Ashish.R.Jain et al /J. Pharm. Sci. & Res. Vol. 8(12), 2016, 1358-1366

ISSN:0975-1459
Journal of Pharmaceutical Sciences and Research
www.jpsr.pharmainfo.in

Clinical Demonstration of Various Radiation Stents- An Overview

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Abstract

The success rate of head and neck cancer treatment has tremendously increased after the advent of radiotherapy. Radiotherapy is of immense help in treating head and neck cancer along with surgery and chemotherapy. In spite of the recent advancements, radiation therapy has its own disadvantage in the form of post-operative complications. Complications arise when the unaffected tissues surrounding the affected area is exposed to radiation and exceeds its tissue tolerance level. The complications not only add to patients suffering but also affect the prognosis of the treatment. Preventing the complications is not a tough task as treating them. Therefore it is wise to prevent the complications before it occurs. Radiation stents are devices that serve this purpose. A radiation stent is an intraoral prosthesis designed to position/shield tissues during radiotherapy of the head and neck regions. This article will give a clear view of all the various types of radiations stents that can be fabricated.

Key Words: Radiotherapy, Head and neck cancer, Post-operative complications, Tissue tolerance level, Radiation stent.

INTRODUCTION

Radiotherapy (RT) is the standard and widely used procedure for treatment of patients with head and neck cancer with successful results.[1] Statistics says, of all the cancers found in India 40% are oral cancers.[2] In spite of the advancement of radiation techniques, this procedure is frequently associated with a wide range of oral complications, such as radiation caries, loss of taste, xerostomia, erythema, mucositis, trismus, and osteoradionecrosis, with significant impairment of the patient's quality of life.[3]. Hypersensitivity of the teeth, taste loss, oral bacterial shift and periodontal breakdown are other problems of concern while treating patients undergoing radiotherapy[4,5]. The actual success of any treatment is being free of post-operative complications. The post-operative complications hamper the prognosis of the treatment. Therefore it is inevitable to protect the surrounding tissues from radiation exposure. Various physical methods are also commonly used to reduce damage, which include shielding, proper positioning and the use of multiple fields. As a preventive measure, radiotherapy protective devices/stents can be fabricated and used during the treatment. These devices are used to displace the position or to shield tissues or to assist in the efficient administration of radiotherapy to the affected areas, thus limiting the post therapy morbidity.[6,7,8] Few studies have reported the use of intraoral stents during each fraction of Radiotherapy in order to spare normal adjacent tissue from the radiation dose and prevent these complications.[9-12] This article presents a review of the current applications of customized intraoral stents which can help to prevent the unnecessary irradiation of surrounding normal tissues, thus reducing the severity of the reaction and also throws light on the various types of stents that can be fabricated , their uses and its importance.

MATERIALS USED TO FABRICATE RADIATION STENTS

Heat cure acrylic resin is commonly used for the fabrication of stents. The alloys used for shielding are Cerroband, and Lipowitz. Cerrobend (Cerrosafe, Cerrolow, Cerrotru) is the most commonly used shielding alloy, which is a low fusing alloy (158F) composed of bismuth-50% lead-26.7%, tin-13.3%, cadmium-10%. Cerrobend is mostly preferred than lead as its melting temperature is 140F and hence it can be melted and poured into the cavity prepared, block out with clay and back scatter prevented by autopolymerizing MMA resin, where as lead has high melting point (600F) and hence cannot be poured into prosthesis in molten state. Used mainly when patient receives unilateral dose of radiation eg-buccal mucosa, skin, alveolar ridge. 1cm thickness of lipowitz alloy will effectively reduce an 18MeV electron beam by approximately 95%. The walls of reservoir should be atleast 0.5% thick to prevent back scatter of radiation. Normal dosage of radiation for head and neck tumors are 67.2, 72, 76.8, 81.6 Gy at 1.2 to 1.5 Gy given twice daily atleast 6 hour interval between sequential radiation treatment. [RTOG].

Various radiation stents

Depending on the location of the tumors like Squamous cell carcinoma, lymphoma of mandibular gingiva, carcinoma of cheek, carcinoma of lip and types of radiation source there are various types of radiation stents that have been designed. They can be classified as in Fig 1.

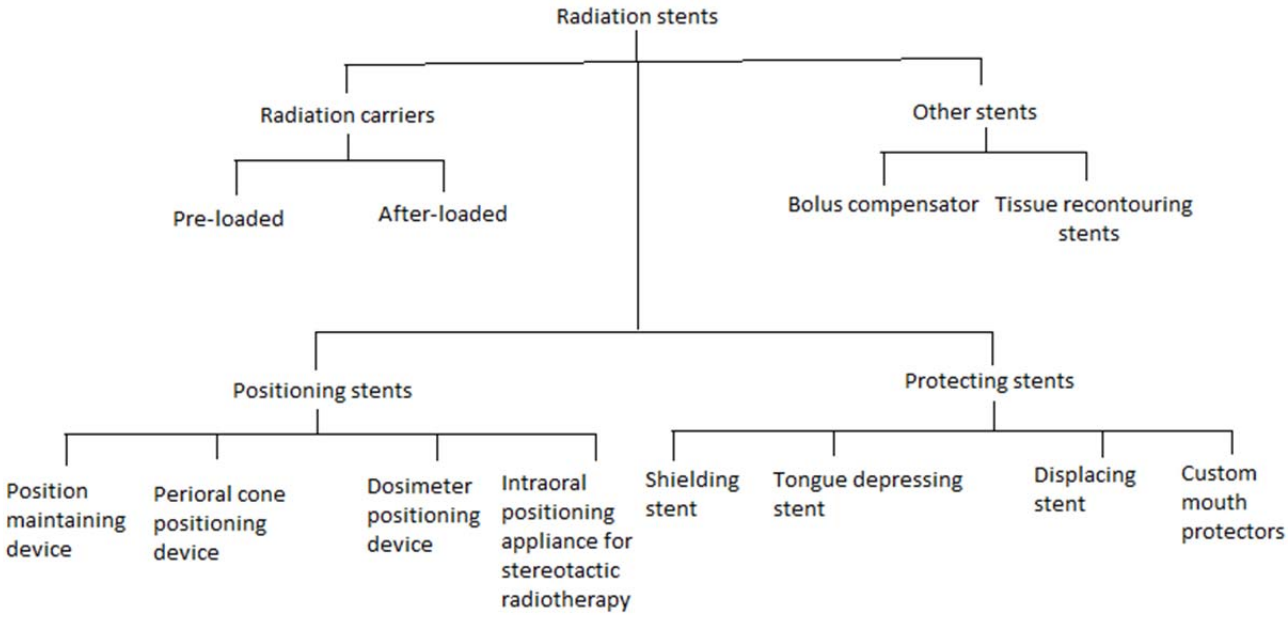

Figure 1: Classification of radiation stents

RADIATION CARRIERS

Radiotherapy for carcinomas of cheek, buccal mucosa, lower lips, tongue and Squamous cell carcinoma, adenocarcinomas of salivary and mucous gland, carcinoma of maxilla and mandible that involve the oral cavity has been enhanced by the use of prostheses known as radiation carriers or surface applicators. Radiation carriers are used when radiation is to be administered to a particular area without exposing the unaffected healthy tissues to radiation. They usually carry capsules, beads, tubes or needles made of radioactive element such as radium^{226}, iridium^{192} or cesium^{132}. The prosthesis is intended to maintain the radiation source in the same place throughout the treatment. It should be easy to load and unload. The location and the number of sources are determined by the radiotherapist. They are used to carry the radiation sources close to the site of treatment (intracavitary) or directly into the tumor (interstitial). They are of two types; preloaded carriers and after loaded carriers.[13]

Pre-loaded carriers

In pre-loaded carriers the radioactive sources are placed and sealed within the carrier. In this kind of carrier the radioactive material like iridium seeds are incorporated within a smaller diameter polyethylene tube. The tubing is then incorporated within the stent and cerrobend shield is added. This might subject the radiotherapist and the patient to unnecessary exposure to the radiation during placement. (Fig 2)

After-loaded carrier:

After loading technique is usually preferred over preloaded technique as the radioactive elements are placed after the carrier is in position, which reduces the radiation exposure to personnel handling and positioning the device. The technique is used for both interstitial and intracavitary radiotherapy. In this technique the radioactive source is implanted into the tissues of the tumor. There are two applications of this technique: permanent and removable implantation. In permanent implantation technique hollow stainless steel needles are placed in and around the affected tissue in the required positions (Fig 3a and b). After placing the needles radioactive sources are introduced into the tissues through the needles. The needles are then removed and the sources are left permanently implanted in the tumor. In the removable implantation technique, hollow flexible nylon tubes are used instead of stainless steel needles (Fig 3c and 3d). The radioactive material is guided into the tubes in the same way as in the previous technique. But the entire assembly is removed from the tissues after radiotherapy. The after-loading technique has been adapted for use with surface applicators in the treatment of soft tissue tumors of the body like lymphoma of maxillary gingiva, carcinoma of cheek and buccal mucosa.

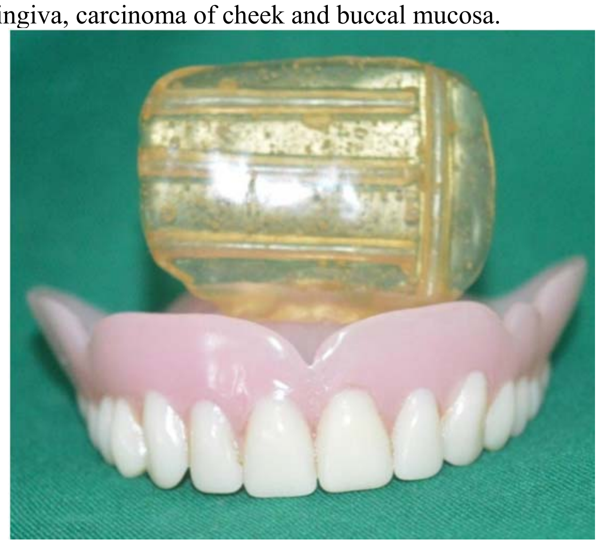

Figure 2: Preloaded carriers

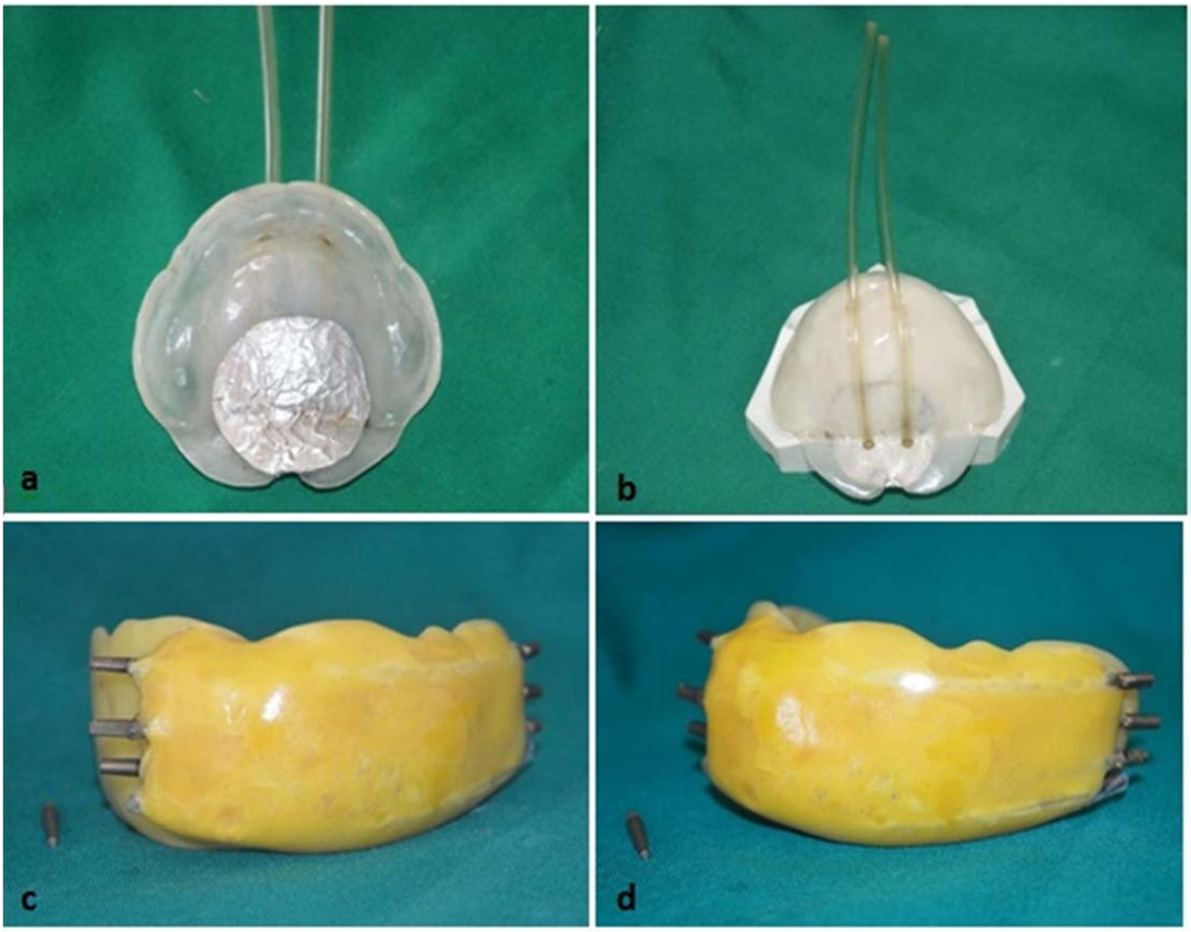

Figure 3: After loaded carrier

Figure 4: Position maintaining stent

Advancements in prosthetic carriers

Early methods of fabricating customized radiation carriers for inaccessible areas such as the nasopharyngeal space normally required the patient to be under conscious sedation or general anesthesia to allow impressions for indirect processing techniques. Certain recent advancements eliminate the use of conscious sedation and general anesthesia. They are :

a) Computerized Axial Tomography Scan
b) Rapid Prototyping

Computerized Axial Tomography Scan

In this method X-Rays produced by the computer is used to scan and produce tomographic images of the required area. Using this tomographic image prosthetic device of required design can be fabricated without the need for impression making under conscious sedation or general anesthesia. A prosthodontist's guidance is important during the fabrication of the prosthesis.[15]

Rapid Prototyping

Rapid prototyping (RP) is a method which can construct physical models automatically from 3-dimensional (3D) data obtained by the computer with the help of sensors. It operates on the basis of additive technique in which the model is fabricated by depositing material in successive layers. The primary advantage of this process is that the model created directly retains all the detail of the internal geometry rather than just the outer surface contours. This technique is now being used to design and fabricate extra-oral radiation shield. This innovative application is not only more comfortable for the patient, but allows more precise treatment delivery.[15]

Position Maintaining Stent:

The purpose of position maintaining stent is to hold the movable structures in position desired by the radiotherapist. It is used in cases where multiple treatment sessions are required and the structures need to be positioned in a fixed and reproducible manner. They are commonly used to position structures like tongue, soft palate etc.(Fig 4)

Advantages:

- Approach structures such as mandible and salivary glands are spared from effects of radiation.
- Usable in both edentulous and dentulous patients and assure repeatable positioning of the stents during therapy.

Disadvantages:

- Large one piece stents are difficult to insert if patient begins developing radiation mucositis and Trismus.

Perioral Cone Positioning Stent

This type of stent serves to direct the beam of radiation only to the required area. Its main objective is to minimize the movement of the cone during the treatment by holding it in a fixed and repeatable position. It is used in the treatment of superficial lesions involving the anterior floor of the mouth and the hard and soft palate like Squamous cell carcinoma, carcinoma of pisiform sinus, subglottic area, lymphoma of tonsils, nasopharynx. To fabricate a perioral cone positioning stent tinfoil is wrapped around the actual cone to be used in the treatment and an acrylic ring of 4 to 6mm is formed around it. The tinfoil acts as a separator from acrylic resin. The acrylic ring is then attached to the maxillary record base in case of edentulous patients and to the occlusal indices in case of dentulous patients. The cone is attached in such a way that it is centered over the lesion.[13] (Fig 5)

Dosimeter positioning stents

Dosimeter is a device which measures the amount of radiation exposure. This device can be used to calculate the amount of dose delivered to a lesion and the amount needs to be delivered. The absorbed dose can be calculated by using the formula-

$D=AE_{ave}*1.6E\text{-}13J/MeV*1E3g/kg$.

Whereas, D= Absorbed dose

A=Radioactivity

E_{ave}= Average energy

E= HxW_1

where H= Equivalent dose

W_1=Weighing factor

J= Joule

MeV= Million electron Volts

Dosimeter positioning stents serves this purpose by holding a dosimeter close to the treatment site. Lithium fluoride capsules are commonly used as dosimeters for its accuracy and efficacy. These stents are designed with a series of slots for holding the capsules. The lithium fluoride capsule is wrapped in a 0.1 inch tinfoil which is wrapped with acrylic resin casing and is allowed to cure. A hole is placed at one end of the stent and an orthodontic wire is used to push the capsule out of the acrylic resin casing. The resin case is attached to the stent in position as directed by the radiotherapist.[13] (Fig 6)

Figure 5: Perioral cone positioning stents

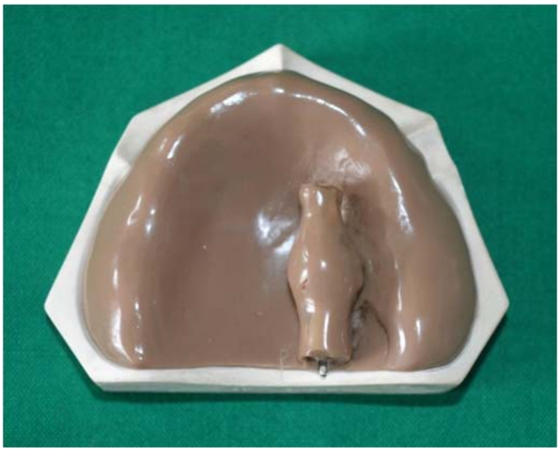

Figure 6: Dosimeter positioning stent

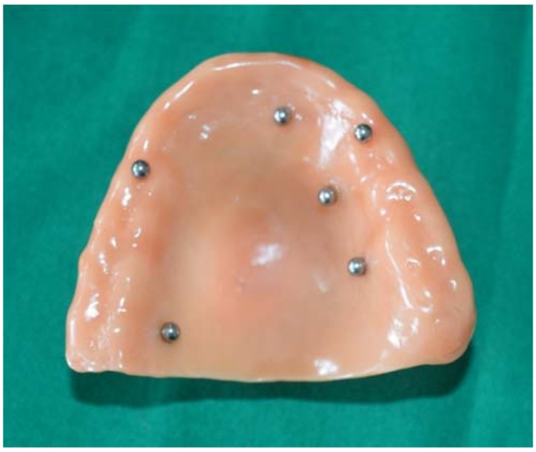

Figure 7: Intraoral positioning appliance for stereotactic radiotherapy

Intraoral positioning appliance for stereotactic radiotherapy

Stereotactic radiotherapy is an alternative to conventional surgery and/or conventional radiation therapy for treatment of intracranial tumors such as pituitary adenomas, acoustic neuromas, meningiomas, and craniopharyngiomas[14]. This nonsurgical procedure delivers fractionated doses of radiation to the lesion from several different positions. It enables the radiation oncologist to maximize the target dose while minimizing the dose to normal tissues to combine the dosimetric advantages of stereotactic precision with the biologic benefits of dosefractionation[15.] In order to maintain the accuracy of the treatment, it is important to position the head in a reproducible manner within the stereotactic space. There are both invasive and non-invasive techniques available for verifying the repositioning accuracy. Invasive techniques for head positioning require that a stereotactic head ring remain fixed to the skull by screws or that reference screws be placed in the cranial cortical bone for docking with the treatment unit or that markers be inserted into the skull. Intraoral positioning appliance serves as a noninvasive technique of verification. The prosthesis consists of tungsten spheres of 3mm diameter embedded into maxillary occlusal splint. In case of completely edentulous patients the positioner is fabricated over the maxillary denture and indexed to the mandibular denture teeth. If the patient does not have dentures, then wax occlusal rims should be made on resin record bases to establish a centric occlusal position at the correct vertical dimension of occlusion and tungsten spheres should be embedded in the palatal portion of the maxillary record base. Orthogonal pair of radiographs will be taken during each treatment session to verify the head position. The metal spheres embedded in the intraoral positioning appliance serve as the reference points to verify the location and orientation of the head within the stereotactic space. [16](Fig 7)

Advantages:

- Nonsurgical procedure used to treat intracranial tumors.
- This permits minimum size of the target beam, which spares more adjacent normal tissue.

Shielding stents

As the name suggests these stents are intended to shield the vital structures adjacent to the affected tissue from radiation exposure. Failing to protect the adjacent structures leads to their damage and painful complications. Many cases of radiotherapy to treat lesions of the buccal mucosa, skin, alveolar ridge, without any protective measure has led to mucositis and xerostomia. Effective shields can be fabricated to protect the tongue, salivary glands and the opposite side of the mandible. These stents consists of a radio-opaque material placed in such a way that it shields the vital structure from radiation exposure. Low melting alloys like Cerroband, Pb-Bi-Sn, and Lipowitz are used as shielding materials. Cerrobend alloy is preferred because of its low melting temperature and it effectively prevents the transmission of the electron beam. During the fabrication of this stent a hollow cavity of required thickness in made in relation to the structure to be protected. Cerrobend alloy is then heated and poured into the hollow cavity and it is sealed with auto polymerizing resin.[17] (Figure 8a, b and c shows shielding stent used in case of radiotherapy to the left buccal mucosa. Figure 8d shows stent with cerrobend alloy in place.)

Tongue depressing stent

The purpose of this stent is to depress the tongue and prevent it from unwanted radiation exposure. The device additionally positions the mandible and prevents the parotid gland from exposure during radiotherapy. It consists of an interocclusal stent which extends lingually from both the alveolar ridges, with a flat plate of acrylic resin which serves to depress the tongue. A hole is made in the anterior segment in which the tip of the tongue is placed in order to establish a reproducible position[17](Fig 9). They are indicated in carcinoma of tongue, head and neck cancers. If the stents are not placed then it results in lesions of retromolar trigone, buccal mucosa and tongue predispose to cheek and tongue biting.

Advantages:

- Stents are more accurate and provide greater patient comfort
- Positions the mandible, depresses the tongue and spares the parotid gland

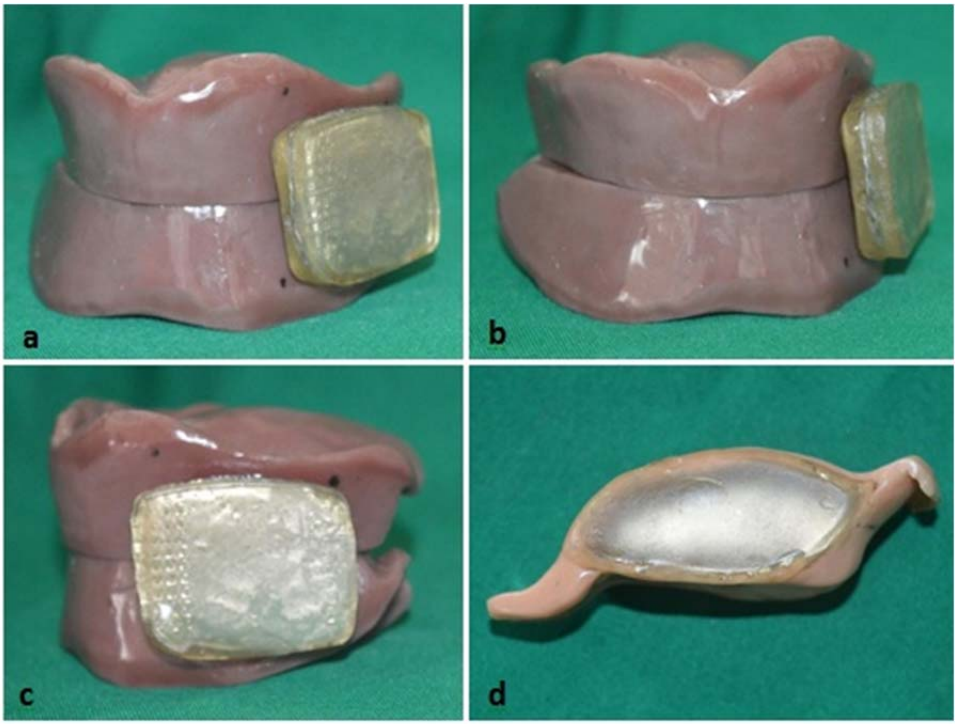

Figure 8: Shielding stents

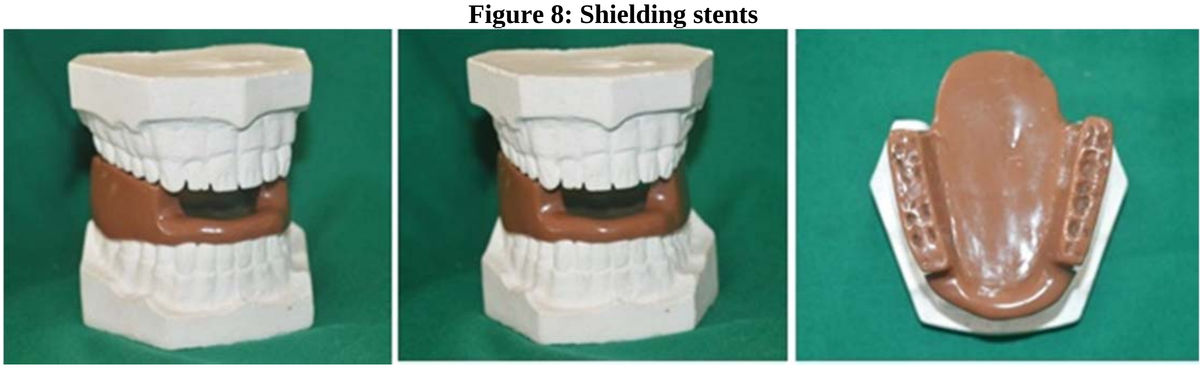

Figure 9: Tongue depressing stent

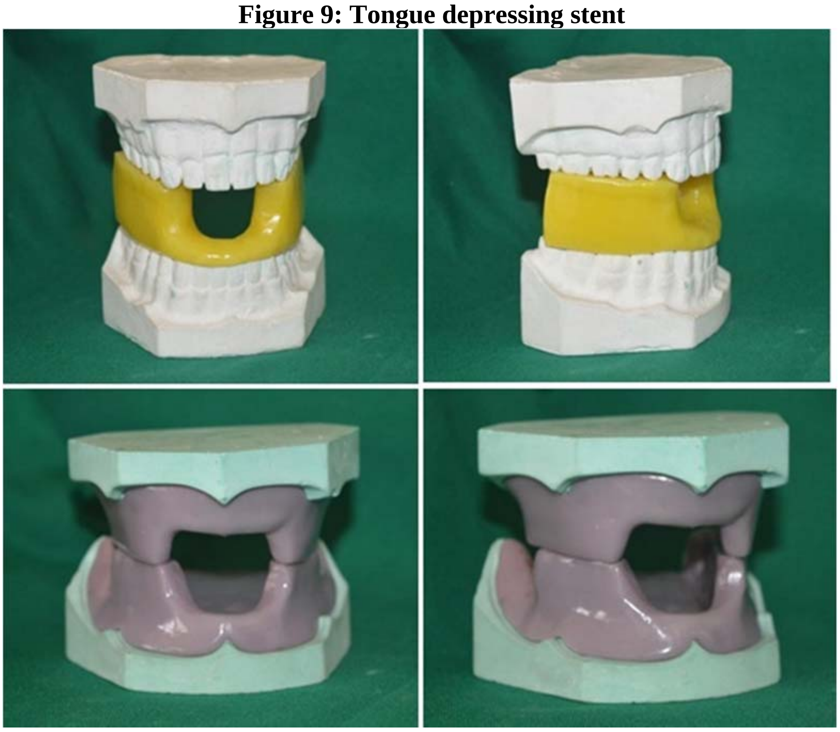

Figure 10: Displacing stents

Displacing stents

They are used to move or displace the vital structures from the radiation field. It is commonly used in the treatment of tumor involving the alveolus of the mandible, posterolateral borders of the tongue and the buccal mucosa. The stent is designed in such a way that it separates the maxilla from mandible, which prevents maxilla from unwanted radiation exposure. (Fig 10)

Custom mouth protectors

Custom mouth protectors find its application greatly in sports-related activities in order to prevent injuries. However, they are used with increasing frequency in other areas such as therapeutic and preventive dentistry and medicine. Mucositis is a common and not a very easy to treat complication. Mucositis appears 2 to 3 weeks after the start of therapy and reaches a peak toward the end of treatment. It is most severe at the tumor site. It is so painful that it causes dysphagia resulting in weight loss. Custom mouth protectors are indicated in severe cases. The flexible smooth protectors protect painful edematous mucosal tissues from irritation by tooth surfaces and irritating foods. This protection aids the irradiated patient in maintaining weight and nutritional status during therapy. Hypersensitivity of teeth to temperature changes is often found in patients who have received radiation treatment. Daily application of fluoride gel in custom mouth protectors for 10 to 15 minutes three times a day usually eliminates the hypersensitivity in 4 to 6 weeks[18] (Fig 11)

Figure 11: Custom mouth protector

Bolus compensators

These prostheses help in the treatment of superficial lesions of the face with irregular contours. Due to irregularities in the lesions, some areas within the field may be untreated, while others may develop isolated hotspots. Bolus is a tissue equivalent material which is placed directly onto or into the irregularities, that helps in converting irregular tissue contours into flat surfaces which are perpendicular to the central axis of the ionizing beam, to thereby more accurately aid in the homogenous distribution of the radiation. The most commonly used materials for bolus are tissue conditioners, water, saline, waxes and acrylic resin.[13]

Tissue Recontouring Stents

These stents are required when treating lesions associated with lips. Due to the curvature of the lip low dose of radiation is delivered at the corners of the mouth and high dose at the center. This stent serves to flatten the lip and ensures that its entire length lies in the same plane. These stents are fabricated by modeling plastic/wax and are processed in acrylic resin.[13,17] (Fig 12)

Figure 12: Tissue recontouring stent

DISCUSSION:

Radiation therapy is defined as "the therapeutic use of ionizing radiation in the management of neoplasms of the body without surgery, or as an adjunctive palliative treatment after surgery, either in combination with or without chemotherapy" The two main categories of ionizing radiations which are used are electromagnetic radiations (photons, x-rays, gamma rays) and particulate radiations (electrons, neutrons and protons). There are two different modalities of radiotherapy, external and interstitial. External radiation therapy which is also called as teletherapy is used to deliver high doses of radiation to tumours that are located within 6 cms of the skin surface. The doses are 6500 rads to 7500 rads for 6-7 weeks. Interstitial Radiotherapy is also called as brachytherapy. It is the most commonly used mode which can deliver high doses (upto 20000 rads) of radiation over a short distance for a short time period (10-15 hrs). Radiation therapy is given in a series of treatments or fractions called fractionation. Unfortunately, this treatment causes complications by increasing the morbidity of the surrounding tissues. These include erythema, mucositis, ulcers, fungal infections, xerostomia, caries from decreased salivary flow and pH changes, possibilities of infection in the jaws or the potential for osteoradionecrosis from infection or trauma to irradiated bone, hypersensitivity of the teeth, taste loss, oral bacterial shift and periodontal breakdown.[2,3]

Optimizing the method of radiotherapy, modifying the dose and fractionation regime are the various biological methods through which damage to the normal tissues can be avoided. Shielding of the normal/vital structures, proper positioning and the use of multiple fields are the commonly used physical methods. To be more preventive, radiotherapy protective devices/stents can be fabricated and used during the treatment. These devices are used to displace the position or to shield tissues or to assist in the efficient administration of radiotherapy to the affected areas, thus limiting the post therapy morbidity. [4,5,6]. The need for a radiation stent is determined by the treating radiotherapist. The prosthodontist can actively help in the rehabilitation of cancer patients by fabricating a whole array of possible prostheses that can be constructed to meet specific patient needs, thereby limiting complications following therapy [7].

Radiation stents are commonly fabricated from acrylic resin and may or may not contain a shielding metal/alloy, depending upon several conditions; type of the radiation given, condition of the diseased hard and soft tissues, mouth opening ability and the needs of the treating radiotherapist. Conventional prosthetic techniques are used to fabricate these stents.[8,9] Silicone is the other material of choice. With the advancements in technology, computer tomography is recently being used for the fabrication of brachytherapy carriers. Radiation stents typically incorporate a tissue-equivalent bolus material coupled with shielding. Lipowitz metal or cerrobend alloy is commonly used to shield uninvolved tissues from electron beams used in therapeutic radiation treatment of head and neck cancers.[33] This fusible eutectic alloy is composed of 50% Bi, 26.7% Pb, 13.3% Sn, and 10% Cd. Conventional facial moulage technique is commonly used to fabricate these stents. Recently, computer-aided designing/computer aided manufacturing (CAD/CAM) and rapid prototyping technologies have been utilized.[34]

Dentate patients with metallic crowns or fixed partial dentures in the treatment field may suffer significant irritation to adjacent soft tissue as a result of backscatter and forward-scatter. It causes backscatter and forward-scatter mucositis. The interaction of high-energy photon or electronionizing radiation with the atoms of metal restorations or metal stents liberates electrons and sets them into motion. If the electrons move in a direction that is opposite to that of the primary radiation beam, they are referred to as “back scatter.” “Forward- scattered” radiation moves in a direction that is the same or similar to that of the primary radiation beam. Clinical evidence of mucositis caused by forward- and back-scatter radiation is common, particularly in the cheek and tongue, when gold restorations are present during radiation treatment.[35] Titanium implants are increasingly used in oral and maxillofacia1 surgery for reconstruction purposes. However, there is very little information available in the dental literature postulating how the teeth, dental implants, and dental restorations, such as full gold crowns, affect the response of the surrounding structures to radiotherapy treatment and scatter radiation. Schare[36] reports that, directly adjacent to a metal stent, the back scatter produced is approximately 35% for 18 MV electrons, 73% for 18 MV x-rays, and 74% for Cobalt-60. This effect is reduced with an increased distance from the alloy. A 6-mm methyl-methacrylate tissue guard used in Schare’s study reduced the back-scatter radiation to the adjacent tissue to approximately 10% for 18 MV electrons and for 18 MVx-rays and to less than 1% for cobalt 60. Previously the radiation oncologist placed a block of beeswax over the gold restoration to protect the adjacent tissues. However, the beeswax block broke during each removal because of the undercuts inherent to crown form. The oncologist was also concerned that the instability of the stent on top of the beeswax block might affect the repeatable jaw position during radiotherapy. In 1994, Wang and Boyle[35] used an 8-mm thick hydroplastic acrylic material that was designed to attenuate the scatter radiation and to protect the adjacent tissues and showed that it markedly minimized the treatment sequelae from forward and back-scatter radiation.

At times, the head and neck surgeon and radiotherapist are not fully aware of the many primary and supportive services that the maxillofacial prosthodontist can perform through the use of the prosthesis. Keeping in mind Munshi's opinion that “treating cancer involves a multidisciplinary approach” [30] a prosthodontist must be present in every team treating head and neck cancer.

CLINICAL IMPLICATION:

Radiation therapy has been used with increasing frequency in the recent years for the management of neoplasm of head and neck region. A majority of patients with such tumours will receive radiotherapy at sometime during the course of their treatment. The cancer patient who is to receive curative doses of radiation to the head and neck presents an interesting challenge to the dentist. Since the use of these stents is individualized, close collaboration between the radiotherapist and the prosthodontist is essential. These measures make the patient’s treatment course smoother.

CONCLUSION

As the famous proverb goes ‘Prevention is better than cure’ it is wise to prevent the complications before it occurs. The complications add on to the patients’ pain and increase their suffering. Though these complications can be effectively prevented with the help of these stents, they are not being greatly used. Their use has not become a common practice. Prior to every case of head and neck radiotherapy, the surgeon and the radiotherapist should consult a maxillofacial prosthodontist regarding the type of radiation stent that is required and its fabrication. This simple and effective preventive measure will make the treatment easier and comfortable for the the patient.

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