Introduction

Conventional complete dentures remain the primary source of esthetic and masticatory rehabilitation for patients with edentulism because of financial reasons, especially in developing countries.

Esthetics continues to be an important factor for denture success and patients satisfaction. Artificial teeth are a significant part of the overall esthetical outcome. They should have; good appearance resembling natural teeth as far as possible, color stability, stain resistance, wear resistance, good attachment to the denture base, to absorb some of the energy during function, and allow easy chair adjustment.

Acrylic resin and porcelain are the most commonly used denture teeth materials. The major disadvantages of acrylic teeth are; discoloration and rapid wear of posterior teeth surface which causes loss of vertical dimension of occlusion, loss of masticatory efficiency and loss of esthetics, thus having a short durability period and service life.

In general, denture teeth with high wear resistance are recommended, especially when opposed to natural teeth, crowns, fixed partial dentures, or restorations with ceramic occlusal surfaces.

Although porcelain teeth have higher wear resistance, they tend to transmit the impact of biting forces to the alveolar ridge with greater intensity than acrylic teeth causing more trauma and could result in accelerated bone loss due to their brittleness.

Improved denture teeth materials including high cross-linked acrylic resin teeth and composite resin teeth offer greater wear resistance

and aesthetic characteristics but they are susceptible to staining and have less wear resistance than ceramic teeth.

Recently, computer-aided design/computer-aided manufacturing (CAD/CAM) technology has been applied to the field of removable denture prosthodontics, and the use of ceramics in dentistry has increased. Zirconia is used to manufacture frameworks due to better mechanical properties; higher wear resistance, more resistance to fracture than other brittle dental ceramics and showed low wear of the enamel antagonist as well.

Technological improvements in design and manufacture led to the fabrication of monolithic zirconia teeth for the removable dental prostheses.

However, data concerning the use of monolithic zirconia as a denture teeth material is limited and further future researches are needed.

Review of Literature

I- Edentulism

The removal of all natural teeth results in an irreversible condition known as complete edentulism that may occur due to; progressive diseases such as dental caries and periodontal diseases, that cause tooth loss if not treated adequately, teeth may be missing also for congenital or acquired reasons, or because of trauma, infection, malignancies, failed endodontic treatments. [1-3]

However, economy, oral healthcare system, availability of dental services, dental awareness, cultural tradition, education and other psychosocial factors can potentially strongly influence the decision to remove all remaining teeth as a final clearance. [4-6]

Although preventive dentistry helps protecting teeth and the prevalence of complete tooth loss has declined over the last decade in the developed countries, edentulism remains a major disease worldwide due to the rapid increase in the elderly population.[5,7,8]

It is important to recognize that the extraction of teeth does not simply mean the loss of the visible crowns; teeth loss implies the loss of several orofacial structures. Such a pathological condition may elicit detrimental alterations in the residual bone, oral mucosa, tempromandibular joints, masticatory musculature, nerves, and receptors. [1,9-11]

A- Impact of edentulism on oral health:-

Bone needs stimulation to maintain its form and density; teeth transmit compressive and tensile forces to the bone. Bone loss is a progressive process following tooth extraction, which leads to a reduction in the height as well as the width of the residual alveolar bone that eventually results in unfavorable jaw anatomy. **(12-15)**

Continuous reduction in bone volume is regarded as a major oral disease that includes anatomical, metabolic, prosthetic and functional factors.**(16, 17)**

As a consequence of resorption of the premaxilla, the maxilla shifts upword and backward following the same direction as the loss of bone. While the pattern of mandibular bone loss starts from the inner surface that the mandible moves outward and downward. **(18)**

Impaired mastication; it is well known that bite force and electromyographic activity are considerably reduced and masticatory efficiency is decreased in edentulous patients. **(19)**

They have difficulty in chewing food with hard texture. As a result, research has consistently demonstrated that teeth loss has a negative impact on diet and food selection. **(20-22)**

Soft tissue consequences; as bone losses width then height, the attached gingiva gradually decreases. Decreased tissue regeneration is expected in the edentulous population, which can impair the protective function of the oral mucosa. **(23)**

A thin and atrophic mucosa lies over the advanced atrophic mandible makes it more difficult to withstand the masticatory load. The

mucosa gets impinged between the sharp ridge and the denture resulting in severe pain and discomfort to the patient or abrasion caused by overlying prosthesis.[24, 25] The tongue of edentulous patients often enlarges to accommodate the increased space after teeth loss. [25]

Edentulism can be accompanied by functional and sensory deficiencies of the oral mucosa, oral musculature, and the salivary glands.[26]

Facial esthetics is also compromised; the facial changes that naturally occur due to aging process can be accelerated by teeth loss. Apart from the obvious lack of teeth on opening the mouth, the loss of alveolar bone height and width results in a decreased vertical dimension and therefore, a decrease in the facial height. This leads to substantial changes in the soft-tissue profile; a decrease in horizontal labial angle at the corner of the lips and facial sagging giving the individual an aged look. [14,25]

The orbicularis oris and other facial musculature are supported by the alveolous and teeth, loss of teeth and resorption of the alveolar ridge result in facial collapse and thinning of the vermillion border of the lips due to poor lip support. Deepening of nasolabial groove and increase in the depth of other vertical lines in the upper lip with the bone loss. [25,27]

Occlusion evolves towards a pseudo-class III malocclusion. As a result, the chin rotates forward and the labiomenal angle disappears, creating a prognathic facial appearance. [25,28]

B- Impact of edentulism on TMJ:-

Being edentulous for a long span of time without denture act as a predisposing factor to temporomandibular joint dysfunction (TMD). [29]

The lack of teeth for long periods promotes a shift in the vertical and horizontal mandibular positions; as a result the position of the condyles in the mandibular fossae may also change. Change of the rest position due to the reduction of vertical dimension of occlusion is also considered to be one of the predisposing factors. The loss of natural teeth can cause psychological problems that increase emotional stress and may contribute to the development of TMD. [30]

Etiology of (TMD) is multifactorial and may involve changes in occlusion (posterior occlusal wear producing incisal interference in complete denture wearers), faulty prosthesis (reduced vertical dimension), and traumatic insult to TMJ. [31]

C- Impact of edentulism on the quality of life:-

The World Health Organization (WHO) has defined quality of life (QoL) as “an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns. [4]

The mouth is considered to be one of the focal points of the face, the smile plays a major role in how we perceive ourselves, as well as in the impressions we make on the people around us. Most orofacial functions are diminished in edentulous patients. Consequently, difficulty in accepting teeth loss is a common experience for edentulous patients. [32]

Thus, compromised oral function has a significant impact on the individual, affecting the quality of life and the general health of an individual is also compromised. It has been observed that psychosocial problems are the result of diminished attractive facial appearance, difficulties with speech and avoidance of social contacts were observed due to decreased self-esteem. [4,33,34]

Therefore, dental treatment should start early in the life of the patient. Function, psychology, and esthetics are primary reasons behind such an early approach. [35]

II- Treatment modalities of edentulous mandible:-

When prosthetic treatment is carried out in a patient with complete or partial edentulism, the treatment is expected to have a positive effect on oral health, oral function, and even quality of life. [36-39]

During the past century, the replacement of lost natural teeth could be performed by various types of treatment, including; the use of removable complete dentures, overdentures [37,40], implant supported fixed bridge and implant-supported overdenture, may be indicated for completely edentulous patients. [41]

The introduction of dental implants provides a more stable option for restoring patients who are partially and completely edentulous (IOD) Implant-supported prostheses can nowadays be considered a main option in restorative dentistry for edentulous persons, as it offers a substantial benefit from psycho-social, structural and functional points of view when compared to a conventional complete denture. [41-44]

However, treatment options for the edentulous patient also depend on the remaining bone quality and volume. Thus, dental implants may not

be a suitable solution for various economic and patient-related factors.[45,3] Therefore, when fixed replacement is contraindicated, removable prostheses became more elaborate. [3,7]

Worldwide, complete denture (CD) is considered to be an economic and easy treatment modality that provides a pleasing appearance, maintains normal speech and supplies adequate means for the mastication of food for edentulous patients who have anatomical, psychological, or financial restraints that contradict implant therapy. [2,46,47]

The Glossary of Prosthodontic Terms defines a complete denture as; a removable dental prosthesis that replaces the entire dentition and associated structures of the maxilla or mandible. [48]

Such prosthesis is composed of artificial teeth attached to a denture base. In turn, the denture base derives its support through contact with the oral tissues, teeth, or dental implants. [49] Restoring the edentulous patient comes with a variety of challenges for both the dentist and the patient, and patient's expectation plays a major role in directing the treatment rendered. Thus, treatment should be highly individualized according to the patient and the disease. [50]

III- Denture esthetics

Teeth have an important role in facial appearance, speech, and eating ability. Enhancement of facial beauty is one of the primary elective goals of patients seeking dental care. Hence the planned prosthesis should fulfill esthetic harmony, functional efficiency and structural balance with the rest of the dentofacial structures. [51]

The psychological importance of a pleasing dental appearance is clear and is often discussed in regards to denture success. [45,52,53]

Poor esthetics is one of the primary reasons for nonsuccess of maxillary dentures. [54]

Thus denture esthetics continues to be an important factor for patients' overall satisfaction. [55] Successful complete dentures require a blend of science and art, in addition to the clinician's experience to achieve a pleasing appearance and function. [56]

This artistry strives to soften the marks imposed upon the face by time and enables people to face their world with renewed enthusiasm and confidence. [57]

The growing demand for esthetic dentistry clearly demonstrates increased public awareness of the benefits of a pleasing smile and, as shown in recent studies, this interest is not limited to younger patients. [58,59]

In contrast to previous generations, today's middle-aged and older adults are much more likely to be concerned with maintaining a healthy and youthful dental image. Because of this emphasis on the esthetic aspects of treatment, selection of the denture teeth for their shape, size, color and material is an important phase of complete denture service. [59]

The dentist should be aware of the evolution of dental materials and conventional laboratory techniques that enables him to offer removable restorations with natural appearance. [53,60]

But restoring the appearance of an edentulous patient remains a challenge. [52]

To meet the esthetic needs of the denture patient, the denture teeth should look like the patient's natural teeth. [61]

The size, form and color of the teeth must be in harmony with surrounding oral and facial structures matching anatomic determinants of gender, age, and personality. [62- 64]

A- Selection of size and form of denture teeth:

It requires both artistic skill and scientific knowledge; [51]

- In the early part of 19th century most methods involved “hunt and peck” or “trial and error” until the patient and dental surgeon were satisfied with particular size of a tooth. [65]
- It is well understood that to look pleasing, the maxillary anterior teeth should be in proportion to facial morphology. When no pre-extraction records are available various anatomic measurements such as the intercommissural width, interalar width, bizygomatic width, sagittal cranial diameter, interpupillary distance have been proposed as guidelines for the selection of anterior teeth of complete dentures. [51,53]

It was claimed that the width of the maxillary central incisor exists in a ratio of 1:16 to that of the bizygo-matic width. [66]

However the clinician must be careful not to agree to perpetuate any existing condition that may prove harmful if incorporated into new dentures.

- Personal photographs showing the natural permanent teeth can be a valuable aid in tooth selection. [67]

Existing diastmas, anterior tooth alignment, and shade may be obvious in old photographs. However, many patients will bring in photographs that are decades old, and they must be reminded that the physical changes that have occurred over those decades make it impossible to match the esthetics of the natural dentition or dentures as seen in very old pictures. [67]

- Any old dentures can serve as a guide for both the patient's likes and dislikes. If the patient is satisfied with the size and shape of the teeth, these are usually the best choice for new dentures. [63,64]
- Although the size and shape of the residual ridges cannot actually determine a specific mold selection, they are important guides to overall size. [68,63,64]
- The frontal outline form and size of the face and lateral view of the patient's profile have been considered gross guides in tooth selection. [63,64]

When choosing artificial replacements in the absence of any other information, a large tooth mold is usually appropriate for those patients with a heavier skeletal make up, and vice versa. [52]

Three basic facial shapes have been described – square, ovoid and tapering – and corresponding tooth molds have been produced.[69]

To determine the facial profile, observe the relative straightness or curvature. The facial profile is determined by three points. The forehead, the base of the nose and the prominent point of the chin; Straight—three points are in line, Curved—points of the forehead or chin are recessive. Based on these three points the profile can be straight, convex or concave. **(70)**

Curved facial features are associated with feminity, and square features are associated with masculinity. Since there is harmony between tooth form and face form, it follows that tooth of female are ovoid or tapering than square. **(69)**

However, there was no scientific basis for any of these proposals. Nevertheless these guidelines are worth bearing in mind on purely aesthetic grounds when selecting denture teeth, as their application can increase the chance of creating dentures which harmonize with the patient's facial appearance. **(53,68)**

B- Shade selection:

Shade selection for denture teeth is usually made with a shade guide, which consists of a number of tooth-shaped tabs with varied degrees of hue, value, and chroma, and sometimes characterization. The tabs represent the range of shades available for denture teeth.**(64)**

It is very difficult for some patients because it is not a scientific procedure. The following aids are helpful: **(63,64)**

- The shade of teeth on any previous dentures is often the shade of choice for patients.

- Teeth tend to darken over time, so it is appropriate to choose a shade of denture tooth which is in keeping with the patient's age.
- Denture teeth were selected to harmonize between the color of the skin, hair, and eyes.
- Make use of any pre-extraction shade determination.
- Recently extracted teeth may be useful, but caution is advised Extracted teeth tend to lighten in shade with drying or storage in disinfectant solutions.
- Listen to the patient's desires. Many patients have the misconception that their natural teeth were "pure white," so the clinician must be careful when beginning the shade selection. Showing the patient the entire shade guide is not recommended—at least until an initial shade range is selected. This is because many patients will immediately focus on the lightest shade available regardless of skin complexion and other considerations.

C- Denture teeth materials:

To fabricate a removable dental prosthesis, dentist must select denture teeth with superior physical and mechanical properties, due to their significant role in the overall esthetical outcome. **(71)**

The artificial denture teeth should mimic most of the anatomical and esthetical details. They should be non-toxic, non-reactive with oral soft tissues, inexpensive, and stain resistant; color stability, the property of a material to retain its color over a period of time and in a specified environment, is an important physical property which plays a significant role in the selection of denture teeth. **(40,72)**

In addition, dental prostheses should be fabricated with a goal of reducing the amount of force to the residual ridges. Choosing appropriate denture tooth materials is one of the crucial steps in prostheses fabrication that may reduce pressure and avoid stress concentration to the supporting tissues. Artificial denture teeth composed of different materials showed different amounts and patterns of pressure distribution. [73]

Furthermore, artificial denture teeth should provide good attachment to the denture base [74], absorb some of the energy during function, allow easy chair adjustment and one of the most important physical properties is wear resistance. In case of antagonistic enamel, the denture teeth should have a wear resistance similar to that of enamel and low abrasiveness against enamel. [75]

Prosthetic teeth with less wear increases the longevity of the denture. In general, denture teeth with high wear resistance are recommended, especially when opposed to natural teeth, crowns, fixed partial dentures, or restorations with ceramic occlusal surfaces. [76]

Currently there are various types of commercial artificial denture teeth available, such as conventional acrylic resin teeth, porcelain teeth, improved acrylic, resin teeth including; high cross-linked acrylic resin teeth, PEEK and composite resin teeth for denture fabrication. However, neither type completely accomplishes the requirements for an ideal prosthetic tooth. [40,77,78]

1- Acrylic teeth:

They were introduced in the 1930s. They are the most widely used denture teeth; [79,80]

Advantages of acrylic teeth:

Acrylic teeth are made of polymethyl methacrylate resin (PMMA) which is; highly elastic, have good chemical bond with the denture base, light in weight, better absorption of masticatory forces, high flexural impact strength therefore they are less damaging to the tissues.

Moreover, they can be easily ground, recontoured and polished without compromising their properties, have a desirable natural feel, less prone to fracture, do not abrade opposing natural or artificial tooth, lack of clicking sound, reduced chipping, ease of handling and have a natural appearance. [40,80-83]

Disadvantages of acrylic teeth:

They have also some undesirable properties, such as low thermal conductivity, surface microporosity so they tend to become gradually discolored by pigments contained in drinks with long-term use, causing an aesthetic failure. [83,84] Moreover, Inferior wear resistance of acrylic resin artificial teeth is a significant limitation for complete denture therapy. Wearing away of denture teeth will compromise both the function and the aesthetics of the denture. [72,81,85-87]

Wear affects the health of the stomatognathic system, resulting in excessive reduction in structure, loss of posterior tooth support, loss of vertical dimension of occlusion, loss of masticatory efficiency, alterations in the functional path of masticatory movement, fatigue of masticatory muscles, improper occlusal relationship which may end up in increased horizontal stresses, and loss of esthetics. [72,88]

Approaches to slow the process of wear include altering the occlusal surface of acrylic resin teeth with amalgam or gold. [89]