Marginal Leakage Around Fixed Dental Prosthesis - A review

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ABSTRACT
Marginal leakage is the intrusion into the space between all the restorative materials and cavity walls of fluids, bacteria, and ions. It can cause irritation of the pulp, change of color in the tooth and secondary caries, and may also result in restoration failure. The freshly placed prosthetic margins invariably leak. As time goes by there is a rise in marginal leakage associated with the manufacture of corrosion products and the expansion of other materials into the space between the tooth and the prosthesis. Dental researchers have been interested in the efficacy of the restorative materials to seal cavity margins against the entry of salivary constituents for some time. Some studies have shown that normal dentin would allow the penetration of dyes into human teeth's dentinal tubules. An analysis of later micro-leakage studies reveals that the structure of the dentin is permeable to the diffusion of fluids by natural and acquired defects. Because the enamel surface contains natural cracks and lamellas that allow the fluid to penetrate, the enamel can also have areas of hypo calcification, hypoplasia, chemical breakdown, abrasion, and carious lesions that increase penetration. However, dentine enables the transportation of fluids by odontoblastic processes. Cutting dentin with dental pressure increases the exposed surface area and thus increases the amount of tubules available for fluid transfer into the pulp chamber. While ionic charge and chemical reactivity of diffusing fluids lead to marginal leakage, the physical and chemical character of restorative materials, and the operator’s clinical skills are equally essential.

INTRODUCTION
Marginal leakage is the intrusion into the space between all the restorative materials and cavity walls of fluids, bacteria, and ions. (Kokubo, 1989a) It can cause irritation of the pulp, change of color in the tooth and secondary caries, and may also result in restoration failure. (Kokubo, 1989b) The freshly placed prosthetic margins invariably leak. As time goes by there is a rise in marginal leakage associated with the manufacture of corrosion products and the expansion of other materials into the space between...
the tooth and the prosthesis. (Jones et al., 1988) Dental researchers have been interested in the efficacy of the restorative materials to seal cavity margins against the entry of salivary constituents for some time. Some studies have shown that normal dentin would allow the penetration of dyes into human teeth’s dentinal tubules. (Qvist and Qvist, 1977) An analysis of later micro-leakage studies reveals that the structure of the dentin is permeable to the diffusion of fluids by natural and acquired defects. (Issa, 1968) Because the enamel surface contains natural cracks and lamellas that allow the fluid to penetrate, the enamel can also have areas of hypocalcification, hypoplasia, chemical breakdown, abrasion, and carious lesions that increase penetration. (Barnes, 1970) However, dentine enables the transportation of fluids by odontoblastic processes. Cutting dentin with dental pressure increases the exposed surface area and thus increases the amount of tubules available for fluid transfer into the pulp chamber. (Khalaf, 1990) While ionic charge and chemical reactivity of diffusing fluids lead to marginal leakage, the physical and chemical character of restorative materials, and the operator’s clinical skills are equally essential. (Hasani et al., 2019) Recent emphasis on prevention through plaque and sugar control in restorative dentistry may also be an important factor in lessening the negative effects associated with defective margins. (Chan and Jones, 1992) Although marginal leakage has not been identified readily with the prevention, the clinician should appreciate that restorative procedures performed well are an important part of prevention in a safe community. (Chan et al., 2008; Natarajan et al., 2019) New dental materials and techniques, as well as new analytical and diagnostic methods, may eventually provide an opportunity to eliminate marginal leakage in dental restorations. (Hisamitsu et al., 1990; Saleh and Taşar-Faruk, 2019)

Biological and technical complications appear to be common in all forms of dentistry supported by fixed implants. (Chen et al., 2012) These complications often endanger the functional and/or esthetic characteristics of a given prosthetic and occur despite sound prosthesis and high levels of clinical expertise. (Hembree, 1983) Numerous techniques were developed to test the restoration cavity-sealing properties both in vitro, in vivo. These methods include the air pressure, use of dyes, radioactive isotopes, bacteria, artificial neutron activation analysis, caries, and electron microscopy scanning. (Fanian, 1981) Sometimes types of thermal stress have also been documented included in the Protocol of Experiment. Much attention has been focused on the problem of microleakage (Abbott, 1997) in the last 25 years and it has been involved in a variety of conditions, including recurrent caries, change of color of the tooth under amalgam, hypersensitivity of restored teeth, pulpal damage and the acceleration of breakdown of certain filling material. (Belli et al., 2001; Yap and Mok, 1997)

**Research on how to detect micro leakage**

Microleakage was researched extensively through the last 25 years. (Juhász, 2008) Many different methods of demonstrating the phenomenon were developed and applied to commonly used restorative materials. (Ariga et al., 2018) Of the many microleakage tests available, the techniques of artificial caries tend to be of particular clinical significance because they relate microleakage to its effect, (Jyothi et al., 2017) lesion formation. It has also been shown that the use of a cavity varnish or liner will significantly minimize this leakage; it would naturally be best to use these products regularly in caries-prone mouths. These varnishes may also be needed for the production of new corrosion-resistant alloys. (Selvan and Ganapathy, 2016) On the newer composite materials, very few microleakage tests have been conducted, but there is some evidence that they may form a strong seal of the cavity (Kannan and Venugopalan, 2018).

**Techniques to detect and analyse microleakage**

One of the oldest but commonest methods of microleakage detection is the use of organic dyes as tracers. (Ganapathy et al., 2016) The method generally involved placing a restoration in an extracted tooth and immersing the specimen in the solution of the dye. (Subasree et al., 2016) The tooth has been cut, cleaned after an interval of time, sectioned and examined for the extent to which the dye penetrates around the filling material. Air pressure was used to detect microleakage as early as 1912 when Harper engineered Class II amalgam restorations in steel dye, the air was delivered to the floor under pressure, the cavity, and the restorations under water were studied. (Jain et al., 2017) A similar procedure was used in human teeth with air supplied to Class V restoration. That way, acrylic and amalgam were also examined. Analysis of activation of neutrons was used to study microleakage in vitro as well as in vivo. (Vijayalakshmi and Ganapathy, 2016) The restored teeth had been soaked in a non-radioactive manganese salt aqueous solution. All salts that adhere to the outside of the tooth underwent removal. Whole teeth were then positioned at the core of a nuclear reactor; the Mn was triggered to Mn, and the Mn’s X-ray emission was measured during irradiation. (Jain and Dhanraj, 2016) The number of radioactive counts was proportional...
to the Mn per tooth being taken up. In vitro artificial secondary caries-like lesions were created using either bacterial cultures or a chemical method—-the technique of acidified gelatin gel. (Ajay et al., 2017)

Complications due to marginal leakage

Dentists have been reported to spend 60 percent to 75 percent of their working time restoring restorations, causing high personal and social costs. (Duraisamy et al., 2019) Replacing restorations is mainly related to the development of secondary caries. Secondary caries may be treated as primary restoration lesions and may also be referred to as “dental caries past restorations.” The key sites are areas of accumulation of biofilms, (Kannan, 2017) such as the cervical margins of restorations. Secondary caries can occur as an adjacent wall lesion or superficial lesion, or as a result of a restoration. (Ashok and Suvitha, 2016) In case of marginal leakage in amalgam restorations, the margins of a fresh amalgam restoration inevitably leak. (Ashok et al., 2014) With the passage of time, there is a decline in marginal leakage related to the manufacture of corrosion products and the dissemination of other materials into the space between the tooth and the restoration. (Venugopalan et al., 2014) Correct preparation of the cavity margin and proper condensation of the restorative material minimize marginal leakage of restored, fresh amalgam. Lacquered varnish on the cavity walls is most important and an indispensable method to prevent marginal leakage. (Basha et al., 2018) The finishing and polishing process often affects the integrity of the edges of restorations, through the heat produced by the instrument’s rotation, and can cause marginal leakage of resin restorations of composites. (Akhoundi et al., 2017; Karagoz-Yildirak and Gozneli, 2020) Some clinicians do rebonding after finishing and polishing using a bonding agent to address these problems. A bonding agent’s main purpose is to establish a stable bond between the restorative material and the tooth structure in order to close the gap. (Manjunath et al., 2020)

The marginal fit of fixed dental prostheses is determined by the size of the distance between the restoration margin and the prepared tooth finish line. (Daou and Baba, 2020) The most important factors affecting marginal and internal fit of fixed dental prostheses are the material used, the finish line form as well as the peculiarities of different restoration manufacturing techniques. When these factors do not align well enough together, complications arise involving marginal leakage in the fixed prosthesis. (Jurado et al., 2020)

Methods to minimize marginal leakage

In order to achieve good results, consideration should be given to a number of factors such as the milling machine, bur parameters (diameter, sharpness), software, design preparation, smooth preparation margins and the incorporation of rounded line angles on the tooth preparation, finish type, construction material and manufacturing method and type of impression method. (Brignardello-Petersen, 1939) The right marginal and internal match is a guarantee of sustainability and building performance. A large marginal opening allows more plaque deposition, gingival sulcular fluid flow and bone degradation, resulting in microleakage, recurrent caries, periodontal disease, and a decline in prosthetic restoration longevity. (Shankar et al., 2020) Currently used restoration manufacturing techniques, including constructions manufactured through computer-aided design / computer-aided manufacturing system, may provide marginal clinically permissible fit. Although considerable progress has been made in reducing the issue of marginal leakage, it is important to find methods to reduce the interface distance between restoration and tooth. Even in the absence of chemical bonding, the production of hydrophobic composites can minimize or eliminate marginal leakages. (Fuks et al., 1990) While considerable progress has been made with the advent of composite restorative materials and related techniques, the issue of marginal leakage has been lessened but not resolved. The primary goal of future work, therefore, needs to be to avoid a void between the restoration and the tooth.

CONCLUSIONS

A fixed dental prosthesis success or failure to a great extent is influenced by the margin adaptation which is dictated by meticulously following the clinical and laboratory steps, choosing the best possible luting agents and prosthetic materials for meeting the purpose of the area of restoration, favours in minimizing the marginal gaps between the natural tooth margin and the restorations. It is mandatory to follow adequate protocols to safeguard the marginal integrity post fixed restoration treatments by the patient and also by clinician during further visits while performing routine oral hygiene procedures.

Conflict of interest

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