CLINICAL AND RADIOLOGICAL BONE DENSITY STUDY OF IMMEDIATE PLACEMENT OF CORAL COATED DENTAL IMPLANT

By

ALI ABDUL KAWI ALI TAHER

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KAJIAN KLINIKAL DAN DENSITI RADIOLOGIKAL TULANG BAGI IMPLAN PERGIGIAN PASANG TERUS YANG DISALUT BATU KARANG

ABSTRAK

Implan yang dipasang terus atau sejurus selepas gigi dicabut telah membuktikan suatu strategi rawatan yang telah memberi kejayaan yang baik. Implan yang dipasang terus mempunyai beberapa kelebihan seperti mengurangkan sesi rawatan pembedahan, memendekkan masa antara cabutan gigi dan rawatan restoratif yang kekal, mengurangkan resobsi tulang dan mengekalkan mutu tulang rahang yang memberi banyak kebaikan dari segi estetik dan fungsi. Penggunaan implan yang disalut bahan yang bioserasi boleh membantu integrasi implan. Tujuan kajian ini ialah untuk menentukan keberkesanan klinikal dalam baikpulih tulang untuk implan pergigian yang disalut batu karang yang dipasang terus dan membandingkan secara radiograf kepadatan tulang disekeliling implan yang disaluti batu karang dengan implan yang tidak disaluti batu karang.Tiga belas orang pesakit telah dipilih untuk kajian ini. Ciri-ciri inklusinya ialah pesakit yang sihat, berumur 18-40 tahun, untuk cabutan sebatang gigi sahaja, tiada lesi penyakit gusi dikawasan cabutan dan liang cabutan mempunyai empat dinding. Ciri-ciri eksklusi pula ialah pesakit yang mempuyai penyakit sistemik dan liang cabutan sudah kehilangan satu atau lebih dinding. Lapan orang pesakit dalam kumpulan kajian telah menerima implan yang disaluti dengan batu karang manakala 5 orang pesakit didalam kumpulan kawalan menerima implan yang tidak disaluti batu karang. Dua orang pesakit dari kumpulan kawalan telah keluar dari kajian. Penelitian secara klinikal dan densitometrik dilakukan pada satu, dua dan tiga minggu dan empat bulan selepas pembedahan. Keputusan klinikal menunjukkan kesemua sebelas orang pesakit telah sembuh dengan baik. Kajian densitometrik menunjukkan kepadatan tulang yang lebih tinggi dalam kumpulan pesakit yang menerima implan yang disaluti batu karang berbanding dengan kontrol sekurang kurangnya pada satu bahagian implan ($p<0.001$). Analisa densitometrik menunjukkan kepadatan tulang yang

lebih tinggi di semua lima bahagian implant dalam kumpulan implan yang disaluti batu karang berbanding dengan kumpulan control. Walaubagaimana pun hanya bahagian coronal mesial dan midway distal telah mempunyai kepadatan tulang yang lebih signifikan, ($p<0.002$ dan $p<0.024$). Keputusan kajian ini membuktikan bahawa batu karang buatan tempatan ialah suatu bahan bio yang sesuai untuk menyaluti implan kerana kestabilan primer yang dihasilkan telah menyokong pertumbuhan tulang yang mendorong kepada kestabilan sekunder. Graf batu karang yang bioserasi dan sifat osteokonduktornya telah merangsangkan fenomena yang sangat bermakna dalam implantologi.

CLINICAL AND RADIOLOGICAL BONE DENSITY STUDY OF IMMEDIATE PLACEMENT OF CORAL COATED DENTAL IMPLANT

ABSTRACT

The placement of implants immediately or shortly after tooth extraction has proven to be a predictable treatment strategy with a very high rate of success. Immediate implant placement has several advantages, such as reduction of the number of surgical treatments, reduction of the time between tooth extraction and placement of the definitive prosthetic restoration, prevention of bone resorption, and preservation of the alveolar ridge in terms of height and width, which in turn has esthetic and functional benefits. The use of coated implants with a biocompatible material may bring better integration of the implant. The aim of this study was to determine clinically the efficacy of bone healing of immediate dental implantation with coral augmentation at the bone - implant interphase and to compare radiographic bone density around immediate dental implants with and without coral augmentation. Thirteen patients were selected for this study. The inclusion criteria were healthy patients, aged between 18 and 40 years old, indicated for single tooth extraction, without endo-perio lesion at site of extraction and extraction socket was left with intact four walls while exclusion criteria were patients with systemic disease, and extraction socket has lost one or more wall. Eight patients in the test group had immediate implant with coral coating and five patients in the control group used non- coated implant. Two patients were dropped from the study in the test group. Clinical and densitometric assessments were done at one, two and three weeks and four months postoperative. Clinically all the eleven patients in both groups showed normal wound healing. Densitometric analysis showed that the bone density was significantly higher in the immediate coral coated implant group compared to the control group on at least one point around the implant ($p<001$). The values for densitometric analysis at five different points were higher in coral coated implant group. However, the difference was significant only at the coronal mesial and midway distal

points, ($p<0.002$ and $p<0.024$) respectively. Based upon the results of the present study, it can be concluded that locally produced coral seemed to be a suitable material for coating the surface of implants since it provided primary stability to the immediate placement of the coated implants in the extraction sockets. This primary stability will ensure new bone growth to provide the more stable secondary stability. The biocompatibility of the coral graft and its role as an osteoconductor would have encourage this very useful phenomena in implantology.

CHAPTER ONE

INTRODUCTION

1.1 Background

Immediate implants are defined as placement of implants in the course of surgical extraction of the teeth to be replaced (Penarrocha, 2001). The insertion of implants immediately after extraction is not new. In the eighties the University of Tubingen advocated the procedure as the technique of choice for Tubingen and München ceramic implants (Schulte, 1984). As a result of the success of the protocol designed by Branemark and his team for their dental implant system, other procedures were largely relegated for many years. Initially, a healing period of 9 -12 months was advised between tooth extraction and implant placement (Bascones *et al.*, 2001). Nevertheless, as a result of continued research, a number of the concepts contained in the Branemark protocol and previously regarded as axiomatic – such as the submerged technique concept, delayed loading, machined titanium surface, and others have since been revised and improved upon even by the actual creators of the procedure.

Implantation immediately after tooth extraction offers several advantages for both patients and clinicians, including shorter treatment time, less bone resorption, fewer surgical sessions and easier definition of the implant position. It makes the use of longer implants possible due to the preservation of ridge height and width. Moreover, it provides better opportunities for osseointegration because of the healing potential of the fresh extraction socket (Lazzara, 1989; Parel, 1990; Becker *et al.*, 1992; Werbitt, 1992; Fontana, 1994; Grunder *et al.*, 1999). Several human studies have been carried out to compare the results of immediate and delayed implantation in extraction sockets, (Yukna, 1991; Aughtun, 1995; Watzek, 1995; Van Steenberge, 2000), showing that the immediate placement could provide a success rate for osseointegration similar to

that obtained from the placement of implants into ossified extraction sites (Tolman, 1991; Watzek, 1995; Rosenquist, 1996).

Placement of an implant immediately following loss or extraction of a tooth is associated with the following advantages, particularly in the anterior region as follows:

- It is not necessary to wait approximately 12 months for complete bony healing and reossification of the alveolus before implant placement.
- Placement of an implant will inhibit the alveolar ridge resorption that normally occurs following tooth loss.
- The number of surgical procedures is reduced.
- The time during which the patient is partially edentulous is shortened, because healing of the alveolus and healing-in of the implant occur simultaneously (Rateitschak and Wolf, 1995).

Implants placed immediately post-extraction have proven to be a successful, predictable treatment modality. The number of surgical appointments and length of surgical restorative procedures are reduced, thereby preserving esthetics and functional benefits. However, there are some limitations to immediate implant procedures. These limitations include a probable lack of soft tissue closure over the extraction site (El Charkawi, 2001).

The clinical efficacy of the Frialit-2 Implant has been well documented (Schulte *et al.*, 1992; Gomez- Roman *et al.*, 2001; Vogel *et al.*, 1999; Wheeler 2000; Krennmair, 2002). The system, developed from the Tübingen Implant, is based on over 25 years of clinical experience with root-analog implants (Schulte and Heimke., 1976; D'Hoedt and Schulte, 1989; Quayle *et al.*, 1989).

To achieve osseointegration, various authors have advocated a healing period under mucosal cover-age, thereby avoiding premature loading, infection and apical migration

of the epithelial attachment. Some authorities do not regard this as a prerequisite for osseointegration. The Tubingen Immediate Implant (Frialit-1) has been successfully used in transmucosal applications since 1975 (Gomez-Roman *et al.*, 1997).

In recent years, the use of dental implants with a wider diameter than that of standard implants has been increasingly common in clinical practice. Wide-diameter implants were initially introduced as rescue implants and were predominantly used in the posterior region upon failure of standard-width implants to allow adequate anchorage of endosseous implants in cases of reduced bone quantity and/or quality (Krennmair and Waldenberger, 2004).

Traditional protocols for the extraction of teeth in preparation for root-form implant placement advocate healing periods of 6 to 12 months before actual implant placement. However, the alveolar ridge resorption that occurs during this healing period may limit the treatment options. To avoid many limitations, a number of immediate implant placement protocols have been suggested. However, their predictability and long-term success have yet to be determined. Some of these protocols advocate the use of alloplastic materials to aid in alveolar ridge preservation and gap-filling around an implant placed immediately into and around an extraction socket (Glickman *et al.*, 2001). In this study coral bone grafts was inserted into and surface the immediate implant. The aim of the present study was to evaluate the success rates of the immediate placement of implants with coral graft augmentation within the extraction socket and compare to the immediate placement of implants without coral graft augmentation.

1.2 Statement of the problem

Mobility of implant, delayed wound healing, unstable implant, poor healing of bone and soft tissue around the implant may by complicated by large bony defects and alveolar bone loss. Dental implant is today a routine form of oral rehabilitation option and immediate placement implant technique is still a controversial issue.

1.3 Hypothesis

Immediate insertion of dental implants with coral graft augmentation into fresh extraction socket in human provide better osseointegration than immediate insertion of dental implants without coral graft.

1.4 Objectives

1.4.1 General objectives

To study the efficacy of dental implant coated with coral graft immediately placed into dental post extraction socket of human.

1.4.2 Specific objectives

I. To determine clinically the efficacy of bone healing of immediate dental implantation with coral augmentation at the bone - implant interphase.

II. To compare radiographic bone density around immediate dental implants with and without coral augmentation.

1.5 Significance of the study

The results of this study will provide information on the bone healing and implants stability after immediate placement of the coated implants using the locally (Tissue Bank, Universiti Sains Malaysia (USM)) produced coral material which extracted from marine invertebrates. This information will aid clinicians in selecting the appropriate

implants coating material for improve implants stability and biocompatibility. The innovative aspect of this study is to propose a method to analyze the bone density, reducing the need for histological analysis from human biopsy.

CHAPTER TWO

LITERATURE REVIEW

2.1 History of implant

In 1809 Maggilio inserted a gold implant into a freshly extracted tooth socket. His technique actually could be considered a two-stage procedure, as the crown was attached only after soft tissue healing. In 1895 Bonnell implanted tubes of gold or iridium in order to support teeth or crowns. In 1898 at the National Dental Association meeting, R. E. Payne gave the first clinic on the art of dental implants, describing "The Implantation of a Silver Capsule" (Fonseca and Davis, 1995).

Modern implantology began in the 1940's with a screw-type implant introduced by Formiggini. In 1962, Chercheve introduced another screw-type implant which became popular and was made of chrome-cobalt. In 1967, Hodosh used acrylic resin to make implants in tooth forms and tested biocompatibility in monkeys. Acrylic resin could be made into any shape and have the advantage of corrosion resistance. The tooth-shaped implant had a porous root type structure which was said to allow for bony ingrowth; however, results did not support that claim. Use of Vitreous carbon implants was developed to enhance biocompatibility. In 1975 Hodosh *et al.*, stated that the connective tissue interface between the implant and bone was well organized and comparable to natural periodontal ligaments. Vitreous carbon was felt to have the advantage of superior biocompatibility, inducing bone growth; the vitreous carbon implant system, made from 99.99% pure carbon with a stainless steel sleeve, had widespread use. Also they were used as single tooth replacement by embedding the implant into bone sockets (Hobo *et al.*, 1996).

The development of implants continued in the twentieth century as Payne and Scholl independently used porcelain as an implant material. Greenfield documented his

implant technique with photographs and diagrams and called implant dentistry the missing link of dentistry. He consistently described the phenomenon of oral tissue healing around immobile implants made of 20 - gauge iridioplatinum wire soldered with 24-carat gold. He too used a two-stage procedure, allowing 6 to 8 weeks for bone to "form through the root" before placing the crown or bridge (Fonseca and Davis, 1995).

In 1951, Branemark began research leading to the development of an endosseous implant system that popularized the concept of osseointegration. In 1981, when Adel and his colleagues reported on a 15-year study of Branemark's ossseointegrated implants in the treatment of the edentulous jaw, many dental practitioners believed that dental implants could perhaps finally provide predictable high-level long-term success rates. Evidence suggests that the earliest recorded use of artificial dental implants dates back to ancient Egyptian and pre-Columbian eras. The first implant specimen found appears to be from an excavated Mayan skull from A.D. 600, showing an implanted tooth-shaped piece of shell to replace a missing lower incisor (Fonseca and Davis, 1995) (Figure 2.1).

Figure 2.1: Seashells hammered into the jaw to replace missing teeth (Adapted from http://www.woodmandentistry.com).

2.2 Implant Materials

Implant materials are foreign materials that are brought into contact with a biological system. Biomaterials are nonliving materials used for medical application (for example as a dental implant) with the goal of achieving a reaction (interaction) with the biological system (Rateitschak and Wolf, 1995).

2.3 Classification of Materials

The materials available for transplantation and implantation can be grouped according to immunologic criteria as shown in table 2.1.

Types of Bone Graft	Description	Example
1- Autologous (autogenous) materials	Autoplastic (from the same organism)	Transplantation of implanted teeth, reimplantation of teeth ,bone transplants
2- Homologous (Allogenic) materials	Homoplastic (from another individual of the same species)	Banked bone (lyophilization)
3- Heterologous (xenogenic) materials	Heteroplastic (from an individual of another species)	Devitalized, deproteinated bone (Kiet bone chips), collagen, gelatin
4- Alloplastic materials	Alloplastic (foreign substances)	Metals, ceramics, plastics

Table 2.1: Classification of Materials (Klaus and Herbert, 1995).

2.4 Types of Implant

- Screw and Cylinder-shaped Implants are commonly referred to as "root form implants".
- Blade Implants: Fibro-Osseous integration could occur around blade implants, defined as the development of a functionally oriented, peri-implant connective tissue that would dampen or absorb the forces of mastication (Rateitschak and Wolf, 1995) (Figure 2.2).

Implants types can be divided also into:

2.4.1 SUB-PERIOSTEAL IMPLANTS

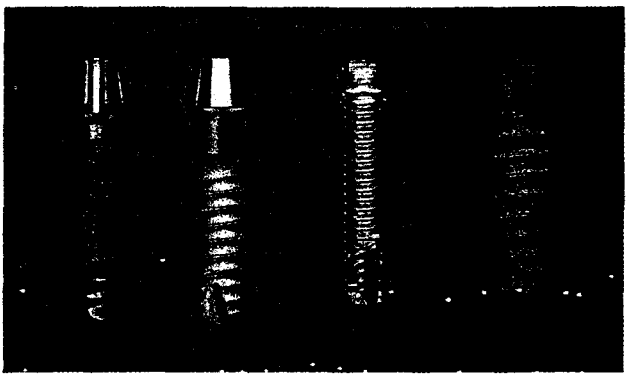
A subperiosteal implant is a framework fabricated to fit intimately on top of the mandible or maxilla under the mucoperiosteum.

2.4.2 TRANS-OSTEAL IMPLANTS

The transosteal implant is an implant with a bone plate fitted against the inferior border of the symphysis.

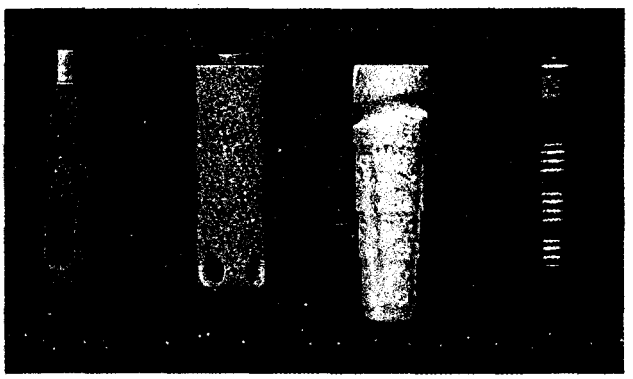
2.4.3 ENDO-OSTEAL IMPLANTS

Endosseous implants are most frequently utilized. They are placed in the bone of the maxilla or mandible via intraoral incisions. There are several different designs available commercially, including screw, cylindrical and blade types (Alberto, 1998).



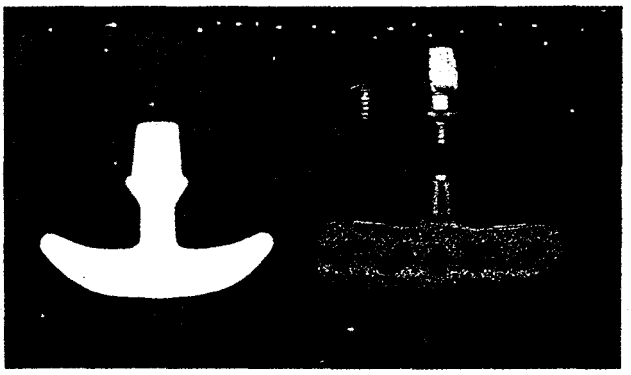
Screw Implants

From left to right:
-TPS screw
- Ledermann screw
- Branemark screw
- ITI Bonefit screw



Cylinder Implant

From left to right:
- IMZ implant
- Integral implant
- Frialit–1 step–cylinder
- Frialit–2 step–cylinder



Blade Implants

- Left: Single-post Biolox implant
- Right: Single-post, two Stage titanium blade Implant

Figure 2.2: Types of Implant (Klaus and Herbert, 1995).

2.5 Titanium

Titanium is widely used as dental implant material, because direct contact occurs between bone and the implant surface (Knabe *et al.*, 2002).

It is the ideal metal for intra-osseous dental implants. It provokes a spontaneous oxide layer formation on its surface protecting the metal from chemical attack, including potentially aggressive body fluids (Sergio *et al.*, 2005).

Titanium alloy dental implants as an aid to prosthodontic rehabilitation are a relatively new but important part of dentistry. The dental, biomaterials, and orthopedic literature clearly show that titanium and other trace metals maybe found in the peri-implant tissues, regional lymph, nodes, lungs, kidneys, livers, serum, and hair after implant placement (Millennium, 2001).

Implants made of commercially pure titanium (cpTi) were the first to gain widespread acceptance. Bone does not bond directly to either cpTi or titanium alloy (Ti-6A1-4V) implants. It attaches by means of a complex interaction between the extracellular matrix tissues and the titanium – oxide layer formed when the metals are exposed to air or tissue fluids (Kasemo and Lausmaa, 1985; Stanford and Keller, 1991).

2.6 Osseointegration

Osseointegration is defined as a "direct structural and functional connection between ordered living bone and the surface of a load-carrying implant" and as "direct anchorage of an implant by the formation of bony tissue around the implant without the growth of fibrous tissue at the bone-implant interface" (Branemark, 1983; Osseointegration, 2000) (Figure 2.3).

It is now said that an implant is regarded as osseointegrated when there is no progressive relative movement between the implant and the bone with which it has direct contact (Brănemark, 1983).

It also defined as the direct connection from implant to living remodeling bone without any soft tissue component between implant and bone on the light microscopic the light microscopic level (Götz *et al.*, 2004).

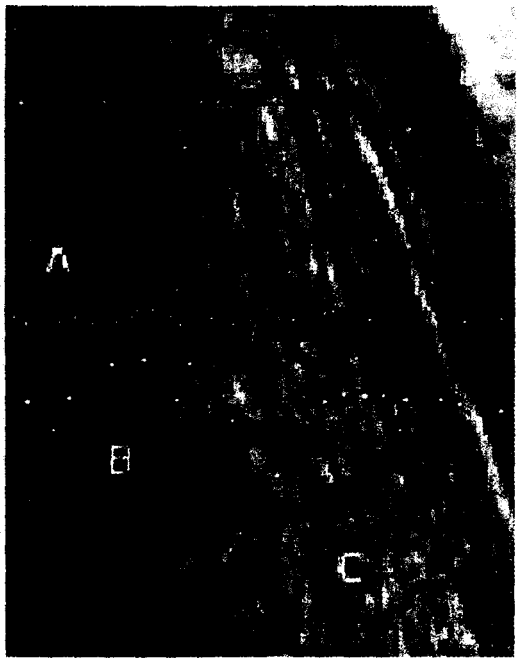


Figure 2.3: Dental implant osseointegration micrograph (Courtesy of Dr. Lyndon Cooper) A: dental implant, B: implant and alveolar bone interface, C: alveolar bone.

2.7 Bone remodeling

Osseointegration requires new bone formation around the fixture, a process resulting from remodeling within bone tissue. Remodeling, bone resorption and apposition, helps maintain blood calcium levels and does not change the mass quantity of bone (Hobo, 1996).

The development of a dynamic functioning attachment of implants to bone is imperative for the long-term success of implant-supported dental prostheses. The most successful material in long-term clinical studies of osseointegrated oral implants is commercially pure titanium (Konig *et al.*, 1998; Sul *et al.*, 2002). Special surfaces have been studied in order to be used in more complex surgical situations such as: immediate implant placement, expansion of the residual ridge, or maxillary sinus floor elevation. The HA-coated implants should have the advantage of providing an osteoconductive surface for enhanced bone growth (Kay, 1992; Reddy, 1995). More recently, novel types of implant systems have been developed with rough surfaces using different methods such as: plasma spraying, blasting, etching, beading or sintering in order to increase the bone implant contact surface.

Bone has a unique capability of self-regeneration and remodeling to a certain extent throughout life without leaving scar. If self-remodeling fails due to certain conditions such as trauma, bone metabolic diseases, neoplasm and others, in used for bone regeneration dental synthetic bone grafts and coated implant materials can be applications (Lobato, 2006).

2.8 Bone healing

Bone is a unique tissue. It can be injured and then can repair itself and return to full function with or without scarring or deformity (Salter, 1983). Embryonic bone

development is repeated in the healing of bone. The pattern of bony healing is dictated by the host bed, vascular supply, oxygen tension and the stability of the bone segments (Buckwalter *et al.*, 1995). Healing can occur either directly as primary bone healing or secondarily, demonstrating an intermediate cartilaginous phase (Hollinger *et al.*, 1994).

2.9 Bone density

Available bone is particularly important in implant density, and describes the external architecture or volume of the edentulous area considered for implants. In addition, bone has an internal structure described in terms of quality of density, which reflects the strength of the bone (Scortecci *et al.*, 2001).

2.10 Dental implant interface

The health or quality of the soft tissue surrounding an implant may be influenced by many factors. The presence of keratinizing mucosa surrounding an implant is thought to be a positive factor in maintaining soft-tissue health. In many implant systems, the con-notion between the implant and the prosthesis creates a small microgram that has been implicated in the ongoing health of soft tissue surrounding implants (Myshin and Wiens, 2005).

Coating of implants with locally acting growth factors may influence the remodeling process at the tissue-implant interface and therefore the integration of implants into healing bone. Growth factors like plate-let-derived growth factor (PDGF), bone morphogenetic proteins (BMPs), insulin-like growth factor (IGF) or TGF-β facilitate the osseointegration of different kinds of implants (Fischer *et al.*, 2003).

2.11 Hydroxyapatite-coated implant

Since the initial development of hydroxyapatite (HA)-coated dental implant in 1984, numerous studies have demonstrated favorable or superior results for HA-coated implants as compared with uncoated titanium implants. von Vlitterwijk demonstrated 65% of the 50μm thick HA coating was reabsorbed during unstable mechanical condition. Despite numerous claims about one surface or another, there have been no randomized clinical trials to compare efficacy of HA-coated versus titanium-coated endosseous implant in various types of the alveolar bones. The purpose of this study was to compare the early success rate of HA-coated cylinder implants and TPS cylinders in different regions of the mouth (Jones *et al.*, 1997).

Lekholm *et al.* (1996) observed no differences between implants with and without exposed threads after placement over a 5-year period of loading. Several studies indicate low failure rates when placing implants in immediate extraction sockets (Gomez-Roman *et al.*, 1997; Tolman and Keller, 1991; Becker *et al.*, 1994; Schwartz-Arad and Chaushu, 1997; Fugazzotto, 1997). Yukna (1991) compared placement of HA-coated implants in extraction sockets and healed sites in 14 patients and found no differences.

The first clinical use of HA as a coating for endosseous dental implants appeared in 1984. HA is a naturally occurring calcium phosphate ceramic that is found in abundance in tooth enamel, dentin, and bone. In its synthesized form, it is applied to a Ti-6A1-4V substrate (the usual method is plasma spraying) to form a nontoxic bioactive coating that bonds chemically with adjacent bone. Block *et al.*, (1987) and Meffert *et al.*, (1987) when HA implants are compared with titanium, there is evidence for more rapid osseointegration (Gerner *et al.*, 1988). In animal studies, Block *et al.*, (1987) observed biointegration of HA implants as early as 4 weeks. After 10 months, 90% of the coated implants had a continuous surface layer of lamellar bone connecting the

implant with the trabecular bone. In contrast, titanium implants exhibited osseointegration only at 4 months, with 50% implant-bone contact at 10 months (Block, 1991).

In a second study Block *et al.*, (1989) found gingival fibers inserting directly into the osseoid tissue covering the HA coating. The relative merits of HA and non-HA implants remain controversial, and debate between their respective adherents continues to enliven discussions in the field of implant dentistry. Reports based on anecdotal data have suggested that HA coatings are unstable, have an increased susceptibility to bacterial infection, and may be disposed to rapid bone loss or saucerization (Biesbrock and Edgerton, 1995). In addition to being based on isolated case reports, these arguments do not reflect the current state of implant technology. Improvements in the crystallinity of HA coatings have eliminated a cause of failure in some early implant designs (Kay, 1993; Lacefield, 1994). The incorporation of a machined metal collar in most modern HA implants further enhances survival, because the machined surface resists plaque formation and microbial colonization, both of which were common in early implants when soft tissue changes exposed the porous HA coatings to the oral cavity.

Calcium phosphate coated titanium and titanium alloy are widely used as dental implant materials. These coatings have been found to accelerate initial stabilization of implants by enhancing bony in growth and stimulating osseous apposition to the implant surface, promoting a rapid fixation of the devices to the skeleton. Hence their use as coatings of the endosteal portions implants. Of the various calcium phosphates available, HA has been most commonly used as coating for titanium and its alloy (Knabe *et al.*, 2004).

In the first phase, the postoperative stability is usually obtained using a proper surgical technique and proper implant hardware. In the second, the long-term stability depends on the bone adaptation to the stress pattern induced by the fixture. It follows that for the proper evaluation of the long-term stability of the fixture it is fundamental to take into consideration the mechanical properties of the bone surrounding the implant as a remodeling tissue. It is well-known that the morphology of a bone is first established by genetic factors and afterward the bone goes through dynamic shape and density optimisation to adapt its mechanical properties and structural behavior to the local stress (Soncini *et al.*, 2002).

2.12 Calcium Carbonate, Natural coral (NC)

Natural coral (NC) is considered as a xenograft. NC has been used as a biomaterial for bone replacement because of several reasons such as the material simplifies the surgical procedure, harvesting of autologous bone is no longer necessary and no risk of transmission of infection of Human Immunodeficiency Virus, Hepatitis B, Hepatitis C and Creutzfeld Jacob-disease can be avoided with certainty (Volpi, 1999).

Coral is made by marine invertebrates that extract calcium and phosphates from the sea to build a limestone exostructure in which they live in. This exostructure porous and mimic the structure of natural bones. Therefore these limestone structures are appropriate for bone grafting.

The NC used in this study is natural coral in the form of aragonite (more than 98% $CaCO_3$) that is not altered by processing and it is a resorbable, porous, calcium carbonate graft material produced by the National Tissue Bank, Universiti Sains Malaysia. In recent studies dead sea coral of Porites species has been harvested from Malaysian costal region for production of coral bone substitute (A license was provided

by the Department of Fisheries Malaysia to harvest dead coral for this purpose) (Figure 2.4).

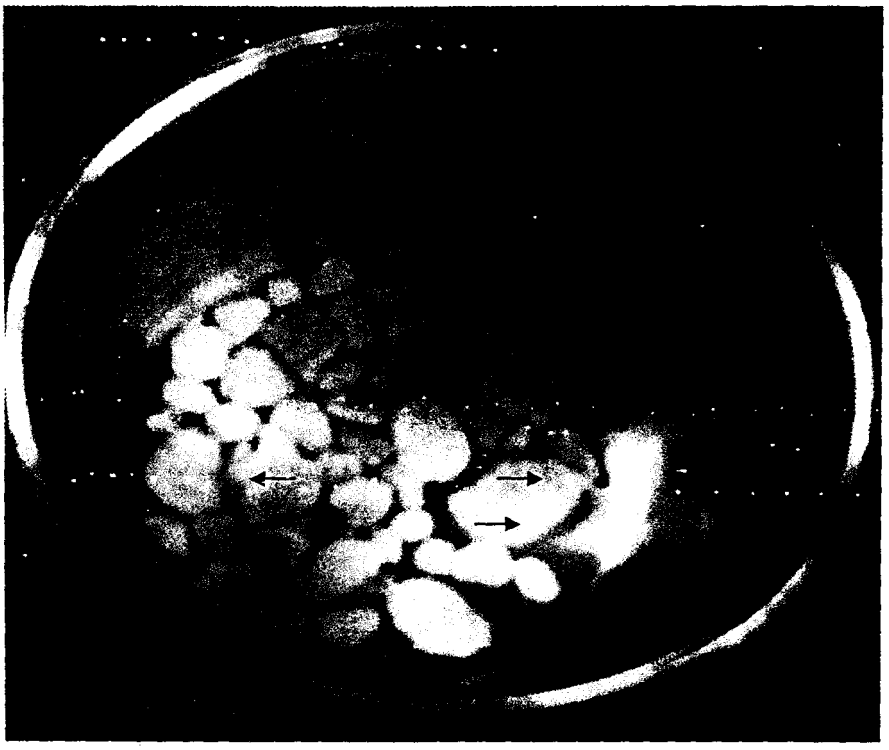


Figure 2.4: Natural processed coral. The arrows point at the pores that can be detected with the naked eyes.

This prepared coral graft went through material characterization studies, biological validation studies, in vitro and in vivo studies and finally followed by a controlled clinical trial as shown in table 2.2 (Suzina *et al.*, 2002).

The Ames test results demonstrated that the prepared coral material did not exhibit mutagenic activity under the chosen conditions. Thus, the material can be considered non-genotoxic (Suzina *et al.*, 2004).

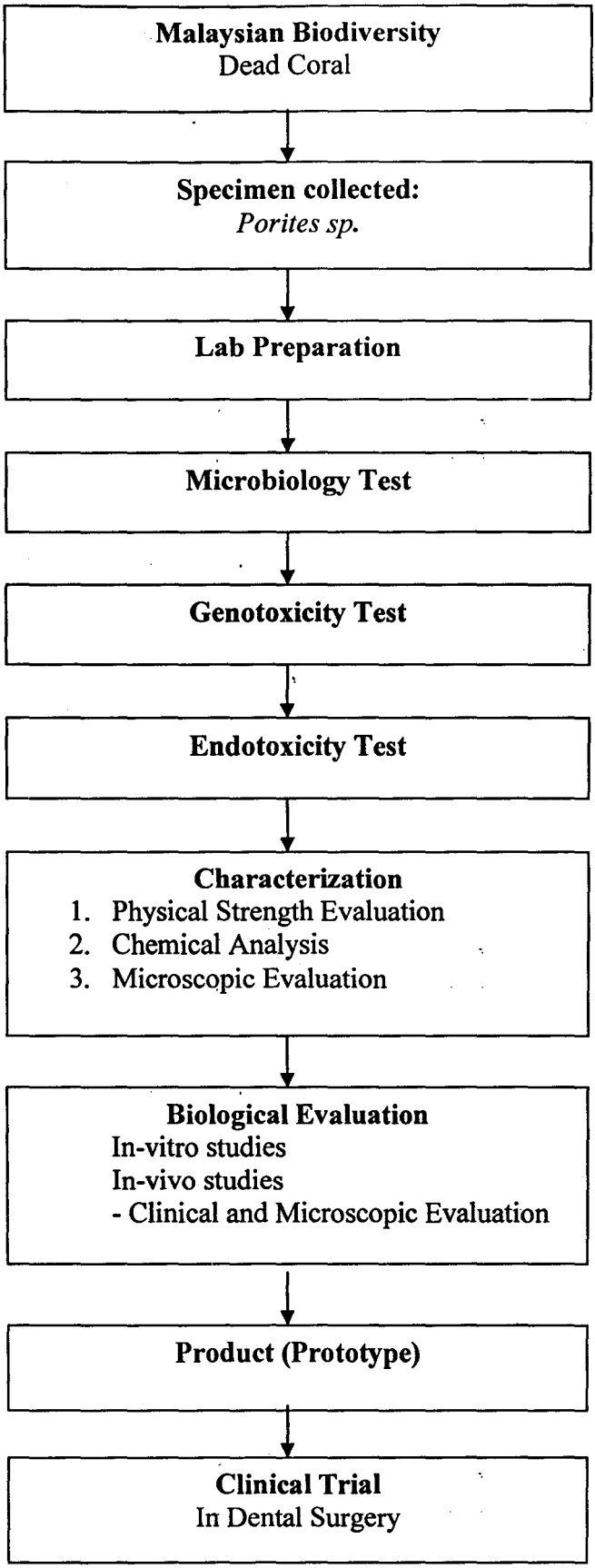


Table2.2: Flow chart showing the phases of Development and Evaluation of sea coral for bone grafting (Suzina *et al.*, 2002).

Biological evaluation is of utmost important in assessing the potential benefit of implantable material for human use. In vitro study, it was found that the coral material was biocompatible and non cytotoxic to fibroblast (MRC-5) and osteoblast (NHOst) human cell-lines (Shamsuria *et al.*, 2004).

Coral blocks were also implanted in a defect created in the mandible of New Zealand white rabbits and similar histological findings were found. Histological assessment with the aid of light microscope and confocal laser scanning microscopy also showed bony in growth into the pores of implanted coral material block (Rosdan *et al.*, 2004).

Yukna reported that the clinical response to this kind of material, particularly related to periodontal osseous defects fill, was essentially similar to or slightly better than other grafts. The size and shape of the particles made it easy to manipulate the material during surgical procedures. Furthermore calcium carbonate appeared to have good homeostatic properties and was not readily displaced from the treatment site (Yukna, 1994).

In other studies natural coral showed a significant increase in the absolute contact length measurements of endosteal bone growth along the Nickel-Titanium implants coated with coral powder. Therefore studies have shown earlier and higher osseointegration phenomena compared to the non-coated implants and, there was significantly greater bone-to-implant contact at the apical 1/3rd of the implants coated with coral (Najafpour *et al.*, 2004).

A prospective clinical analysis on preservation of ridge dimensions following grafting with coral granules was done by Sandor. The ridge dimensions were grafted with coral

and afterwards implant was placed. They claimed the grafting was successful and dental implants were stable (Sandor *et al.*, 2003).

NC exoskeleton is a bioactive material used as bone substitute in different surgical specialties Maxillofacial and buccal surgery (Fricain *et al.*, 2002). On the contrary, Lopez *et al.*, (1992) have recently shown that nacre, which associates calcium carbonate and an organic matrix, might have osteogenic and osteoinductive properties (Lopez *et al.*, 1995). All these results suggest that the organic matrix of coral exoskeleton (COM) could be decisive in the integration or rejection of coral by bone. Moreover, only a few studies have been performed on COM and all concern biochemical analysis COM and all concern the biochemical analysis of coral species which are not used as bone substitutes (Allemand *et al.*, 1994). So the objective of this study was to extract COM to carry out biochemical analysis and to study its specie cytocompatibility in vitro in contact with human bone marrow cells.

The ability of the human body to regenerate bony tissues that are lost or damaged is limited. In the case of important bony defects, an autogenous bone graft is considered as suitable transplant material because differences in biocompatibility and the risk of transferring viruses from one individual to another are non-existent. Removal of the bone graft creates additional surgical trauma. Allogenic and xenogenic bone grafts represent alternatives but several problems are generally associated with them such as in vivo resorption, virus transfer, considerable care, high cost and regular immuno-defensive reaction. For all these reasons, bone substitutes are generating growing interest and are frequently used in orthopedic surgery. They are alternatives to autogenic, allogenic and xenogenic bone grafts. One hopes that they are replaced gradually and completely by neoformed bone with the same bone characteristics at the end of the restoration process. Natural coral, submitted to rigorous protocols of preparation and purification, can be used as a replacement biomaterial for bone grafts

both in orthopaedic surgery and maxillo-craniofacial surgery. It can replace bony tissue without inappropriate response from the human body (biocompatibility); it develops a chemical bond with the bone surface (bioactivity) and is able to form bony tissue when it is in contact with bone (osteoconductivity) (Barbotteau *et al.*, 2003).

Schwartz-Arad and Chaushu (1998) reported a successful clinical outcome for 9 single implants placed immediately after tooth extraction without incisions or primary flap closure. Complete bone healing was achieved with papilla preservation and minimal gingival recession. Clinical cases with extensive bone loss were excluded from the study. The purposes of the present study were to evaluate implants placed immediately after tooth extraction without incision or primary flap closure and to observe the peri-implant soft tissue healing.

Brazilay *et al.*, (1991) used animal models to compare 48 immediately inserted implants with conventionally placed implants. When both techniques were compared, there were no significant changes in bone-to-implant interface 7 months following the delivery of the prosthesis.

In animal and human studies, it has been shown that resorbable barriers can be successfully used for bone augmentation purposes (Kostopoulos and Karring 1994) and (Simion *et al.*, 1997). Furthermore, the combination of resorbable barriers and immediately placed implants seems to be comparable with the combination of nonresorbable barriers and immediately placed implants in terms of integration of the implants.

Cordioli and colleagues (1994) reported the clinical experience of 47 patients rehabilitated with a single-tooth restoration. The total implant survival rate was 94.4%. Engquist and associates (1995) evaluated the outcome of single-tooth restorations