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The Health of Peri-implant Tissues around one and two stage dental implants – A clinical study –

Submitted in fulfilment of the requirements
for the Degree of

Master of Science in Dentistry (MSc)

Candidate:

IMRAN ALI YOUSEF BDS (Istanbul)

Supervisor:
Professor Ibrahim Ghandour

December-2002

DEDICATION

To those people who implanted themselves in the holy land so bravely for our nation to live in honour.

And to the spirit of my beloved daughter "Batoul". You will live in our minds and hearts for ever.

Imran

ACKNOWLEDGEMENTS

My sincere thanks are due to those named below:

My supervisor, Professor Ibrahim A. Ghandour for his advice and encouragement during the preparation of this work. I shall always be indebted to Professor Ghandour for the help and support he provided throughout my study.

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At last but not least, my thanks are due to my wife and my family whom without their patience and support, this work wouldn't have come to this finale.

Imran Ali Yousef

December 2002.

DECLARATION

The accompanying thesis:

"The Health of Peri-implant Tissues around one and two stage dental implants – A clinical study"

is submitted for the degree of Master of Science to the Faculty of Dentistry at the University of Khartoum.

I certify that the contents of this dissertation are based solely upon my own independent work, except where acknowledged in the text or by reference, and have not been submitted previously in part or in full for the candidature of a degree in any other university or examining body.

All the work and ideas are original except where acknowledged.

December 2002.

Imran Ali Yousef,
Department of Oral Rehabilitation
Faculty of Dentistry, University of Khartoum.

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Summery

The health of the peri-implant tissues is essential for the long term success of the dental implant. This study aims to compare the tissue health around dental implants and natural teeth. Also it compares tissue health around one and two stage dental implants.

Records of all patients treated by implants at The Arab Dental Centre in Amman, Jordan were screened. This screening produced a sample of 36 medically healthy patients (18 males and 18 females) with an age range of 17-68 years. The patients in the sample had their implants installed at least one year earlier and had contralateral natural teeth to the installed implants.

Following selection, all patients were examined. The plaque index (Silness and Löe), gingival index (Löe and Silness) and probing depths were recorded around the installed implants and the natural teeth in the contralateral side in the same patient. The appropriate statistical analysis tests (e.g. ANOVA and others) have been used to analyse the data.

The results of this study indicate that females and younger age groups have healthier tissues around their implants when compared to males and older patients respectively.

It appears that there are lower plaque accumulations, lower levels of gingival inflammation and lower levels of periodontal disease (probing pocket depths) around dental implants when compared to natural teeth within the same subject.

Moreover, the results of the study indicate that the recorded data around one stage dental implants are significantly better than those around two stage implants.

Chapter 1

Introduction and Literature review

Introduction:

Although treatment with dental implantation has proved to be predictable and highly successful over long periods of time, there remain a number of situations where this modality of treatment becomes complex or fails and requires the carrying out of certain corrective procedures.

Many criteria for success have been suggested, however, one of the widely accepted was defined by Albrektsson et al (1), which includes the following:

- an individual, unattached implant is immobile when tested clinically;
- absence of peri-implant radiolucency;
- vertical bone loss should be less than 0.2 mm annually after the first year;
- absence of persistent and/or irreversible signs and symptoms such as pain, infections, neuropathies, para-esthesia, or violation of the mandibular canal;
- as a minimum criterion for success and in the context of the above, there should be success rate of 85%, at the end of a five year observation period and 80% at the end of a ten-year period.

Whereas early failures of dental implant will present as pain, infection or loss of sensation, late failures will present as peri-implant radiolucency or continuous resorption of the bone around the installed fixture (2). Resorption takes place rapidly during the first year and then at a slower rate. If this continues it may demoralize the support of the implant and result in its failure and loss. Peri-implant tissue health is mandatory for the success of the dental implant. Plaque accumulations are considered the most important single factor in the initiation of gingivitis around natural teeth and dental implants. If left untreated, the condition might result in the resorption of the underlying bone, a

condition that is termed periodontitis around natural teeth and peri-implantitis around dental implants.

These facts and others indicate that reasonable periodontal health is important prior to the placement of implants. In addition to that the health of peri-implant tissues is important for the success of implant therapy and its prognosis. However, few studies were carried out to study the health of peri-implant tissues compared to periodontal health around natural teeth in humans. On the other hand very few studies where conducted to examine the health of peri-implant tissues in relation to the timing of the implant therapy.

1.1. The role of implantology in modern dentistry:

The rate of tooth loss remains high in the developing countries. On the other hand a vast improvement has been achieved in the western world throughout the last twenty years. This is linked to the public awareness of the importance of the different oral hygiene measures in combating caries and periodontal diseases. Water fluoridation, periodic dental checkups and the topical application of fluoride have also resulted in a significant reduction to the incidence of dental caries and have decreased the rate of tooth loss.

However, dental implantation as a treatment option is not nowadays confined to the western societies and countries. This modality of treatment has been made now widely available for patients in most of the developing countries and is gradually gaining more popularity among patients regardless of the level of awareness and motivation they have about their dentition.

Dental implants can now be used for the replacement of any single or multiple missing teeth. They can be used to support a fixed bridge; a removable partial or complete denture or a single missing tooth. Besides, they

have also a role in orthodontics as some practitioners have utilized them to obtain added anchorage for orthodontic tooth movement.

1.2. History of dental implants:

Dental implantation itself is not new, implanted alloplastic or nonorganic materials, have been discovered dating back to the Mayas several thousand years ago. These can be considered the earliest endosseous alloplastic implants.

Evidence indicates that ancient dentists used to replace lost teeth with alloplastic or homologous materials such as human and animal teeth, carved bone, and fragments of ivory, pearl and other materials. The essential aim of those replacements was to meet the esthetic needs rather than to improve the functionall disability. Various dental implant designs were discovered in the Middle East, Western Europe, Asia, and Central and South America. One of the best-known tooth replacements was found in Honduran where one of the lower lateral incisors was a black stone. The stone is believed to have been in place for a long time, because it was covered with nearly the same amount of dental calculus as the adjacent natural teeth (3).

About 1,000 years ago, the Spaniard Alabucasim recommended the replacement of teeth by transplantation. Several hundred years ago in France and England, it was fashionable to replace lost teeth with transplanted teeth obtained from young people who were paid for their extracted teeth. However, the transplantation failure rate with these xenografts was very high, and it was noted that highly infectious diseases such as tuberculosis and syphilis were often transferred at the same time (4, 5).

By the end of the 19th century, biological systems of alloplastic materials became more popular such as rubber, gold, porcelain or ivory. Those materials were often shaped to resemble tooth roots and surgically placed in artificially created sockets. A single tooth or denture was anchored to those alloplastic roots with screws. The number of failures and infections with this procedure was very high, and the process was discontinued.

Greenfield reported the use of iridio-platinum implants. He constructed a fixture of iridio-platinum wires soldered together with 24-carat gold to form a latticed cylinder. The abutment was a disc cast on top of the fixture in 22-carat gold and which had a slot for the attachment of the artificial tooth which was usually attached six weeks after implantation. The same author stated that his first trials of implantation were met with little success, and attributed that to the improper instrumentation and imprecision of the implant bed to match the size of the implant. Greenfield designed cutting burs to match the shape of his implants and stated that these implants were firm in their beds with no apparent movement and with no evidence of radiolucency around the fixtures when these were examined radiographically. With his meticulous surgical procedure and carefully designed implants, Greenfield may have achieved osseointegration at that early date (6).

During the 1930s, modern dental implantology developed with the emergence of three strategies: the endosteal root-form or cylindrical implant; the endosteal blade implant and the subperiosteal implant, each with both detachable and non-detachable head variants. These three strategies are the most commonly used, but several other implant designs such as: the ramus frame; mandibular staple and intramucosal inserts have also been used.

The second half of the twentieth century is characterized by more attention being paid to dental implantation. Considerable research effort has been directed to determine the effect of the different variables on the success of dental implants and many implant designs have been introduced.

1.3. Endosteal root-form implants

Endosteal implant procedures are techniques that lead to the anchoring of implants into the maxilla or mandible, whereby the implant body generally penetrates the cortical bony plate and reside within the cancellous bone of the jaw. Strock first attempted to change the shape of the dental implant from that of a root like to an implant with a threaded body resembling a wood screw. He constructed the implant from an alloy of chromium-cobalt-molybdenum (Vitallium) alloy, recognizing the need for implants to be biologically compatible. He found that when certain metals get in contact with tissue fluids, produce a galvanic action; this ultimately corrodes the metal structure. Vitallium was the only metal used at that time that produced no electrolytic activity when implanted into biological tissues (7). Among Strock's implants are the earliest documented long-term endosteal dental implants. Furthermore, he appreciated the need to direct axial forces and minimizes nonaxial forces to the dental implant (7).

Figure 1: A root form dental implant.

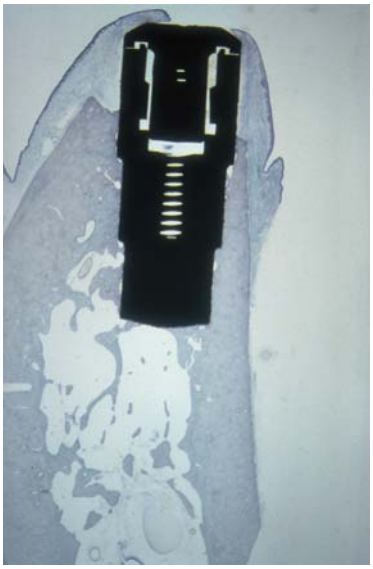
1.3.1. The concept of osseointegration

In 1952, Per-Ingver Brånemark (8) an innovative orthopedic surgeon embarked on a series of basic pioneering studies unrelated to implants that could define the conditions necessary for regeneration of highly differentiated tissue after injury. Using optical chambers made of titanium to follow the repair of bone, Brånemark reported that a direct functional and structural bond had occurred between organized vital bone and the inanimate alloplastic material comprising the chamber - a process called osseointegration. He suggested that osseointegration occurred only with the titanium chamber and not with chambers made of other materials (8).

On the basis of this interaction, he broadened his focus to include the need in dental implantation for the strength and durability that came from osseointegration. He designed and executed a series of investigations using titanium shaped into cylindrical threaded endosteal implant for replacing a single tooth or anchoring fixed bridgework.

By 1965, Brånemark's implants were placed in the first group of patients. They consisted of a cylindrical screw-type implant made of pure titanium and induced osseointegration between the titanium metal and the peri-implant bone. Degradation of the titanium in vivo is minimal because of a protective oxide layer that develops between the titanium implant and the bone (8).

Figure 2: Osseointegration: the adaptation of the bone onto the surface of the implant under a light microscopic level.



1.3.2. Titanium as an implant material

Many materials have been tested for their suitability to be implanted in the living tissues; these include: porcelain; platinum; vanadium; cobalt-chromium; zirconium …etc. However, titanium (Ti) has been found to be the ideal material for endosseous implant manufacturing (8).

Titanium is biocompatible material and has sufficient strength that makes it suitable for implantation in the human body. It has low density (4.51 gm/cm^3), and high corrosion resistance, non-magnetic activity and it is a bad heat

conductor. The properties of the material can be enhanced by dipping the implant in a bath of titanium nitride or by adding some elements to it to yield a harder material suitable for the construction of drills, screws and implants. There are no documented cases of titanium allergies. The following table displays some of the properties of the metal:

Atomic number	22
Atomic weight	47.8
Boiling point	3260
Melting point	1688 C
Density	4.51gr/cm^3

Commercial titanium is classified into 4 grades. Titanium alaminium vanadium alloy can be considered the fifth grade. The following table explains this classification:

Type	**Ti%**	**N%**	**C%**	**H%**	**Fe%**	**O%**	**Al%**	**V%**	**Breaking load MPa**
Grade 1	99	0.05	0.08	0.01	0.20	0.12	0	0	350
Grade 2	99	0.05	0.08	0.01	0.25	0.18	0	0	470
Grade 3	99	0.05	0.10	0.01	0.30	0.25	0	0	560
Grade 4	99	0.05	0.10	0.01	0.35	0.35	0	0	640
Grade 5 (Ti alloy)	89	0.05	0.08	0.012	0.25	0.13	5.5-6.5	3.5-4.5	800-1000

Titanium in itself is a very reactive substance that reacts immediately when exposed to air forming a layer of a very inert and stable material: titanium oxide. It is the titanium oxide that gives the metal its favorable characteristics when implanted in the living tissues.

1.3.3. Design variations of the root form dental implants

Root form dental implants have many shapes and designs. They can be cylindrical; threaded (either horizontally or helically); stepped or conical. Dentall implants on the market frequently have some additional characteristics on their surfaces e.g. grooves; fissures or they might be vented.

Figure 3: Different designs of the root form dental implants

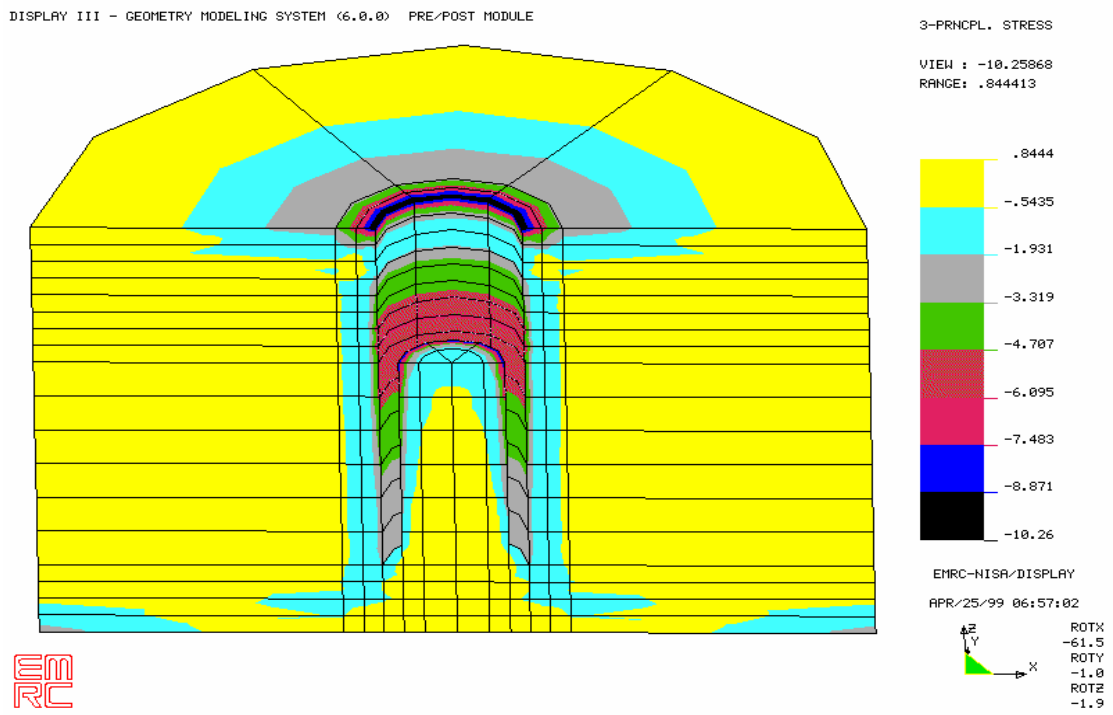
1.3.3.1. Implant design and stress distribution in bone

As some authorities claim most of the load is transferred through the neck region of the dental implant (Figure 4) resulting in various degrees of crestal bone resorption. This led to the appearance of designs of implants with necks wider than the rest of the fixture to allow for less stress concentrations at

that vulnerable region. For the same reason, stress breaking designs have been introduced to allow for a better stress distribution (9).

Stepped implants are claimed to provide for a better distribution of the occlusal load than other designs as this structure of the implant will reduce shear stresses between the implant surfaces and the surrounding bone (10).

Figure 4: Finite element model displaying stresses in the bone bed of a dental implant.



1.3.3.2. Design variations and the primary stability

As primary stability of the dental implant is a very important factor in implant success, some designs were introduced to allow for better primary stability after installation in bone. Some manufacturers have designed their fixtures to be divided into a number of vertical components and a middle component that fits inside a hole in the center of the fixture after implantation.

This will cause the vertical parts of the fixture to expand compressing against the bone, significantly enhancing primary stability. Others have designed their implants to accommodate a side approaching horizontal pin that will lock into the implant body enhancing primary stability.

Some authorities believe that primary stability remains very important and should always be provided for the implant regardless of the quality of the bone. However, to avoid bone necrosis in the implant bed when the bone is very hard (type 1), the implant installed should be of fine threads.

Some implants are designed with no helical screws. Such implants can only be retained within the socket with sufficient primary stability by tapping over the implant with a suitable hummer over an implant-seating instrument. Clinicians prefer to use these implants when the bone of the jaw is of an inferior quality (very soft). Moreover, these implants are preferred when the bone is very hard and solid (type 1) as there is a risk of fracturing the bone when screwing-in a helically threaded implant.

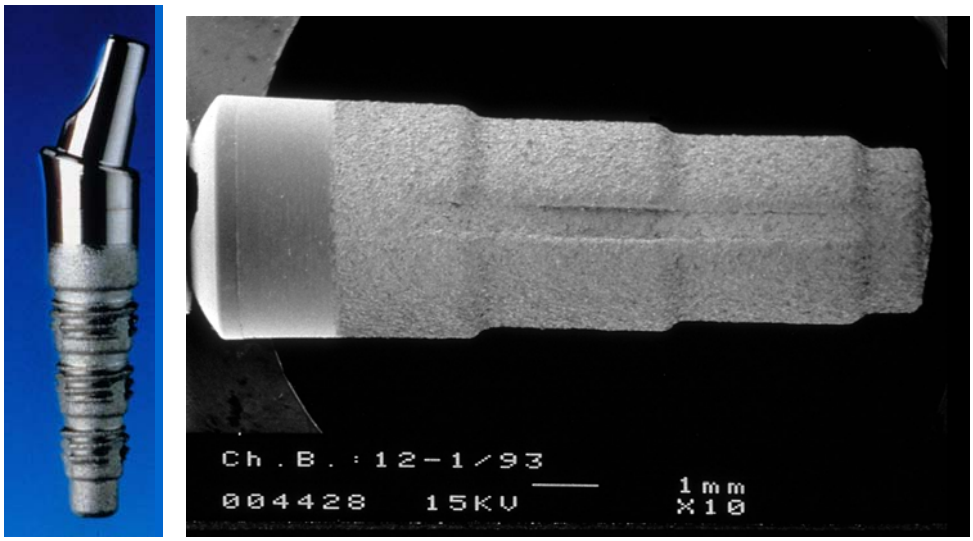
Threaded implants also vary in the shape and design of the threads. Variations can be introduced by varying the fillet angle of the thread and the vertical distance between successive threads. These variations will have an effect on the overall surface area of the fixture and the bulk of bone directly supporting a load transferring thread.

The bottom of the fixture might be of different designs. Some manufacturers make it flat, while others advocate the rounded base design, as this design will lessen the chances of side perforations and trauma to the adjacent anatomic structures. The rounded base design however, is closer to the shape of the natural root apex.

1.3.3.3. Design features necessary for the health of peri-implant tissue

Regardless of the texture of the implant surface, the neck region of the dental implant should always be highly polished to allow for better attachment of the soft tissues and to avoid bacterial colonization, as the rough surface is a good harbor for microorganisms. This connection of the soft tissue to this highly polished margin of the implant will form a barrier against bacterial transmission from the oral cavity to the implant bed.

Figure 5: The highly polished surfaces of the abutment are also continuous with a highly polished coronal portion of the implant.



In a study carried out to examine the composition of the connective tissue that forms an attachment to a dental implant (11). Six beagle dogs were used. All mandibular premolars were extracted. After 3 months of healing, 6 Astra fixtures -3 in each side of the mandible- were installed. After another 3 months of healing, abutment connection was performed and a plaque control program was initiated. The animals were sacrificed and perfused with a fixative

through the carotid arteries. At each implantation site, the implant and the soft and hard peri-implant tissues, were dissected, decalcified in EDTA and further processed using a "fracture technique". The specimens were subsequently embedded in EPON, cut with the microtome set at 3 micron and the sections stained in PAS and toluidine blue. From the EPON-embedded blocks, ultra-thin sections were cut and electron micrographs were prepared. The detailed histologic and morphometrical examinations were restricted to a 200 micron wide zone of connective tissue interposed between the apical border of the junctional epithelium and the bone tissue. In the analysis, this zone was further subdivided into 2 different units; (i) one central, 40 micron wide unit (zone A) located immediately next to the implant surface, and (ii) one lateral, 160 micron wide unit (zone B) that was continuous with the central unit. The implant surface apical to the junctional epithelium and coronal to the crest of the bone appeared to be in direct contact with a connective tissue. Zone A of this connective tissue was characterized by (i) the absence of blood vessels and (ii) abundance of fibroblasts that were interposed between thin collagen fibers. The more lateral zone B contained comparatively fewer fibroblasts, but more collagen fibers and blood vessels. There are reasons to assume that the fibroblast rich barrier tissue next to the titanium surface plays a role in the maintenance of a proper seal between the oral environment and the peri-implant bone.

A similar study (12) examined bone and soft tissue integration to titanium implants with different surface topography in the dog. The histometric measurements performed revealed that the peri-implant soft tissues and the marginal level of bone-to-implant contact were similar for the different implantation sites. In the ground sections, bone-to-implant contact (BIC%) and

bone density assessments were made in 2 different zones. Zone I represented the contact area measured from the marginal level of bone-to-implant contact to a position 4 mm above the apex of the implant, and zone II represented the apical 4 mm of the implant. The different implantation sites represented different BIC% that ranged from 56.1% in zone II and 58.1% in zones I + II in one of the implantation sites to 76.7% and 72.0% for zone II and zones I + II respectively around the zones of the implants.

Another study (13) measured in beagle dogs the dimension of the peri-implant mucosa. The objective of their study was to determine the dimension of the mucosal-implant attachment at sites with insufficient width of the ridge mucosa. Five beagle dogs were used. On the right or left side of the mandible, abutment connection was performed according to the Branemark System (control side). On the contralateral side (test side), an incision not extending through the periosteum was made at the crest of the ridge. The soft tissue was dissected and a critical amount of connective tissue on the inside of the flap was excised. The periosteum was subsequently incised, abutment connection performed, and the trimmed flaps sutured. The sutures were removed after 10 days. After a 6-month period of plaque control, the animals were sacrificed, biopsies sampled and processed for light microscopy. The results of that study showed that the length of the junctional epithelium varied within a rather narrow range; 2.1 mm (control side) and 2.0 mm (test side). The height of the suprabony connective tissue in this model varied between 1.3±0.3 mm (test side) and 1.8±0.4 mm (control side). At sites where the ridge mucosa prior to abutment connection was made thin (≤ 2 mm), wound healing consistently included bone resorption. The authors concluded that, the results of their study

implied that a certain minimum width of the peri-implant mucosa may be required, and that bone resorption may take place to allow a stable soft tissue attachment to form.

1.3.4. Surface characteristics

The surface characteristics of dental implants are another important feature that has interested both clinicians and researchers. Some implants have no surface coating and its titanium surfaces are left up as machined. However, some authorities advocate the use of a coating of a biological material that will facilitate osseointegration and provide more surface area for the bone to attachment. Rough implant surfaces are claimed to enhance the secretion of more tissue growth factors stimulating cellular activity in the surrounding bone structure. Some authorities (14) suggested that incorporation of microscopic irregularities into the implant surface provides a large surface contact area for tissue growth and reduces the magnitude of stress transmitted to the supporting tissues.

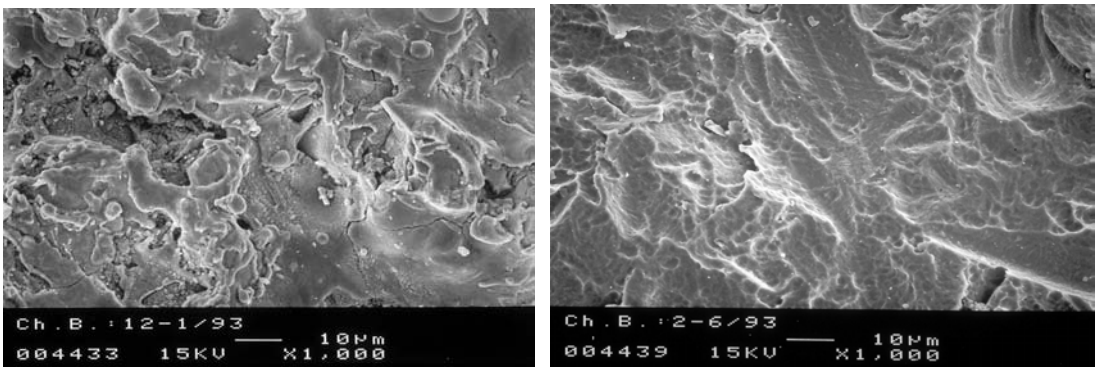
Some implants are coated with ‘titanium plasma spray material’ which can be achieved by spraying titanium powder through a stream of argon gas onto the surface of the implant passing through an electric arc that will raise the temperature of the titanium particles up to 20000 C.

Others are coated with hydroxyapatite or aluminum oxide that forms a porous material onto the surface of the implant. The problem with these coatings is the detachment from the surface of the implant that can take place upon loading. Moreover, there are indications that the body can resorb these materials.

The surface of the implant can still be treated to yield a porous surface that will stimulate tissue growth without the unfavorable outcome of the above-mentioned ceramic coatings. Some of these surface treatment techniques include sand blasting; acid etching and the treatment of the surface of the implant with laser.

It has been found that the surface treatment of the dental implant will influence more hard tissue growth around the surface of the implant. It is claimed that with acid etching followed by sand blasting, the implant can be loaded just six weeks after implantation.

Figure 6: The titanium plasma spray material to the left and the SLA surface to the right.

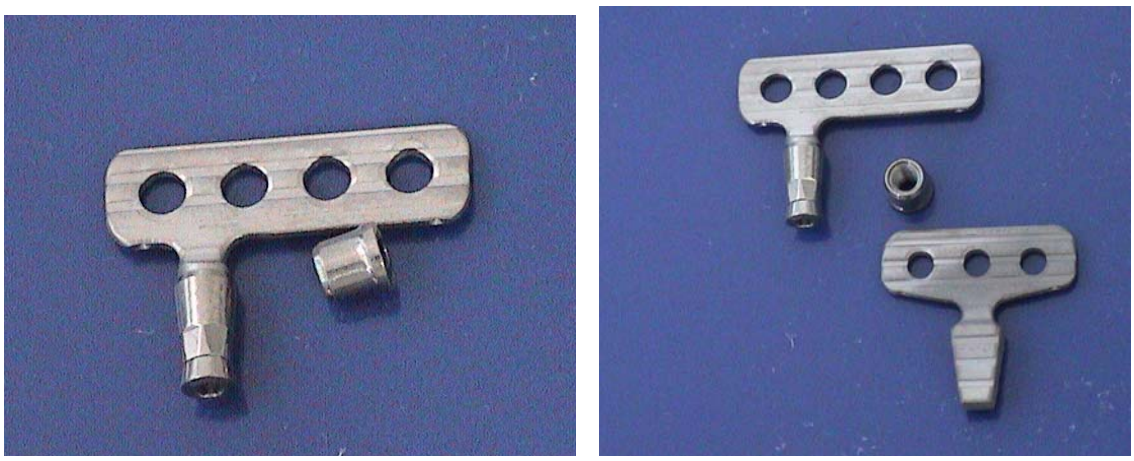


1.4. Endosteal blade implants

In 1968, a flat titanium endosteal blade implant was introduced (15), which often serves as a means of using the narrow and/or shallow areas of remaining alveolar bone where dimensions do not permit the use of the cylindrical or root-shaped implants. These implants primarily form a connective-

tissue interface, a process called fibro-osseous integration, a process in which a connective tissue forming around the implant takes the form of collagenous fibers that are interposed between the implant and the bone and orientated parallel to the dental implant surface (15).

Figure 7: Examples of the blade vent implants.



1.5. Subperiosteal implants

The third type of dental implants is the subperiosteal, or on-the-bone implant such as the pterygoid frame subperiosteal implant. It incorporates a rigid, plate-like element and is often used for areas without adequate bone for cylindrical endosteal implants.

1.6. Factors influencing implant success

Clinically successful dental implantation requires a collaborative approach integration of the expertise and clinical judgment of oral and maxillofacial surgeons, periodontists, endodontists, prosthodontists, general dentists and dental hygienists as well as the patient. The long-term success of dental implants depends largely on the continued health of peri-implant soft and hard tissues. Failures in dental implantology are often traced to insufficient professional education and continuing education, insufficient experience by the treating dentist or dental team, poor selection of patients for specific procedures despite an extensive medical history, inadequate management of infectious microbes, insufficient prosthodontic superstructures, and inappropriate implant selection and/or material failures.

Failures can also occur if improper instruments have been used e.g.: improper hand piece that does not produce the appropriate speed and torque or the use of blunt or old cutting burs. Also badly suturing the surgical wound or the implantation over a pathology e.g. remnants of the granulation tissue or a cyst; the violation of anatomic structures like the mandibular canal or the maxillary sinus or the nasal cavity.

Causes of failure can be due to the application of excessive drill speeds or the drilling with excessive pressure or the operation in septic conditions. Also the use of improper implants for the available bone quantity and quality can result in failure. The premature loading of the implant before the conclusion of the osseointegration process would result in the formation of a granulation

soft tissue encapsulating the fixture. However, the immediate loading of implants is nowadays thought to be safe if there have been sufficient primary stability for the implant. The use of improper abutment size or angulation. The non homogenous non optimized occlusal scheme would result in overloading of the implant. And very important are the infections in the implant bed that can be detrimental to the success of the procedure.

The team approach to the treatment with dental implants will provide the necessary expertise to carry out this modality of treatment.

Figure 8: Radiolucent areas around failing implants.

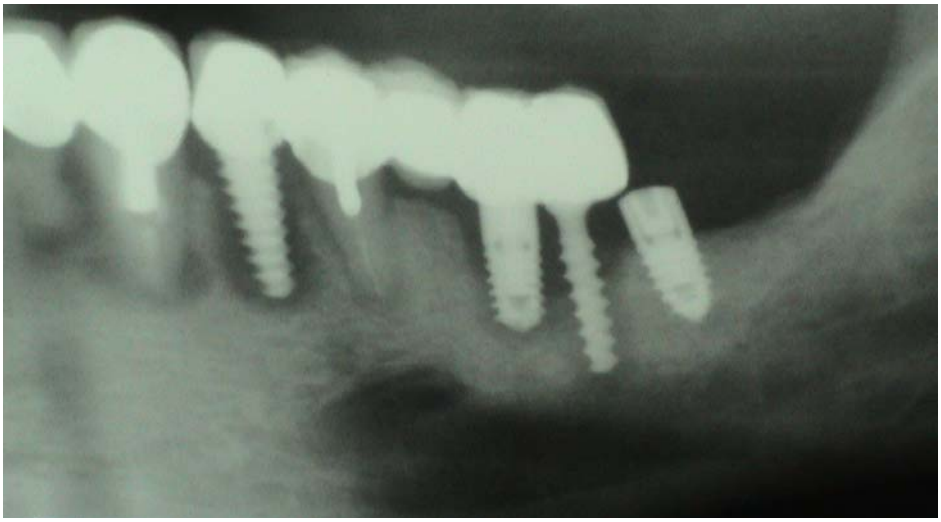
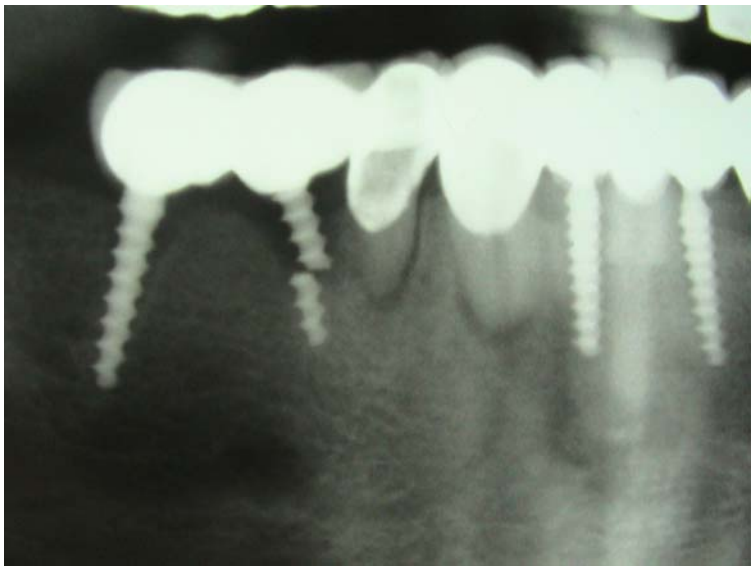


Figure 9: A broken implant under a fixed bridge.



1.7. Patient selection

Nowadays, as life expectations are increasing in many of the countries around the globe, more edentulous elderly people are encountered who are 65 years of age and older seeking implant treatment. These people often have medically compromising conditions including, cardiovascular diseases; osteoporosis; osteoarthritis; diabetes; the long-term use of medications such as corticosteroids, immunosuppressants, non-steroidal anti-inflammatory drugs and antibiotics; and hematological disorders such as anemia, immunosuppression and hemorrhagic diathesis. In addition, in considering patients for implant therapy, the clinician must be aware of other less prevalent osseous metabolic disturbances, poor general health, and collagen and related connective-tissue disorders such as scleroderma, Sjögren's syndrome and rheumatoid arthritis. The high rate of bacteremia, which exists in patients with a heart valve prosthesis or a history of endocarditis, also must be taken into

account. Clearly, patient selection is of paramount importance when dental implants are being considered.

1.8. Implantation techniques

Brånemark's implantation methods (8), for example, have undergone minimal modifications during 25 years of clinical application. The procedure has been studied for durability and survival over time. Brånemark's implant procedure is a two-stage technique and requires two surgical operations. The first implant placement is followed by a healing phase without loading (three months in the mandible, six months in the maxilla). The second stage involves uncovering the implant and adapting the abutment, followed by initiating the prosthetic phase of treatment when soft-tissue healing is complete. The implant body has an internal thread that receives the cover screw during healing; after being uncovered, it receives the central screw to affix the abutment. A gold cylinder is screwed onto the abutment and becomes part of the prosthesis. The gold cylinder and prosthesis are secured to each other by means of an occlusal screw, to create a unit that can be removed by a prosthodontist (8).

Single-stage, single-body implants require only one surgical procedure, during which the fixture is inserted and the prosthetic pole extends into the mouth immediately. An intermediate type of implant requires only one step because the healing occurs with a transgingival component in place. In these procedures, the biggest problem is stability. The requirements for primary postoperative stability are easier to achieve in the two-stage system, in which the implants heal beneath a mucosal covering.

Recent research (16) indicate that immediate placement of implants into extraction sockets is a safe and predictable procedure if certain guidelines are

followed. The two common difficulties associated with implantation in extraction sockets are: insufficient available bone for ideal implant placement and, prolonged treatment time (17).

1.9. The effect of the implant installation on the health of the peri-implant tissues and the role of bacterial plaque

In a research work (18) it has been stated that bacterial plaque accumulation on abutments or implant surfaces induces an inflammatory reaction in the gingiva/alveolar mucosa just as around teeth. The longevity of oral implants can be jeopardized by either peri-implantitis and/or an occlusal overload. In the partially edentulous patient in whom pockets around teeth act as a reservoir for the colonization of the bacterial plaque around implants, the risk for inflammatory reactions of the peri-implant soft tissues seems especially more plausible than in the fully edentulous patient. This is especially true for implants with a very rough surface (e.g., plasma-sprayed), because of the positive relationship between surface roughness and supra- as well as subgingival plaque formation. Several medium-term (from 5 to 10 years) clinical studies support this hypothesis, through the observation of ongoing bone loss and subsequent decreasing success/survival percentages. Moreover, the authors also stated that occlusal overload increases the risk for microfractures at the implant-bone interface in two-stage implants, which can result in significant marginal bone loss and even failure. There is ample evidence that occlusal factors are related to marginal angular defects around two-stage implants (18).

Figure 10: Calculus accumulations onto parts of the superstructure in a patient with bad oral hygiene.

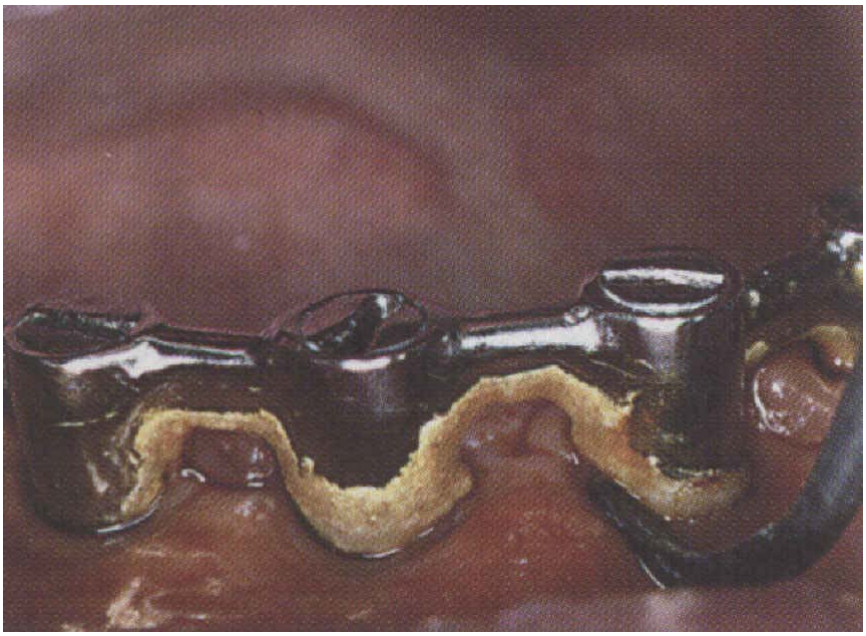
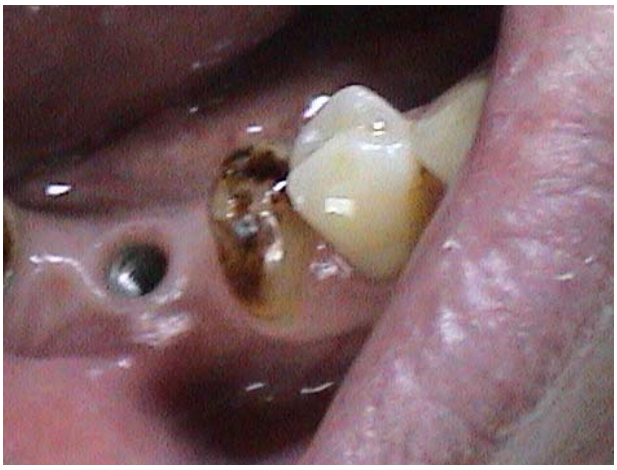


Figure 11: A healthy gingiva around a dental implant



There is evidence that sonic brushing is an effective means of dental implant maintenance (19).

A study (20) compared the marginal peri-implant hard and soft tissues around different implant systems in dogs. The implant systems in that study were submerged (the Astra Tech Implants Dental System and the Branemark system) and non-submerged (ITI) dental implant systems. Following a healing period of 3 months, abutment connection was carried out in the 2-stage systems. A 6-month period of plaque control was initiated. The animals were sacrificed and biopsies representing each important region dissected. The mucosal barrier that formed to the titanium surface following 1-stage and 2-stage implant installations comprised an epithelial and a connective tissue component, which for those 3 systems studied, had similar dimensions and composition. The amount of lamellar bone contained in the peri-implant region close to the fixture part of the 3-implant systems was almost identical. It is suggested that the geometry of the titanium implant seems to be of limited importance.

Another study (21) analyzed the composition of plaque associated lesions in the gingiva and the peri-implant mucosa in 20 partially edentulous patients (12 female and 8 male, 30-60 years of age) who volunteered to participate in the study. All patients had been treated for moderate to advanced periodontal disease. Edentulous regions had been restored with implants. The restorative therapy had been completed 6-24 months prior to soft tissue biopsy. Samples of gingival tissue (GM) and periimplant mucosa (PIM) from an "interproximal surface" of one tooth site and one implant site of the same jaw were harvested. One portion of the biopsy was embedded in EPON, stained in

PAS and toluidine blue and used for histometric and morphometric analyses. The 2nd portion of the biopsy was snap frozen in liquid nitrogen. 15 sections, about 5 microns thick, were prepared in a cryostat and used for immune histochemical staining. The analysis of the sections included determination of the size of the lesions as well as assessments of various cells and cell markers. In all samples of both PIM and GM discrete infiltrates of inflammatory cells (ICT) were found in the connective tissue lateral to the junctional epithelium. The ICT of PIM occupied on the average 0.17±0.14 mm^2 of the soft tissue, while the corresponding lesion in GM occupied an area that was 0.25 mm2±0.21 mm^2 large. The density of CD19 positive cells was 7 times higher in GM than in PIM (3.7 versus 0.5) while the densities of CD3 positive cells were 7.5 (GM) and 4.7 (PIM) respectively. The density of polymorphonuclear elastase positive cells was about 3 times higher in GM than in PIM (3.7 versus 1.2). Care must be exercised when these differences are interpreted. It is possible that a prolonged exposure of the implant site to the oral environment may induce both qualitative and quantitative changes of the infiltrate in PIM.

Another study (22) investigated the effect on the marginal peri-implant tissues following repeated abutment removal and subsequent reconnection. Five beagle dogs were used. The findings indicate that the disconnection and subsequent reconnection of the abutment component of the implant compromised the mucosal barrier and resulted in a more "apically" positioned zone of connective tissue. The additional marginal bone resorption observed at the test sites following abutment manipulation might be the result of tissue reactions initiated to establish a proper "biological width" of the mucosal-implant barrier.

In a study (23) of the soft tissue response to plaque formation at different implant systems in the dog. The authors used implant systems that differed with respect to both geometry and dimension. At day 0 extraction of the mandibular premolars was performed. After a healing period of 3 months, fixtures of the Astra Tech Implants, Dental System, the Branemark System and the ITI Dental Implant System were installed. In each mandibular quadrant 1 fixture of each implant system was installed in a randomized order. A period of plaque control was initiated. Following another 3 months of healing, abutment connection was performed in the 2-stage systems (the Astra Tech Implants, Dental System and the Branemark System). After 1 month, the plaque control measures were abandoned and plaque formation was allowed for 5 months. The animals were killed and biopsies representing each implant region obtained. The tissue samples were prepared for light microscopy and exposed to histometric and morphometric measurements. The present study demonstrated that plaque formation resulted in the establishment of an ICT (inflammatory cell infiltrate) lateral to a pocket epithelium. The lesion was found to be similar regarding extension and composition in the peri-implant mucosa of the three implant systems tested. The vertical extension of the ICT was in all systems within 91-99% of the vertical dimension of the junctional epithelium. The marginal bone level, measured from the abutment/fixture (PS) border, did not differ between the three systems.

A study (24) examined the mucosal attachment at different abutments in dogs. The findings from the analysis demonstrated that the material used in the abutment portion of the implant influenced the location and the quality of the attachment that occurred between the peri-implant mucosa and the implant.

Abutments made of commercially pure titanium or ceramic, allowed the formation of a mucosal attachment which included one epithelial and one connective tissue portion that were about 2 mm and 1-1.5 mm high, respectively. At sites where abutments made of gold alloy or dental porcelain were used, no proper attachment formed at the abutment level, but the soft tissue margin receded and bone resorption occurred. The abutment fixture junction was hereby occasionally exposed and the mucosal barrier became established to the fixture portion of the implant. It was suggested that the observed differences were the result of varying adhesive properties of the materials studied or by variations in their resistance to corrosion.

In an experiment (25) conducted to evaluate the effects of long-standing plaque on the gingiva and peri-implant mucosa, five beagle dogs were used. The mandibular right premolars were extracted. 3 months later, 3 titanium fixtures were installed and after another 3 months, abutment connection was performed. Plaque control, in the implant as well as the contralateral tooth regions, was maintained during a 4-month period prior to the start of the main experiment. On Day 0, the teeth and implant sections were examined with respect to plaque and gingivitis. The plaque control program was terminated. The animals were subsequently fed a diet that allowed gross plaque accumulation. After 90 days of undisturbed plaque formation, the dogs were re-examined and biopsies harvested from implants and contralateral teeth. On day 90, all teeth and implants had accumulated large amounts of plaque. The soft tissue at implants and teeth bled on gentle probing. The histological examination of the gingiva and the peri-implant mucosa revealed: (i) both tissues contained an inflammatory cell infiltrate; ICT, (ii) the apical extension of

ICT was more pronounced in the peri-implant mucosa than in the gingiva and (iii) the composition of the 2 lesions had many features in common.

In an experiment (26) carried out to study the peri-implant tissue response to non-submerged (1-stage) and initially submerged (2-stage) implant systems, six beagle dogs were used. All mandibular premolars and the 1st, 2nd and 3rd maxillary premolars were extracted. After 3 months of healing, 3 fixtures of the Astra Tech System were installed and submerged in the right (or the left) edentulous, premolar region in each of the 6 dogs. Radiographs were obtained immediately after fixture installation. In the radiographs, the distance between the abutment-fixture junction and the most "coronal" bone in contact with the implant surface was determined. Three months later, abutments were connected to the initially submerged fixtures and another 3 fixtures of the same system were installed in the contralateral, edentulous premolar region. Abutments were, however, immediately connected to the newly-installed fixtures (non-submerged side; test side). The mucosal flaps were replaced, adjusted and sutured in such a way that the coronal portion of the abutments remained exposed in the oral cavity. A new set of radiographs were obtained from all 6 implant sites in each animal. A period of plaque control was initiated. Clinical examinations were performed and radiographs obtained from all implant sites after another 3 months and at the termination of the experiment. Nine months after the 1st fixture installation procedure, the animals were sacrificed, the mandibles were removed, and each implant region dissected. The most mesially-located implant sites were processed for ground sectioning. The remaining biopsies were processed and embedded in EPON. The histometric analysis included assessment of the vertical dimension of the marginal soft and

mineralized peri-implant tissues. The ground sections were used for measurements describing (i) "bone to implant contact" and (ii) "bone density". It was observed that the mucosa and bone tissue that formed at implants placed in a non-submerged or a submerged procedure had many features in common. Thus, figures describing (i) the height of the mucosa, (ii) the length of the junctional epithelium and the height and quality of the zone of "connective tissue integration", (iii) the % of bone to implant contact as well as (iv) the density of the peri-implant bone, were similar in the submerged and the non-submerged groups. It is therefore suggested that a non-submerged (1-stage) installation technique may provide conditions for tissue integration that are similar to those obtained using a submerged (2-stage) approach.

A study (27) compared probing depth around implants and control teeth in dogs. Five beagle dogs were used in the experiment. The results of the present experiment demonstrated that differences in terms of tissue composition, organization and attachment between the gingiva and the root surface on one hand and between the peri-implant mucosa and the implant surface on the other hand make the conditions for probing depth measurements at teeth and implants different.

Another study (28) examined the initial healing in the dog of submerged versus non-submerged porous-coated endosseous dental implants. Histomorphometric analysis revealed bone-implant contact, as assessed by absolute bone contact (ABC) and contact length fraction (CLF), to be greater for the submerged design, suggesting that bone healing may be delayed with the non-submerged approach. As well, at an early stage of healing, for both

implant designs, ABC and CLF were significantly greater on proximal than on buccal and lingual aspects.

1.10. The inadequacy of the bone tissue volume and techniques to overcome the problem.

Difficulties are more likely to arise when there is little bone volume for the dental implant. Some authorities (29) suggested the placement of platelet-rich plasma in the prepared implant socket prior to the placement of the dental implant in cases of insufficient bone volume as platelets have a prime role in bone healing. Resorbed maxillary ridges can be augmented by means of an autogenous bone graft from the mandibular cortex, the tibia and the ileum, (30). Ridge widening technique in accordance with split-crest-bone manipulation may be beneficial and allow immediate implant placement in resorbed maxillary ridges (31).

The presence of the widely pneumatised maxillary antrum presents another challenge to the implantologist. Top hinge door method is a method which creates a new floor of the maxillary sinus, where underneath the new floor the existing space is filled with a bone graft (32). This procedure is termed the external sinus lift procedure. However, drills of different and increasing lengths can be alternatively used to approach the sinus membrane with care being exercised not to tear it.(33).

The initial application of sinus lift augmentation and implant placement was done in the mid-1970s. Since then there have been some variations in the technique used and graft material applied. Although most authors continue to use the lateral wall, Caldwell-Luc approach, less invasive procedures such as

the osteotome procedure for sinus elevation, graft, and implant placement have been proposed. (34-37).

Figure 12: Insufficient bone volume as a result of pneumatized antrum.

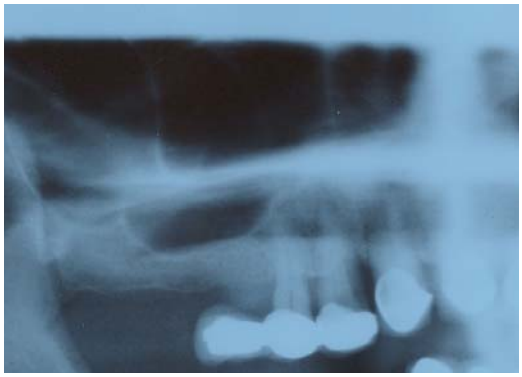
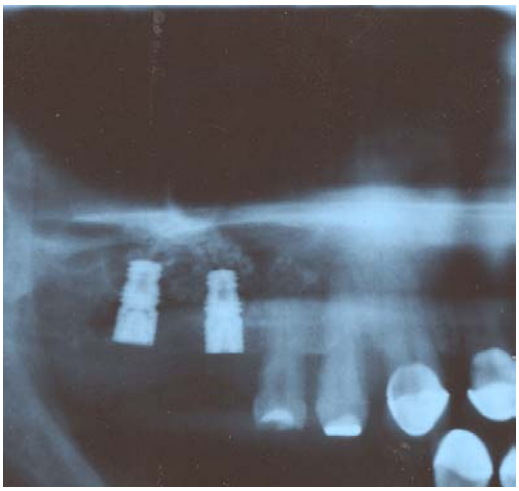


Figure 13: The case after an external sinus lift and the installation of two implants and the placement of bone substitute.



Guided bone regeneration coupled with immediate implantation of xenogenic freeze-dried demineralised bone matrix proved successful in closing bone defects such as: dehiscence defects; crater defects around the neck of the immediately placed implant after natural tooth extraction (38).

Artificial bone when used either alone or in conjunction with a bone regeneration membrane clearly has a role in overcoming the difficult implantation procedure. Bioactive glass of a narrow size range (300-355 microns) has been shown to be osteoconductive and allows for good integration and regeneration of surrounding bony tissue. This alloplastic bone graft material has the advantage of reducing implant morbidity (39).

Some authorities (40) found that the ramus area provided essentially a cortical graft that was well suited for veneering ridge deficiencies; however, the surgical access in some cases was more difficult than in the anterior mandible.

Bone augmentation can be done by osteogenic distractor (41). Intraoral distraction osteogenesis to vertically elongate insufficient alveolar ridges and thereby improve local anatomy for ideal implant placement has proved to be a reliable method (42).

The necessity for alveolar bone preservation may force clinicians to utilize flapless anterior implant surgery to preserve marginal bone often jeopardized by full thickness periosteal flaps (43).

However, when such manoeuvres and techniques are impossible for whatever reason, a narrow-diameter self-tapping implant placed in less available bone volume may be another option for insufficient bone volume (44).

Landi et al (45) investigated the osteoconductive potential of bovine-derived porous hydroxyapatite (HA) in combination with demineralized freeze-dried bone allograft. This combination was found to be a valid alternative to autogenous bone grafts in sinus lift procedures.

Immediate placement of implants into fresh extraction sockets has the advantages of decreasing the recommended period of healing, reducing the resorption of the alveolar bone, and achieving optimal esthetic results (46). Human demineralized freeze dried bone (DFDB) in the maxillary sinus floor elevation surgery has proved a reliable technique prior to implant placement (47). Bone formation following maxillary sinus augmentation using bovine bone substitute material Bio-Oss in combination with venous blood was assessed by a study (48) which found that the survival rate of the implants prior to implant loading was 89.5%. Another study (49) used guided bone regeneration to increase the volume of bone during implant placement. The membrane was placed on blood clot, with allogenic bone and with autogenous bone; the latter showed predictable results. Microvascular bone flaps using prefabricated fibular flaps presented a solution where extensive bone defect existed (50). Many clinical studies have shown that replacement of molars with only one implant is commonly associated with various functional complications, such as implant fracture and screw loosening, however some implants proved successful in many clinical cases (51).

Bone block grafts harvested from the retromolar or symphysis areas of the mandible can be used for sinus floor augmentation, with negligible complications as the only complication that was observed is sensory deficit in

the mandibular anterior region (52). Since 1996 alveolar ridge distraction has enabled local osseous build-up without bone transplantation. (53).

Hahn (54) mentioned that Osteotomes can offer several significant advantages over the traditional graded series of drills. Osteotomes take advantage of the fact that bone is visco-elastic and can be compressed and manipulated. Compression creates a denser area for implant placement. Heat is a major detriment to osseointegration, but the osteotome technique does not generate heat. This technique also allows for greater tactile sensitivity.

Some clinicians (55) suggested that in a percentage of implant cases, there is no need for flap surgery for implant placement, or for a follow-up surgical procedure for abutment connection

Single-tooth implant restorations were introduced in the late eighties, and since then they have showed great developments. A review of literature (56) for studies investigating clinical uses of single-tooth restoration during the nineties revealed that Single-tooth implants show an acceptable short-term survival of 4years, but crown complications are common.

In periodontally compromised subjects treated for chronic (adult) periodontitis with minimal maxillary bone height less than 5 mm the endosseous implantation with simultaneous sinus augmentation is recommended as an appropriate technique for long-term oral implant rehabilitation (57).

In the event of moderate to severe mandibular bone resorption posterior to the mental foramen, repositioning of the inferior alveolar nerve provides a greater amount of available bone for implant placement and reduces the risk of nerve injury. While neural paresthesia may initially occur, this altered sensation generally resolves spontaneously. Alveolar nerve repositioning may be

possible in cases in which other procedures cannot be performed due to the extent of atrophy of the posterior mandibular alveolar crest (58).

A combination implant reconstruction using both subperiosteal and endosseous root-form implants for advanced mandibular resorption was presented (59); With follow-up periods ranging from 6 to 28 months. The three patients investigated indicated satisfaction with comfort, function, and appearance.

The use of collagen membranes has been reported (60). There is evidence that the use of this bioresorbable material was not associated with any complications.

The available evidence can be interpreted to suggest two different patterns of behavior for the two basic types of implants. Implants with a connective-tissue interface appear to be incrementally lost over time at the rate of about 3 percent per year (blades and subperiosteal implants). Osseointegrated implant loss appears to be concentrated in the first year and then is reduced to a rate of less than 1 percent per year, when Brånemark implants are used. Increased pocket depths are usually associated with failing implants and correlate with increased inflammation of the peri-implant mucosa. Radiographic radiolucencies and mobility also are indications of a failing implant.

In a review of success criteria in oral implantology (61), the authors stated that success rates represent the quality of the implant system and / or the skill of the clinician and can be influenced by a number of factors. These include patient selection criteria, surgical technique, design of the superstructure, oral hygiene and also the definition of “success”. They also

stated the importance of including the patient's emotional factors and satisfaction in the evaluation of the implant's success.

Many researchers (62 and 63) have reviewed success criteria for dental implants and attempted better definitions for implant success in light of possible complications.

Many authorities (64 and 67) explained that radiographic examinations together with implant mobility tests seem to be the most reliable parameters in the assessment of the prognosis for osseointegrated implants. Furthermore surgical trauma together with anatomical conditions are believed to be the most important etiological factors for early implant losses

1.11. Complications

To achieve high success rates in implantation the operator should have a thorough understanding of the limitations, indications, advantages and disadvantages of the technique.

Ten Bruggenkate et al (61) reported on the complications that could arise following dental implantation. These include surgical problems, sinus perforation, inflammation, gingival pocketing, gingival hyperplasia, gingival recession, pain, fracture of the implant or superstructure, implant mobility, and radiolucencies around the implant.

Barber et al (62) warned that if the patient is treated with implants in the lower jaw opposing an upper complete denture, such a situation is very likely to cause significant bone loss in the maxillary alveolar ridge. The situation is similar to that occurring when a maxillary complete denture is left opposing natural mandibular anterior teeth.

Mason et al (65) reported cases of mandibular fractures through

endosseous cylinder implants. Mason and co-workers attributed jaw fractures to osteoporotic quality of bone in those reported cases, stating that the alveolar ridge can be one of the areas most sensitive to systemic alterations in bone metabolism and remodelling.

Three fatalities from air embolism have been reported by Davies and Campbell (66) following the use of a coolant spray of compressed air and water with internally irrigated drills. Such compressed air/water spray can also result in excessive surgical emphysema.

In a review article (67, 68), infection, impaired healing, and overload were considered the major etiologic factors for the loss of dental implants.

To prevent complications in cases of unclear anatomic identification of the fossa sublingualis, preoperative lingual probing or elevation of the periosteum of the lingual aspect of the mandible is necessary. An alternative diagnostic procedure is precise preoperative noninvasive imaging (eg, computed tomography) (69)

In a review article (70) for clinical studies during 1981-1997 surgical complications included neurosensory disturbance, hematoma, mandibular fracture, hemorrhage, and tooth devitalization. Initial and long-term marginal bone changes were identified. Peri-implant soft tissue complications included dehiscence, fistulas, and gingival inflammation / proliferation. Mechanical complications were screw loosening/fracture, implant fractures, framework, resin base and veneering material fractures, opposing prosthesis fractures, and overdenture mechanical retention problems. Some studies also presented phonetic and esthetic complications.

Injury to the peripheral branches of the trigeminal nerve and subsequent sensory disturbances are potential complications following implant surgery. Cross-sectional studies suggest that gross tactile sensation was regained in the vast majority of patients. However, data on the spatial and temporal patterns of recovery of this and other somatic sensation such as fine touch, nociception, and temperature sense after implant surgery is still lacking (71).

It has been suggested that the occurrence of postoperative chronic sinusitis appears to be limited to patients with a predisposition for this condition (72). These predisposing factors need to be considered when evaluating patients for sinus lift procedures.

Some researchers believe root-form implants to be by far the best implants in the reconstructed sinus sites (73). Complications also include the rare complication of fatal venous air embolism arising as a direct result of dental implant surgery in the mandible (74).

Since mandibular implant surgery involves mucoperiosteal flap elevation and bone removal during site preparation, complications involving altered sensation are to be expected (75).

A rare complication of intraoperative aspiration of a screwdriver as a rare and life-threatening complication has also been presented (76). It was followed by a chain of further complications including pneumothorax, late laryngeal obstruction requiring tracheotomy, and pleural effusion requiring drainage

Complications encountered with implantology in the mandible include: complete mandibular fracture, partial mandibular fracture, and a temporary bilateral mental nerve hypoesthesia (77).

The six major categories of potential complications include: (1) esthetic, (2) phonetic, (3) functional, (4) biologic, (5) mechanical, and (6) ergonomic. The most frequently observed difficulty with any implant prosthesis relates to esthetics in the maxillary anterior and is followed then equally by phonetic, functional, biologic, and mechanical complications. Ergonomic complications should be minimal with continued improvement in instrumentation and clinical techniques. Complications form a challenge to our professional knowledge and ingenuity. Ultimately their avoidance benefits both patient and clinician alike (78).

Some clinicians (79) observed that the most frequent tissue complications include fistulae and mucosal hyperplasia adjacent to abutments. The authors also observed that the most frequent prosthetic complications were phonetic problems in the maxilla only, acrylic fractures in bridges and fractures or distortion of the metallic framework as well.

1.12. Prognosis of dental implants in the osseointegration technique

The Brånemark system was the first to follow the defined criteria for osseointegration and the results of its use have been continuously reported in the literature (80, 81).

The results from studies of dental implants of different designs also vary and the trend now for all the root form systems is to follow the recommendations of Brånemark et al (8) in the surgical, healing, and loading aspects of the implantation procedure (82, 83).

Adell et al (84), in a long-term follow-up study, reviewed the outcome of prostheses and fixtures in 759 totally edentulous jaws (700 patients). A total of 4,636 standard fixtures were placed according to the Brånemark method and

followed up for a maximum of 24 years. Standardized annual clinical and radiographic examinations were conducted as far as possible. A lifetable approach was applied for statistical analysis. Sufficient numbers of fixtures and prostheses to allow a detailed statistical analysis were present for observation times of up to 15 years. More than 95% of maxillae had continuous prosthesis stability at 5 and 10 years, and at least 92% at 15 years. The figure for mandibles was 99% at all time intervals. The individual fixture survival rate is different to the prosthesis survival rate. The prosthesis survival rate is usually higher as the prosthesis is often supported by more than one fixture. This implies that the prosthesis has a good chance of survival even if one of the fixtures fails. Calculated from the time of fixture placement, the estimated fixtures' survival rates in the maxilla were 84%, 89%, and 92% at 5 years; 81% and 82% at 10 years; and 78% at 15 years. In the mandible they were 91%, 98%, and 99% at 5 years; 89% and 98% at 10 years; and 86% at 15 years. (The different percentages at 5 and 10 years refer to results for different routine groups of fixtures with 5 to 10, 10 to 15, and 1 to 5 years of observation time, respectively.) The results of this study are in agreement with multicenter and earlier results for the osseointegration method.

For the Brånemark system, the five year success rate has been reported for the individual implants to be 86.4% in the maxilla, and 96.8% in the mandible (83, 85). Also a total of 80 Brånemark maxillary bridges were followed for 5, 10, and 15 years with success rates of 96, 95, and 93 % respectively. The figures for the mandible were even higher, in 83 mandibular bridges there was a success rate of 99% over 5, 10, and 15 years of follow-up.

Not only has the Brånemark system proved to be successful, but also

many of the systems that have followed and applied this technique have demonstrated similar success.

Numerous techniques have been described to create a more favorable surgical site for implant placement.

The challenge facing the clinicians today is to achieve an optimal long-term aesthetic result. To address this challenge, the volume of the underlying hard and soft tissue must be restored either prior to or simultaneously with the implant placement.

Dental implant placement associated with sinus floor augmentation in a severely atrophied maxilla can be performed in a 1- or 2-stage surgical procedure, depending on the height of the residual alveolar bone; its main advantage is its ability to provide initial stability required for osseointegration and proper implant location and parallelism (86).

1.13. Causes of failure

The main etiologic factors in implant failure are infection and occlusal force stresses. The microbiota around stable vs. failing implants seem to parallel the patterns observed around healthy vs. diseased natural periodontal sites. Recent studies indicate that microorganisms associated with periodontal disease are found in higher proportions in failing implant sites. Periodic plaque removal and health maintenance should help prevent such failures.

Of the medical and mechanical risk factors, current use of nicotine, history of sinusitis, and shorter implant lengths had the most influence on implant failure. Patients with severe osteoporosis and chronic polyarthritis may receive dental implants (87).

Maintenance and treatment should be directed towards eliminating two main factors associated with implant failure: plaque and occlusal stress. If the implant begins to progressively lose bony support, the treatment should include débridement, antimicrobial drugs (taking into account the antibiotic susceptibility of subgingival microflora), surgical intervention and/or occlusal adjustment. Partially edentulous patients should receive complete periodontal treatment before and after the implant therapy.

Some clinicians (88) believe that periodontally compromised patients, who have experienced a considerable loss of alveolar bony support, can be successfully treated with implants.

Cardiovascular disease may not be a risk factor for successful osseointegration (89).

A review of literature (64) identified some factors to be associated with biological failures of oral implants. These include: medical status of the patient including smoking; bone quality; bone grafting, irradiation therapy; parafunctions; operator experience; degree of surgical trauma; bacterial contamination; lack of preoperative antibiotics; immediate loading; non-submerged procedur; number of implants supporting a prosthesis and implant surface characteristics and design. Excessive surgical trauma together with an impaired healing ability, premature loading and infection are likely to be the most common causes of early implant losses. Whereas progressive chronic marginal infection (peri-implantitis) and overload in conjunction with the host characteristics are the major etiological agents causing late implant failures. Furthermore, it appears that implant surface properties (roughness and type of coating) may influence the failure pattern.

With single-implant therapy, survival also depends on the implant's position in the mouth. One study (90) reported on a 24-month life-table analysis study on two-stage implant survival, using a variety of implant designs. They reported survival to be 100 percent in the anterior mandible, 92 percent in the posterior mandible, 94 percent in the anterior maxilla and 78 percent in the posterior maxilla. The lower survival rate in the latter area is probably the result of the cancellous nature of the bone and the thin cortical plates. Of the failures, 13 occurred at the time of abutment connection owing to non-integration, and one occurred within one year of abutment connection. Bridge survival in the group was 100 percent. Small-diameter cylinders appear to do less well than large diameters or blades in hollow, cancellous bone and thin cortical plates. Various implant shapes are needed to overcome bone morphological limitations and meet restorative requirements. Unfortunately, implants for partially edentulous patients are most often needed in the posterior mandible and maxilla, reflecting the pattern of natural tooth loss.

Another study (91) showed that fixture dehiscence and fenestrations, augmented with a bioabsorbable membrane, demonstrated a highly significant amount of new bone formation.

1.14. Timing of implant therapy

There have been many reports about and discussions of the relative benefits of both individual and multiple implants used to anchor a fixed denture compared with other appliances such as removable dentures. A general consensus seems to be that there is no clear upper-age limit for implant

therapy. The biological age vs. the chronological age is important, as are the patient's general vigor, manual dexterity (to perform adequate oral hygiene), and the health status and mental capacity (whether they are sufficient to equip the patient to receive implants). In the more mature American population, removable dentures are considered a significant handicap in regard to mastication, speech, esthetics, reduction of the residual ridges of the mandible and maxilla and body self-image. The dental implant is a decided improvement in most of these categories, and the removable denture remains an alternative as appropriate.

A more difficult question, however, concerns how early in life dental implants may be placed. Generally, clinical judgment suggests that dental implants should not be placed before the age of 15 or 16 years, when it is assumed that maxillary and mandibular growth is completed. However, there is clinical evidence to indicate that craniofacial growth continues in women until their late teens and in men into their 20s. Specific scientific evidence supporting or negating the placing of dental implants into a young person's mandible or maxilla is not yet available. Randomized, prospective clinical trials are needed.

Dental implantation is the state of dental art and is becoming increasingly popular among the dental professionals. With more general practitioners getting involved in this type of treatment, it is important to ensure higher success rates in order to make it equally popular and understandable by the patient. One important factor that can ensure higher success is to control the health condition of the tissues around the implant to a degree of no disease. This can be attained through the exertion of more effort by the dentist at all

stages of the implant therapy – i.e. case assessment stage, the flap design, abutment selection…etc.- along with the concurrent and subsequent understanding of the patient to the need of proper plaque control around his new teeth. Moreover, the present investigation was designed to study one important factor that determines the success or failure of dental implants namely the health of peri-implant tissues and compare it around one and two stage dental implants with the health of periodontal tissues around natural teeth of the same patient.

The aim of this study is to:

1. To compare the health of peri-implant tissues around one and two stage dental implants.
2. To compare the health of peri-implant tissues with the health of periodontal tissues in the same patient.

Chapter 2

Materials and methods

Materials

The records of all patients treated with dental implants in one specialized centre in the Capital City of Amman / Jordan (Arab Dental Centre) were screened for suitable subjects for this study.

All patients were treated by the same dentist (the author of this work) with different dental implant systems following a standardized method and according to the manufacturer's instructions. The treatment commenced with interviewing the patient and conduction of a thorough clinical examination particularly to the condition of the existing soft and hard tissues. A pre-operative orthopantomogram was then taken for each subject. The surgery was always conducted after administration of a local anaesthetic solution infiltration injection. Infiltration was sufficient even in the mandibular posterior region as it fully anaesthetized the tissues there and left some sensation in the inferior dental nerve itself to monitor it and guard it against any subsequent injury during the surgery.

The flap design was then carefully carried out according to the type of the implant to be installed. The use of one stage dental implants always necessitates the placement of the flap in an attached band of the mucosa at the centre of emergence of the future abutment. This was important to ensure sufficient band of attached mucosa around the abutment and the restoration in the future.

After the installation of the implant according to the manufacturer's instructions and using the successive widths drilling burs, the flap was sutured, and the patient was given sufficient time to complete the healing of the hard

tissues around the implant (i.e. four months in the mandible and six months in the maxilla).

When a two stage implant was used the soft tissues were opened at the end of the healing period and the abutment was connected. One stage implants had their abutments already attached to the body of the implant and remained protruding into the oral cavity throughout the healing period.

The impressions were then made and the fixed superstructure was then attached onto the abutment.

All patients having natural teeth in the opposite (contralateral) same locations to the implant site in the jaw were chosen. All patients included were medically healthy having their implants installed at least one year ago and had received verbal and written instructions on necessary oral hygiene procedures.

This screening yielded a total number of 36 patients: 18 males and 18 females with an age range of 17-68 years.

Methods

A pilot study was carried out in order to standardize the probing procedure. Ten patients were randomly chosen. The probing pocket depth (92, 93 and 94) was registered for the tissues around both implants and natural teeth in their mouths. The patients were called again: three days, one week and one month later and every time the measurements were repeated again. Each time the measurements for any given patient were repeated, the original data were reviewed and compared to the newly registered data. The differences were noted and attempts were made every time to correct the wrong measurements through the application of the correct probing pressure and direction in relation to the long axis of the abutment or crown.

The probing pressure applied each time was between 25 and30 grams.

Base line data:

The carrying out of the pilot study ensured the reproducibility of the probing depth measurements.

Plaque index (92) and gingival index (93) and the probing pocket depth (92, 93 and 94) were registered for the patients in this study. These measurements were carried out for the tissues around both implants and natural teeth (control) that were present symmetrically across the arch in the other side of the jaw. All control teeth in this study were natural teeth with no crowns or faulty restorations.

Plaque index (92 and 93) was recorded for each patient after examining the facial surfaces of the crowns of natural teeth or implants according to the criteria stated in the table below.

For each tooth the gingival index was recorded on four locations around the tooth: mesio-, mid- and disto- facial and one lingual. Eventually, the gingival index for that tooth was calculated as the average of all those recordings.

Plaque index (after Silness and Löe (92)):

Score	Description
0	No visible signs of plaque and no plaque caught by the probe on passing it along the gingival margin
1	No visible signs of plaque but on using the probe, there is plaque onto it.
2	Visible signs of plaque within the gingival third of the crown.
3	Visible signs of plaque within and beyond the gingival third of the crown / or there are evidence of the presence of calculus.

Gingival index (after Löe and Silness (93) and Löe (94)):

Score	Description
0	No signs of the presence of gingivitis and no bleeding on probing
1	Mild inflammation, slight change in colour, slight oedema and no bleeding on probing.
2	Moderate inflammation, redness, oedema and glazing with bleeding on probing.
3	Severe inflammation, marked redness and oedema, ulceration and spontaneous bleeding.

The probing pocket depth (PD) was recorded for each tooth after measurement with a Williams graduated periodontal probe and the recordings were carried out in four locations: 3 facial that included mesio-, disto- and mid facial and one mid-lingual location.

Statistical analysis was carried out in the form of the analysis of variance test (ANOVA), paired and unpaired t-test, Tukey-Kramer, Wilcoxon's matched pairs test, Kruscal-Wallis and Mann-Whitney tests.

Chapter 3

Results

The number, sex and age of the patients included in the study are demonstrated (table 1). The age range of males was 30-68 years and for females it was 17-65 years. The age range of the whole sample was 17-68 years. The distribution of patients according to number of implants is shown in table 2. Most of the patients had one to two implants. However, the maximum number of implants per patient in this study was seven implants (table 2).

The results of comparing plaque and gingival indices as well as the probing depth according to gender indicated statistically significant differences between males and females (table 3). Moreover, comparing the same parameters according to age indicated the same result (table4). When the plaque index was compared between the different age groups, statistically highly significant results were obtained (table 5). The same results were also obtained for the gingival index (table 6) as well as the probing depth (table 7).

However, when the plaque index around implants and natural teeth was compared for different age groups, statistically significant results were only obtained at the age groups 17-45 years (table 8). But when the gingival index readings around implants and natural teeth were compared for different age groups, the results showed statistical significance except for the age groups 46-55 years (table 9). No statistically significant results were obtained when the probing depth around implants and natural teeth was compared for the different age groups (table 10). However, the comparisons for plaque and gingival indices as well as probing depth between implants and natural teeth for the whole group was statistically significant for the three parameters (table11).

When the plaque and gingival indices as well as probing depth was compared between one stage (N=35) and two stage implants (N=57) the results

were statistically significant for the three parameters (table 11). The same result was obtained when the parameters were compared between one stage implants and natural teeth (table 12). However, less statistically significant differences were recorded when the parameters were compared for two stage implants and natural teeth. In fact the comparisons of the plaque index between the two groups indicated statistically non-significant results (table13).

Table 1. The distribution of the sample according to sex and number of implants.

Sex and numbers of Patients	Age-range (years)	Number of implants
Males (18)	30-68	46
Females (18)	17-65	46
Total (36)	17-68	92

Table 2. The distribution of implants per patients.

Group	Number of implants for each patient	Number of patients in the group
A	1	12
B	2	12
C	3	4
D	4	1
E	5	4
F	6	1
G	7	2
		Total = 36 patients

Table 3. A comparison of plaque index, gingival index and probing depths around implants according to sex.

	Mean ±SD		
Sex and P value	**Plaque index**	**Gingival index**	**Probing depth (mm)**
Males	1.4±0.88	0.9±0.63	2.1±0.75
Females	0.6±0.59	0.6±0.44	1.6±0.33
P value	<0.0001***	0.0383*	<0.0001***

Table 4. Mean plaque index, gingival index and probing depth around implants according to age.

Variables	**The groups of age range and no. of implants**				**P value**
	Group 1 17-45 (25 imps)	**Group 2 48-55** (25 imps)	**Group 3 56-60** (27 imps)	**Group 4 64-68** (15 imps)	
Plaque index (mean ±SD)	0.4±0.47	1.0±0.61	1.1±1.0	1.7±0.62	<0.0001***
Gingival index (mean ±SD)	0.4±0.41	0.8±0.62	1.0±0.46	0.9±0.59	0.0008***
Probing depth mm (mean ±SD)	1.7±0.58	1.9±0.58	2.1±0.71	1.7±0.56	0.0716ns

Table 5. Variations in plaque index between the different age groups.

Comparisons	P value
Group 1 vs Group 2	< 0.05*
Group 1 vs Group 3	< 0.05*
Group 1 vs Group 4	< 0.001***

Table 6: Variations in the gingival index between the different age groups.

Comparisons	P value
Group 1 vs group 3	P <0.001

Table 7. A comparison of the mean plaque index around implants and natural teeth according to age group.

	Means and ±SD			
Comparisons and P value	**Group 1 17-45** (25 imps)	**Group 2 46-55** (25 imps)	**Group 3 56-60** (27 imps)	**Group 4 64-68** (15 imps)
Implants	0.4±0.47	1.0±0.61	1.1±1.0	1.7±0.62
Natural teeth	0.8±0.65	0.9±0.61	1.3±1.0	1.7±0.46
P value	0.0342*	0.6377 ns	0.4922 ns	0.8125 ns

Table 8. A comparison of the mean gingival index around implants and natural teeth according to age group.

	Means ±SD

Comparisons and P value	Group 1 17-45 (25 imps)	Group 2 46-55 (25 imps)	Group 3 56-60 (27 imps)	Group 4 64-68 (15 imps)
Implants	0.4±0.41	0.8±0.62	1.0±0.46	0.9±0.59
Natural teeth	0.7±0.55	0.9±0.5	1.1±0.54	1.0±0.44
P value	0.0542 ns	0.6507 ns	0.5202 ns	0.3757 ns

Table 9. A comparison of the probing depths around implants and natural teeth according to age group.

	Means ±SD			
Comparisons and P value	Group 1 17-45 (25 imps)	Group 2 46-55 (25 imps)	Group 3 56-60 (27 imps)	Group 4 64-68 (15 imps)
Implants	1.7±0.58	1.9±0.58	2.1±0.71	1.7±0.56
Natural teeth	1.9±0.59	1.9±0.52	2.3±0.90	2.1±0.45
P value	0.0282*	0.9333 ns	0.0115*	0.0004***

Table 10. A comparison of the mean plaque index, gingival index and probing depth for the patients around implants and natural teeth.

	Means ±SD		
Examination within the same subject	**Plaque index (average)**	**Gingival index (average)**	**Probing depth(mm)**
Implants	1.0±0.83	0.8±0.56	1.9±0.63
Natural teeth	1.1±0.8	0.9±0.55	2.1±0.68
P value	0.3436ns	0.089ns	0.0046**

Table 11. A comparison of the mean plaque index, gingival index and probing depth for patients around one and two stage dental implants.

	Means ±SD		
Comparisons and P value	**Mean plaque index**	**Mean gingival index**	**Mean probing depth (mm)**
One stage implants (35 implants)	0.5±0.48	0.5±0.41	1.6±0.55
Two stage implants (57 implants)	1.3±0.87	0.9±0.57	1.9±0.69
P value	0.0001***	0.0293*	0.0313*

Table 12. A comparison of the mean plaque index, gingival index and probing depth for patients around one stage dental implants and natural teeth.

	Means ±SD		
Comparisons and P value	**Mean plaque index**	**Mean gingival index**	**Mean probing depth (mm)**
One stage implants (35 implants)	0.5±0.48	0.5±0.41	1.6±0.55
Natural teeth in same patients	0.7±0.69	0.7±0.49	1.9±0.6
P value	0.1336ns	0.1341ns	0.0077**

Table 13. A comparison of the mean plaque index, gingival index and probing depth for patients around two stage dental implants and natural teeth.

	Means ±SD		
Comparisons and P value	**Mean plaque index**	**Mean gingival index**	**Mean probing depth (mm)**
Two stage implants (57 implants)	1.3±0.86	0.9±0.57	1.9±0.69
Natural teeth in same patients	1.4±0.79	1.1±0.52	2.2±0.72
P value	0.4100 ns	0.0493*	0.0157*

Chapter 4

Discussion, Conclusions and Recommendations

Discussion

Patient's evaluation before implant surgery should include determination of general health, oral hygiene habits, motivation towards good dental care, and anatomic acceptability. Periodontal disease, abnormal bone conditions, severe bruxism and occlusal discrepancies must be identified and corrected otherwise implant therapy would be unpredictable and might be contraindicated. Generally, the minimum bone requirements for implant placement are 5mm of ridge width and 8mm of ridge height. Though some authorities stated that periodontally compromised patients, who have experienced a considerable loss of alveolar bone support, can be successfully treated with implants (85), but in general the health of the periodontium before and peri-implant tissues after the placement of the implant is detrimental to the success of the implant therapy (27). So following treatment with implants, patients should be instructed to carry out careful, meticulous oral hygiene home care.

Since bacterial accumulation on abutments or implant surfaces induces an inflammatory reaction in the gingiva / alveolar mucosa just as around teeth, the success of implant treatment can be jeopardized by peri-implantitis (18).

This study aimed at studying the health of peri-implant tissues around one and two stage dental implants and compare this with the health of natural teeth of the same patient.

The selection of the patients have yielded equal numbers of males and females as displayed in table 1. This reflects the resemblance in attitude of both sexes towards this modality of treatment.

However, the age range for females is less than for males, indicating that younger females care more for their teeth than do males.

Although many cases of implant supported full mouth restorations have been screened for suitability for this study, yet those had to be excluded and rejected as the presence of contra-lateral natural teeth in the same arch was a necessity for comparison purposes.

The periodontal tissues differ histologically to the peri-implant tissues. This makes the probing around teeth incomparable to that around dental implants. Although this subject is controversial, this study compares the two situations and draws conclusions from their data. This can be accepted providing that probing conditions around those structures are standardized.

Standardization was achieved by the conduction of the pilot study as explained in the materials and methods section. This study ensured the exertion of nearly the same amount of pressure each time probing was carried out around either teeth or dental implants. Standardization entailed the use of the same probe in probing around teeth and dental implants. For this reason the Williams graduated periodontal metal probe has been used. This endangered the surface integrity of the adjacent highly polished abutment surface as the use of a metal probe is contraindicated adjacent to dental implants. However, meticulous probing was carried out and great care was exerted not to inflict damage to the surface of the abutment.

The results in table 3 show better (less) values for the plaque index, gingival index and probing depth around dental implant for females. This indicates better oral hygiene, indicating that implants may be more successful for females in general. This finding is in accordance with epidemiological and clinical studies that females generally exert more efforts in undertaking the daily oral hygiene measures.

Table 4 indicates that plaque accumulations in the four age groups around dental implants increase with age. The same table also shows that there is a similar increase in the values of gingival index and probing depth for the first three groups with the increase in the amount of plaque accumulations. However, this does not apply to the older age group (64-68 years) as they showed the heaviest plaque accumulations around their implants while their registrations for the gingival inflammation and the probing depths were not as high as would be expected. This can be explained on the basis that this age group only contained 3 patients: 2 with 7 implants each and one with one implant only. For those elderly patients the aesthetics was not important and the abutments were chosen to be with a shoulder some distance above the gingival margin. So, although those patients registered higher values for the plaque accumulations on their artificial teeth, those plaque accumulations did not affect the far-away gingival margins and did not influence the gingival health or periodontal health. Besides the older age group (64-68 years) are characterized by having a large number of implants for each patient (2 patients of them having 7 implants each) this might have made it even more difficult for those patients to care enough for their implants. This produced heavier amounts of plaque accumulations on the implants and natural teeth in these groups. Table 4 indicates that although there are huge statistical variations in the plaque accumulations around the implants in the four groups, the clinical importance of this variation is limited (mean plaque indices in group1, 2, 3 and 4 were 0.4, 1.0, 1.1, and 1.7 respectively) reflecting little clinical variations in those accumulations. This would not induce huge differences between the

groups in the gingival inflammation or probing depths as illustrated also in table 4.

Table 7 shows statistically significant difference between the plaque accumulations around implants and natural teeth, only for the younger age group (17-45 years). This might be explained in that this age group displays more interest in this modality of treatment and exerts more effort to keep their implants clean enough ignoring in the process to bring their natural teeth to the same standards. Besides, this younger age group consists of 17 patients most of them having either one or two implants, this might have made it easy for each patient in this age group to keep his single (or 2) implants so clean. The early loss of teeth in patients within this age group has inflicted significant psychological trauma, this must have induced huge motivation to keep their new teeth (implants) for a longer life to come. On the other hand the other age groups who lake this motivation cared less about their mouths and exerted equal attention to the teeth and the implants as displayed in table 7.

For the other age groups table 7 states that plaque levels around implants and natural teeth is not very much different for the same patient indicating that personal factors like diet, and oral hygiene practices and other local factors dictate the amount of plaque, rather than whether the examined surface is around a natural tooth or a dental implant. This finding is in accordance with the findings of Ericsson et al (25) that the lesions around implants and natural teeth have many features in common, and that the inflammatory reaction of both tissues is similar.

Table 8 displays statistically and clinically similar values for the gingival index around dental implants when compared to natural teeth for all of the

groups. This is caused by the clinically similar mean plaque indices registered for all of the groups as indicated in table 7.

Table 9 displays significantly lower values for the probing depths around dental implants when compared to natural teeth. However, this difference is again not significant clinically as it is evident from the mean recordings for the groups in the same table.

Table 10 compares between the implants and natural teeth for all the patients in the study. The table displays statistically significant differences between implants and natural teeth for probing depths, however, the data clinically are very close to each other displaying little clinical differences between implants and natural teeth.

Table 10 shows statistically significant values but clinically differences between implants and natural teeth are small. In fact the probing depths for the dental implants were better and lower than around natural teeth, this may be due to the difference in age between the dental implants (that has been installed on the most 5 years ago) and natural teeth. This finding supports earlier conclusions by Moon et al (11) who studied the composition of the connective tissue that forms an attachment to a dental implant. The authors concluded that “The fibroblast rich barrier tissue next to the titanium surface plays a role in the maintenance of a proper seal between the oral environment and the peri-implant bone”.

The recorded values around one-stage dental implants are significantly lower than those around two-stage dental implants (table 11). This might be due to the absence of the separation phase between the abutment and the implant in the one stage dental implant or perhaps because the need for the

second stage surgery is eliminated when these types of implants are used reducing the amount of trauma inflicted to the periodontium around these implants.

This finding is again emphasized when comparing each implant type to the adjacent natural teeth. Although there are highly significant differences between the one stage dental implants and natural teeth, the differences are less significant between two stage dental implants and natural teeth. These findings are in contradiction to the findings of Abrahamsson et al (26) who suggested that one stage dental implants installation technique may provide conditions for tissue integration that are similar to those obtained using a two stage approach.

Many dental implant systems have been used comprising either the one-stage group or the two-stage group. The large number of implant brands made it statistically impossible to compare between them as the number of implants for each brand used would be un-suitable for the conduction of statistical analysis. The grouping of those brands into a one-stage group and a two-stage group was acceptable for comparing as each group possessed criteria that were similar within the same group and differed completely to the other group.

Conclusions:

1. Patients who are fitted with implants must be followed up to ensure that they practice appropriate oral hygiene measures.
2. The health of peri-implant tissues in the younger age group are better than those in the older age groups.
3. Females show better oral hygiene values, and better gingival and periodontal health around their implants.
4. Considering periodontal health around the different implant types, one stage implants give better results compared to the two stage variety in this study.

Recommendations

1. There is a need for a more precise definition of the probing depth around dental implants.
2. There is a need follow up studies to examine the development of pockets around dental implants at different stages of the service life of the implants.

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ملخص

إن صحة الانسجة المحيطة بالغرسات السنية هي الاساس لاستمرارية الغرسة نفسها.

وتأتي هذه الدراسة لتقارن بين صحة الانسحة المحيطة بالسن الطبيعي وتلك المحيطة بالغرسة السنية. كما وتهدف هذه الدراسة للمقارنة بين صحة الأنسجة حول الغرسات السنية ذات المرحلة الواحدة وتلك ذات المرحلتين.

تم أختيار ستة وثلاثين مريضا ومريضة (18 ذكرا و 18 انثى) من مجمل المرضى الذين أجريت لهم عمليات زرع اسنان في المركز العربي لطب الاسنان / عمان-الاردن ممن إستوفوا المواصفات المطلوبة من حيث كونهم اصحاء وأن عمليات الزرع كانت قد تمت قبل عام على الاقل من فحص المريض لغايات هذه الدراسة التي اشترطت وجود اسنان مقابلة للزرعة في نفس الفك لأغراض المقارنة. كما تراوحت أعمار الذين وقع عليهم الاختيار بين 17- 68 عاما.

بعد الاختيار تم فحص المرضى لقياس مستوى اللويحة الجرثومية المتراكمة بناء على طريقة (Silness and Loe) ومقدار إلتهاب اللثة بناء على طريقة (Loe and Silness) كما تم قياس العمق المسبري حول الاسنان والزرعات.

وقدأظهرت النتائج أن الأنسجة حول الغرسات عند الاناث والمرضى في المجموعة الاصغر عمرا كانت أكثرصحة منها لدى الذكور والاكبر عمرا على الترتيب.

وأظهرت كذلك أن كميات اللويحة المتراكمة على الغرسات ومستوى التهاب اللثة والانسجة حول الغرسات كانت أقل منها حول الاسنان الطبيعية في نفس المريض. وقدكانت تلك الفروقات مختلفة احصائيا في هذا الصدد.

كما واوضحت النتائج مستويات اقل لتراكمات اللويحة الجرثومية وصحه أعلى للانسجة حول الغرسات أحادية المرحلة مقارنة مع تلك ثنائية المرحلة وقد كانت الفروقات بينة احصائيا.