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Comparison The Property Of Tungsten And Lead For Protection Against Radiotherapy In Different Thickness And Position As Shielding Materials'

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Abstract

Background: Osteoradionecrosis (ORN) is a late complication of irradiation that does not resolve spontaneous. The aim of this study was to evaluate the effectiveness of holding tungsten and lead position to decrease radiation dose. **Methods:** The research was performed by using dried skull model covered with paraffin wax representing tissue. The protective devices had 2 models; the first model attached with tungsten or lead sheets (size 2.5x3.5 cm2 12 mm. in thickness), were constructed and placed in the both sides of mandible buccally. The others was similar to the first model, but the difference of it was constructed and placed in the mandible linguo- buccally. The 6 MV (2Gy) of photon was radiated, and then the percentages of remained relative doses in the mandible at different areas were measured. **Results:** The unshielded dried skull phantom radiation dose average ranged from 2.029 to 3.620 nCb. The first models, the percentage mean of remained relative dose were 67.335% and 46.878% in tungsten and lead respectively. The others were 57.494% and 40.677% in tungsten and lead respectively. The tungsten protective device significantly decreased the percentage mean of transmission dose more than the lead shield (p = 0.05), the percentage mean of transmission dose of both shields was difference significantly in each location (p = 0.05) and the first model shield had significantly difference in compare with the others (p = 0.05), exception in the model 2 was 12 mm. tungsten when right radiation beam entried. **Conclusion**: The tungsten protective device can decrease the remained doses more than the lead device. The position holding the metals should be the buccally.

Key Words: Osteoradionecrosis, Radiation, Lead, Tungsten, Intraoral shield, Head and neck cancer.

INTRODUCTION

In Thailand, the rate of head and neck cancer ranks the forth one compared to all neoplasm sites which is the statistic from the National Cancer Institute of Thailand.[1] There are patients with nasopharynx, paranasal sinuses, nose, oropharynx, thyroid, oral cavity. Concurrently, almost 100% of the patients had to receive radiotherapy.[2] Radiotherapy is 3 types, adjuvant therapy, concurrent chemoradiotherapy, therapeutic.[2] Each treatment had different of radiated dose. The aim of therapeutic use radiotherapy is to eliminate a tumor by exposing it to doses of ionizing radiation. Ideally, radiation therapy will be well-tolerated by surrounding structures. In curative radiotherapy, the total radiation dose is more than 60 Gy.[2-5] The modality for radiotherapy which is called as teletherapy which is used to deliver high doses of radiation to tumors that are located within 10 cms. of the skin surface. The doses are 6000 cGy to 7500 cGy for 6-7 weeks. Unfortunately, the latent radiation damage to surrounding tissues can range in severity from slight post-treatment discomfort to life-threatening necrosis. Manifestations of oral complications from head and neck radiotherapy include xerostomia, dysglusia, dysphagia, glossitis, mucositis, changes in oral microflora and salivary chemistry, salivary dysfunction, trismus and possibilities of infection in the jaws or the potential for osteoradionecrosis from infection or trauma to irradiated bone.[2,3] Among different imaging modalities plain X-rays of cervical spine (Lateral view) is known to give accurate and critical information in the diagnosis of cervical spinal stenosis due to cervical lordosis.[7]

Osteoradionecrosis (ORN) is correlated to radiation dose more than 60 Gy and is a more severe complication, which is difficult to treat for head and neck radiotherapy patients. In Thailand, more than 70% used electromagnetic radiation x-rays called LINAC (Linear Accelerator). Photon beams produced by LINAC are currently the most commonly used method of radiotherapy for tumor treatments. Irradiation for head and neck cancer, as well as stringent dose limitation for the mandible, parotid gland, and uninvolved oral cavity, many cases of ORN had developed. The purpose of this project was to determine if we could reduce this radiation dose by the external application of an occlusal-splint like, lead and tungsten custom-designed intraoral shield.

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MATERIALS AND METHODS

Phantom head

We designed a phantom head which prepared from a dry skull covered with paraffin as shown in figure 1. The phantom head was acted for human head and the paraffin thickness is equal to the thickness of human facial tissue.

Radiation beam

For an irradiation, we employed LINAC with 6 megavoltages and 200 MU. The irradiated area was 18x18 cm2. We specified that the distance from LINAC to the middle of facial phantom head was 100 cm, which was also the value in real patients. From the outer buccal side to LINAC was 92 cm.

Fig. 1. The phantom head covered with paraffin (Left), the model 1: the metal used in this study was placed in both buccally (Middle), the model 2 : the metal used in this study was placed in linguo-buccally (Right)

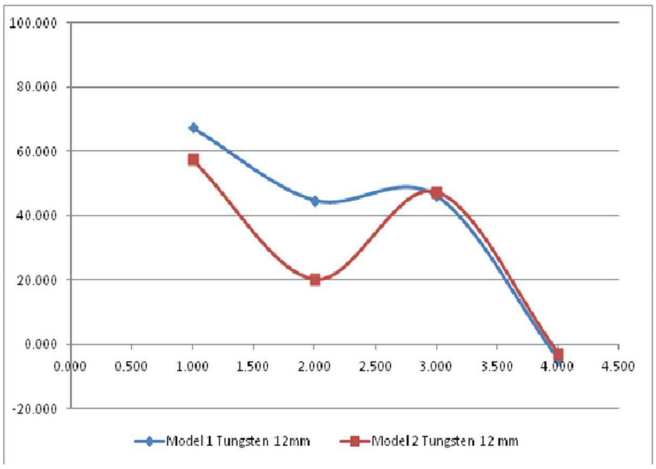

Fig. 3 Comparison of relative decreasing radiation dose for tungsten 12 mm using model 1 and 2

Dosemeter

Our project applied PTW UNIDOSE E and semiflex ionization chambers type 31010 sizes 5.5x6 mm for measurement the relative radiation dose (nanocoulomb).

Intraoral shield

We have 2 models, the first model was attached with tungsten or lead (dental film no.2) sheets (size 2.5x3.5 cm2 10 or 12 mm. in thickness) as shown in figure 2, We constructed an occlusal splint-like from acrylic afterwards we placed it in the both sides of mandible buccally. The second model had a little difference from the first one, whereby we constructed the occlusal splint-like and placed it in the mandible linguo-buccally as shown in Figure 1. In fact we cannot move or shift a patient's head because while irradiation therefore we studied in order to compare between two models

Methods

We held and fixed the phantom head on the irradiation bed, in the first step we placed model 1intraoral shield attached with tungsten 10 mm. We varied in 12 mm of tungsten and without shielding in the both position respectively. the radiation dose was measured by ionized chamber PTW of which position placed at the outermost of shield at the right side (A position), the inner of the shield placed at right side (B position), the lingual at the left mandible (C position), and the outermost of shield at the left side (D position) as shown in figure 1. Irradiation machine is LINAC 6 MV 200 MU in 18x18 cm2 in field sized. Each model that was varied with different material and thickness and without material also was irradiated 3 times. Lead was employed as by using the same condition. The next step we used model 2 and followed a

Fig. 2 The first row is lead in the thickness of 12 mm., 12 mm., 10mm and 10 mm. and the second row is tungsten in the thickness of 12mm., 12 mm., 10mm and 10 mm. respectively.

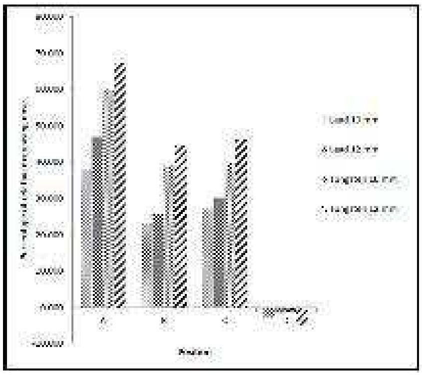

Fig 4. Comparison of radiation absorption efficiency by employing lead and tungsten with their 10 mm and 12 mm thickness.

methodology like the first model. PTW UNIDOSE E is an instrument used for measuring a quantity relative dose and interpreted the remained irradiation dose in nanocoulomb. The obtained relative dose was calculated on a percentage of decreased radiation doses, considering the statistic analysis by using computed T- test ($p \leq 0.05$).

RESULTS

For the irradiated area, the variation of using material and the difference of placing position for 6MV protons is shown in Figure 3. At A and B positions in the model 1 are able to decrease the radiation dose better than the model 2 at the same placing position. Decreases in output observed are 14.62% and 54.93% respectively. The reduction of radiation dose at C position in the Model 1 is almost the same value as Model 2. A tiny decrease in output observed is 1.94%. The presence of backscatter radiation at D position have in both models. This could be interpreted that the placing position for protection at both sides of jaws intraoral buccally is effective for reduction the radiation dose. The applied at Tungsten 12 mm shielding at both sides is a potential means of reducing the radiation dose to the HNCA.

A comparison of the tungsten shielding with lead shielding for radiological protection, the result of our experiment is shown in Figure 4. Tungsten 12 mm shielding is able to reduce the radiation dose better than lead 12 mm shielding at all positions. The percentage of difference relative decreasing dose at A, B, C, and D positions are 30.38%, 42.35%, 34.52%, and 78.05% respectively.

DISCUSSION

The result clearly indicates that the different properties of tungsten and lead due to their density and atomic number have a great influence in absorbility. Atomic numbers of tungsten and lead are 74 and 82. The densities of them are 19.25 g/cm3 and 11.34 g/cm3 respectively. it has also been reported that the dose enhancement magnitude strongly depends on the atomic number of the more scatter for both photon and electron beams, the high atomic number (Z) materials give rise to the maximum dose increasing.[6] The photon beam is better absorbed by material with high atomic number and high density. Although lead has higher atomic number than tungsten, but it has an extremely low level of absorption. Therefore in our studied Tungsten is more effective than lead. Tungsten showed the best protection property 1 cm. of tungsten reduces the dose to 49% of the dose of the open beam. Lead provide inferior protection compared to tungsten.[7] This project showed the intraoral shield can reduce 44-67% of radiation dose which reduce ORN developed. Parker SM, et al constructed custom-designed Tungsten-Antimony composite breast shield reduced this dose between 43 and 73%.[8] In our studies we prefer to employ Tungsten due to the fact that it is an environmentally friendly shielding material in comparison with lead citing U.S. government's Priority list of Hazardous Substances, lead is the second most hazardous substance. Tungsten has a higher density means smaller parts for the same weight, it is also a non-toxic alternative, cheap disposal and recyclable.[8] When the metal is placed near oral mucosa, backscatter will be occurred and oral mucositis is the side effects of this procedure. The increase in radiation-induced oral mucositis with the backscatting radiation is attention, the way to decrease this important side effect should use other materials which is thinner than tungsten and covered with the material. The distant of shield is 3 mm,[9] from metal, being able to decrease backscatter. The future research will study in surface area of tungsten by using nanomaterial.

CONCLUSION

The Tungsten customized intraoral shield can reduce irradiated dose. Furthermore we should research and develop in shielding material

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