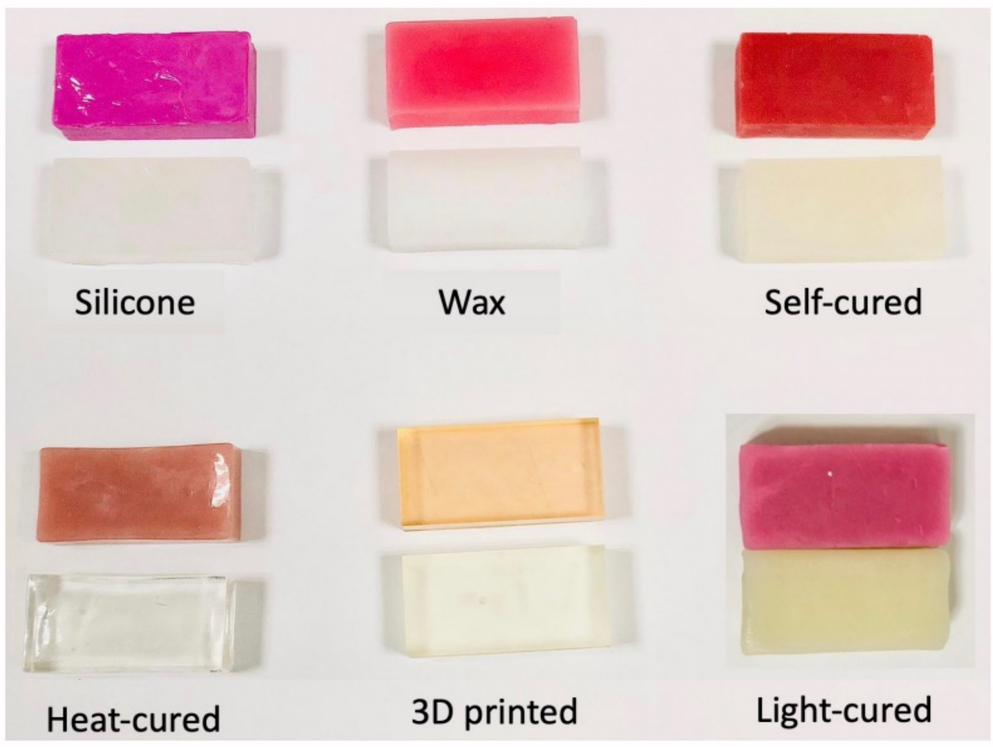

Figure 1. 12 samples of dental materials evaluated. Each material consisted of one clear and one coloured sample.

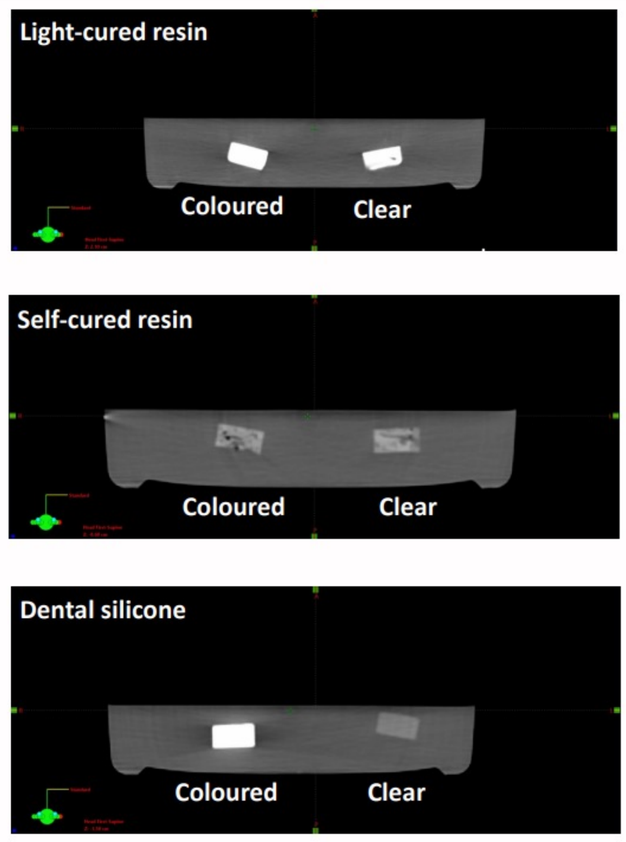

Figure 2. CT scan slices demonstrating presence or absence of image distortion in sample materials.

References

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