ISSN: 2582-9904

LITERATURE REVIEW

Radiation stents – A road less travelled

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ABSTRACT
Radiotherapy has become one of the promising modalities in cancer treatment either as primary or in combination with other forms of therapy. But is also associated with a number of short and long term adverse effects such as pain, mucositis, erythema, ulceration, soft tissue necrosis, altered taste /olfaction, edema, radiation induced fibrosis, trismus, dysphagia, radiation caries, salivary gland dysfunction and Osteoradionecrosis. In almost every case, the adjacent normal tissue also gets irradiated because of its close proximity and worsens the scenario. Hence, their tissue tolerance exceeds, which leads to cell injury and a vicious cycle of adverse effects follows. Radiation stents can be a boon in sparing the adjacent tissues. This literature review summarizes the evidence which suggest actual reduction of adverse effects due to decline in levels of radiation in adjacent tissues.

Keywords: Backscatter radiation, Mucositis, Osteoradionecrosis, Quality of life, Radiation stents.

How to cite this article: Kiruthiga V.P, Shakthi Abarna B, Parameshwari G, Neya S. Radiation stents – A roadless travelled. Journal of Clinical Prosthodontics and Implantology. 2019; 1(2): 10-13

INTRODUCTION

Head and neck cancers are the third most common cancers worldwide standing next only to lung and uterus cancers. Moreover the developing countries solely contribute to over 60% of this global cancer burden.[1] In United kingdom, it's the 8 most common cancers and in America it contributes to about 3% of all cancers and is seen to considerably wane in incidence.[2,3] But then, in India they contribute to a third of all cancers with a significant percentage of mortality rates.[4] Prevention being the core goal worldwide, treatment and palliative care take up equal significance. Radiotherapy has evolved into a more proficient therapy with computer aided hard and software tools. Despite advances, adverse toxic effects after radiation therapy prevails. In developing countries like ours, external beam radiotherapy prevails to be in use, while other modern techniques still remain a dream to a greater proportion. The use of radiation stents can at least minimize the toxic effects to adjacent tissues.

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Radiation Stents

Glossary of Prosthodontic terms, defines “Radiation shield” as an intra-oral device designed to shield adjacent tissues from radiation during Ortho voltage treatment of malignant lesions of head and neck region.

Types:

Amongst the various radiation stents described in literature. The protecting stents are elaborated in the following.

1. Protecting stents:
   a) Shielding stents
   b) Tongue depressing stents
   c) Displacing stents
   d) Custom mouth protectors
2. Materials used:
   a) Heat cure acrylic resin
   b) Cerrobend/ Lipowitz/ Woods metal/ Bend alloy/ Pewtalloy/ MCP 158
   c) Lead
   d) Aluminium

A radiation stent does not require complex techniques. They can be fabricated by commonly available lab armamentarium and materials and can be delivered with a few appointments. Primary impressions made with irreversible hydrocolloid material followed by interocclusal record at an open vertical dimension of occlusion (with a careful consideration of the patient’s mouth opening as trismus could be a common association). With the records taken, the casts are mounted on an appropriate articulator. The stent waxed up according to specific dimensions, which is further flasked and processed in the usual way for most of the stents.

Heat cure acrylic resin:

This material becomes a vital requisite for the fabrication of radiation stent. It can be used solely in varying thickness or in combination with an array of metals with good shielding properties. Its protectiveact is due to the presence of large amount of hydrogen, which shows an exceptional shielding efficiency. Other materials with comparable properties are composites, water, saline etc.

Since the oral cavity is a compact environment with lot of interactions back scatter radiations from metal stent/crowns/restorations/implants can harm the normal tissues. Backscatter radiation can be reduced by increasing the thickness of acrylic material.[5]

Cerrobend/ Lipowitz/ Woods metal/ Bend alloy/ Pewtalloy/ MCP 158:

It’s a eutectic fusible alloy with a melting point of 70°C (158 F). This low fusing alloy is composed of 50% Bismuth (Bi), 26.7% Lead (Pb), 13.3% Tin (Sn), and 10% Cadmium (Cd) by weight. It has a modulus of elasticity of 12.7 GPa, and an yield strength of 26.2 MPa. Cerrobend alloy should be 1 cm or greater in thickness to ensure sufficient protection. A 95% reduction in transmission risk of 18 MeV electron beam can be ensured by using cerrobend alloy with thickness of 1 cm or greater.[6]

Most of the shielding efficacy is attributed to the presence of lead. Whilst, other elements contribute to the mouldability and ease of processing, this alloy should be handled with caution as it contains lead and cadmium both of which are known to pose danger. Cadmium poisoning carries the risk of cancer, anosmia, and damage to liver, kidneys, nerves, bones and respiratory system

Lead:

It’s a bluish gray metal with a molecular weight of 207.2, density of 11.34 g/cm3, melting point of 327.4°C. It has good malleability and corrosion resistance.

Its increased density and atomic number coupled with decreased size of its bond length and atomic radius contributes to its defensive property against radiation. The increased amount of electrons in the metal absorb and scatter energy whereby preventing deleterious ionizing radiation. This metal is more effective against shielding gamma rays and X-rays, both of which are used in radiation therapy whereas they do not show significant effect against neutrons.[7] Khan et al recommends a 1mm increase in thickness of lead for every 2 MeV energy of the electron beam.[8]

Handling Lead has been associated with occupational hazard for ages. Caution in terms of good ventilation and personal protection has to be exercised while handling this material. Some of the adverse effects are neuropathy, nephropathy, diminished hearing acuity etc.

Aluminium:

Its silvery white ductile metal with atomic number 13, density 2.70g/cm3 and Young’s modulus 70 GPa. As a matter of fact when the atomic number decreases the shielding efficiency also decreases, hence it is a weak shielder compared to lead but can be an excellent material to prevent back scatter radiation when given along with a lead shield.[9]

Tongue displacing stents:

They are prosthetic devices that aid to deviate tongue in a repeatable position during radiotherapy.

Figure 1(a) Tongue displacing stent – occlusal view; (b)Lingual view

A minimum distance of 10 -15 mm is mandatory for this type of stent. Johnson et al recommends a technique in which the material is molded to the level of over the cusp tips over which three struts are designed, two in the posterior region and one over the anterior region for constructing a tear shaped paddle to displace the tongue.[10] The tongue is displaced to its maximum yet tolerable limit in order to prevent gagging, soreness and ulcerations. The position of the tongue should be optimized to a repeatable position and the patient be taught the same. In Fig. 1a, 1b the stent is designed such that it occupies one half of the floor of the mouth and extends onto the occlusal surface of posterior teeth from the incisors the thickness of the stent over the floor of the mouth is 8mm from all sides.

Tongue depressing stents:
These types of stent depress and protect the tongue from damage while the patient undergoes radiotherapy. [Fig. 2a,2b] depicts a tongue depressor with bite block intended to keep the mouth open during radiation dose delivery. An inter incisal distance of atleast 10- 20 mm is recommended for this stent.

Figure 2(a) Tongue depressing stent – lingual view; (b) Lateral view

A quick chairside fabrication of this stent with light cure composite is also possible. Here the material is moulded so as to cover the tips of cusps only with two posterior struts to which an anterior triangular pad is attached. The pad is concave towards the tongue and convex above. And the groove (position) for tongue is optimized in the stent such that it is repeatable by the patient. The stent is polished to a satin finish and not a high luster.

Shielding stents:
Most of the requisites needed for other stents apply here also, except a shield metal or alloy (Lead, Lipowitz alloy, Rose metal, Newton's metal) is incorporated into the main framework to provide additional fortification.[11] And also in such stents an additional thickness of acrylic is needed to prevent backscatter radiation from the shield metals which could be even more dangerous than the primary beam itself. To further attenuate backscatter a tin or aluminum cover on top of the acrylic is being recommended by some authors.[12]

Custom mouth protectors:
These devices are effective means of preventing the effects of backscatter during radiation therapy. They are simple stents that extend the whole length of the tooth and prevent backscatter to the teeth.
The other usage is as topical fluoride applicators both pre and post irradiation in order to reduce the incidence of radiation caries.[13]

Figure 4(a)Custom mouth protectors – Occlusal view; (b) lingual view.

MODERN RADIATION THERAPY MODALITIES:

1. External beam radiation therapy:
   a) 3D Conformal radiation therapy
   b) 4D Radiation therapy
   c) Intensity modulated radiation therapy
   d) Stereotactic radiation therapy (gamma knife)
   e) Stereotactic body radiation therapy (cyber knife)
2. Internal radiation therapy:
   a) Temporary brachytherapy implantation
   b) Permanent brachytherapy implantation
   c) Systemic radiation therapy.[14]

AUTHOR (YEAR)	TYPE OF STUDY	RESULTS
Priyanka mall (2016)	Randomized control trial *Treatment*-Positioning Stents	Mean QOL scores in study group was less (p<0.001)
Goel A Tripathi (2010)	Randomized control trial *Treatment*-Positioning Stents	Mucositis (p<0.001) xerostomia (p=0.002,0.006,0.006)were lower in trialgroup
Qin W J (2007)	Randomized control trial *Treatment*-Tongue displacing stents	Taste dysfunction in study group was lower (p<0.001) Grade 3-4 mucositis was lower in trial group (p=0.4)
Miura (1998)	Retrospective analysis (1979-1994) *Treatment*-Acrylic stent	Incidence of osteoradionecrosis was lower in study group p=0.0004 Spacer (p=0.02)&combined Chemotherapy (p=0.02) combined External (p=0.02) are significant independent factors associated with Osteoradionecrosis
Karma Yangchen (2016)	Pilot study *Treatment*-Shielding Stents	Pain on swallowing, salivary changes, zerostomia, mucositis, and dysphagia were lower in study group(p<0.05) Caries incidence lower in study group (p<0.05)
Kenichi Obinata (2003)	Retrospective analysis (78 months) *Treatment*-Acrylic Stent	When spacer distance was >5mm incidence of Osteoradionecrosis was less (p<0.01).[15,16,17, 1 8,19,20.]

DISCUSSION:

Radiation stents as prosthetic devices is a path less trodden. The following is the evidence from the literature based on some of the clinical trials that shows reduction in dose &adverse effects with the use of radiation stents.

Some of the oldest literature regarding radiation stents dates back to 1978, obtained from the unpublished works of Schare L in M.D Anderson hospital, Texas. According to his research, backscatter produced directly adjacent to a metal stent is approximately 35% for 18 MV electrons, 73% for 8 MV x - rays and 74% for Co 60. He suggests that the effect can actually be reduced by increasing the distance from the alloy. A 6mm thickness of polymethyl methacrylate essentially reduces the backscatter radiation by 10% in 18 MV electrons and 18 MV X-rays whereas by 1% in Cobalt 60.5

Some of the invitro research which throws light on dose reduction are those that are conducted by Verrone which utilizes dose volume histogram to describe mean reduction rates and the ones done by Russel wang regarding the correlation between thickness of hydroplastic acrylic material and the reduction of adverse effects and Peter C Levendag dealing with thickness of lead shielding stent and reduction in incidence of osteoradionecrosis.[21,22,23]

A recent systematic search conducted in 2018 by Quiyang tang summarizes a wide array of materials used as radiation spacers ranging from acrylic resin, blood patch balloon filled with saline, human collagen, HLA (Glycosaminoglycans polymer), polyethylene glycol, hydrogel acellular human debris for different types of cancers and their utility in sparing normal tissues from radiation.[24]

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