A Pilot Study
Of Bovine Bone for Orbital Implants in Rabbits

By

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2. DISCLAIMER

I hereby certify that the work in this dissertation is my own except for the quotations and summaries which have been duly acknowledged.

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7. ABSTRAK

Objektif:

Kajian ini adalah untuk mengenal pasti tindakbalas klinikal dan bioserasi tulang bovine yang telah dijadikan implan bagi mata arnab. Kajian ini juga digunakan bagi mengenal pasti samada implan ini tidak mempunyai kesan-kesan sampingan seperti migrasi implan , jangkitan yang keterlaluan mahupun kegagalan bola mata bergerak secara normal dan akhirnya bagi membuktikan bahawa implan ini mempunyai bioserasi ke atas arnab yang menjalani pembedahan implan tersebut. Kajian ini juga dapat memastikan implan ini selamat dan kos efektif bila dibandingkan dengan implan yang sedia ada.

Tatacara:

Kajian ini dijalankan melalui eviserasi ke atas mata kanan 12 ekor arnab New Zealand White. Kumpulan A (n = 6) dieviserasi tanpa meletakkan implan manakala kumpulan B (n = 6) dieviserasi dengan meletakkan implant tulang bovine. Pemeriksaan klinikal dijalankan pada hari pertama , ketujuh , keempat belas , kedua puluh lapan dan hari keempat puluh dua. Pada hari keempat puluh dua , enuklasi dilakukan pada mata yang telah diletakkan implant tulang bovine. Mata tersebut dihantar ke makmal untuk dikulturkan dan pemeriksaan patologi. Ini bertujuan untuk memastikan tindakbalas bioserasi implan ke atas mata arnab

Keputusan:

Ciri-ciri klinikal yang dikaji dari hari pertama hingga hari keempat puluh dua dan akhirnya tindakbalas bioserasi dijalankan di makmal patologi. Keputusan yang telah di dapati menunjukkan tiada tindakbalas klinikal yang ketara meskipun terdapat ciri-ciri jangkitan pada hari pertama tetapi ia menunjukkan respon yang sempurna pada hari yang berikutnya. Komplikasi seperti migrasi implan , luka terkena jangkitan mahupun luka yang terbuka dan bola mata tidak dapat bergerak secara sempurna tidak dapat dijumpai ketika kajian dijalankan . Hasil pemeriksaan histopatologi menunjukkan berlakunya biokeserasian di antara implan kepala tulang femur lembu dengan mata kanan arnab seperti mana yang telah ditunjukkan di dalam ciri-ciri klinikal yang lain seperti yang telah dibuktikan sebelum ini.

Kesimpulan:

Andaian yang dapat dibuat daripada hasil kajian ini mendapati tulang bovine adalah efektif dan kurang kesan sampingan bagi digunakan keatas arnab mahupun kemungkinan besar bagi manusia. Ia agak selamat berdasarkan kurangnya kesan sampingan dan implan ini berjaya menunjukkan ia sebati dengan penerima implan iaitu arnab. Implan ini juga amat selamat dan kos efektif berbanding dengan implan yang sedia ada.

8. ABSTRACT

Objective:

To assess the biocompatibility of bovine bone xenograft as ocular implants in rabbits. At the same time, to determine the presence of histopathological and clinical rejection towards bovine bone xenograft as ocular implant in rabbits.

Methodology:

Eviscerations with and without bovine bone orbital implantation were performed onto the right eye of 12 New Zealand white rabbits. Group A (n = 6) was eviscerated without implant whereas Group B (n = 6) was eviscerated with insertion of an orbital implant using bovine bone. Observation was done at day 1, day 7, day 14, day 28 and day 42. Serial clinical examination was done based on a few fixed criteria including rate of infection, implant migration, any evidence of wound breakdown and any restriction of intraocular movements. The implanted eyes were then enucleated on day 42. The enucleated eyes were sent for histopathological evaluation to record the type of inflammatory reaction and rate of fibrovascular ingrowth.

Results:

Serial clinical examination showed presence of minimal infection in all eyes both in the control group and the implanted first post operative day, which responded well with antibiotics. Infection occured after first post operative day but there was no evidence of orbital migration or extrusion of implant, wound breakdown, restriction of extra ocular

movement, severe infection or any physical abnormality of implanted groups. Histopathological examination revealed good fibrovascular ingrowth in implanted groups, with minimal reaction of rabbit eye towards bovine bone implant.

Conclusion:

Orbital bovine bone implants was highly biocompatible with minimal infection during the early period and no evidence of clinical rejection. Histopathology examination supported the evidence of good fibrovascular ingrowth and minimal inflammatory reaction towards the implants. We can thus conclude that this bovine bone implant has a high potential for use clinically with the added advantage of being cost effective.

Chapter 1
Introduction

1.1 Introduction

The search for the ideal ocular implant for the anopthalmic socket continues to evolve. This ocular implant must be able to compensate the orbital volume deficits in the absence of the globe. It must be biocompatible and should have minimal rates of migration, extrusion, exposure and infection. Finally, the ocular implant should be able to accommodate ocular motility as much as possible reproducing the normal movement of the eyeball.

Many materials and implants types have been used to fulfil the above objectives. Currently synthethic porous ocular implants such as hydroxyappatite and porous polyethylene have yielded excellent motility and cosmesis with minimal complications. However these materials are expensive.

To our knowledge the use of bone grafts as ocular implants have not been conducted either animal or human clinical studies. However, of late bone allograft have been used for the management of orbital floor fractures reconstruction (AR Samsudin , 1995). This result showed that the allograft was well tolerated without failures. The cost of the allograft locally was RM 12.00 for the size of 2 cm × 2 cm × 1 cm and this makes it very cost effective.

In this pilot study, a bone graft will be experimentally used as an ocular implant in rabbits to determine whether it could be successfully used in the anopthalmic socket as an alternative to the expensive synthetic alloplastics.

1.2 Background

Artificial eyes can be dated back to approximately 2500 BC, during the Egyptian Fourth through Sixth Dynasty. The artificial eyes were used in the mummification process and were made of gold, silver, marble and other luxurious materials. There is also evidence that artificial eyes were present in Ancient Rome, Greece and China. In the mid 1500's Ambrose Pare a French military surgeon, the first to document the use of artificial eyes in human by using first made eyes from glasses (Alexander, 1996). During World War II, other materials have been experimentally used such as gold, silver and porcelain.

In 1944, a dentist W.D. Barker created an acrylic eye to be used for orbital implant. His theories stated that this new material was more resistant to scratches; breakage and attack by lacrimal secretions were proved to be true. W.D. Barker continued to develop his ideas and soon was able to produce large quantities of eyes by making half spherical eyes pressed in molds and hand painted.

In 1874, Noyes performed routine evisceration in cases of severe infection. His method involved incising the cornea to remove the contents of the globe and claimed that he was able to obtained good cosmetic results and had no cases of sympathetic ophthalmia. In 1884, Mules was the first to introduce a hollow glass ball into the scleral cavity after the removal of the cornea.

Later these procedures become unpopular because of the fear of sympathetic ophthalmia and reports of shattering of the glass ball. During World Wars I and II a tremendous calamities of facial injuries then generate the interest of many surgeon to renewed the evisceration procedures allowing the best cosmetic outcomes.

1.3 Indication of Orbital Implants

Losing an eye to trauma, tumor or end stage ocular disease such as glaucoma can be devastating at any age. It may have a major impact on ones self-image, self-confidence and self-esteem not to mention the adjustment required in adapting to monocular vision. Furthermore there are several job restrictions that apply for one-eyed patients. Thus it is important for the artificial eye patient to maintain a natural, less interaction and normal appearing prosthetic eye.

Before making the decision to remove an eye, consideration should be given to all alternatives and make every attempt to preserve eyes that have potential for useful vision. In the vast majority patients who had their eye removed, the damaged or diseased eye has little or no vision remaining.

There are several indications that could warrant removal of an eye, including:

1. A painful blind eye.
2. A severely traumatized eye.
3. Life threatening tumors such as malignant melanoma.
4. Poor cosmetic appearance of blind eye.
5. Presence or risk of symphathetic opthalmitis.

1.4 Surgical Procedure

There are two methods available, namely evisceration and enucleation, to remove the eye to provide pain relief and prepare for reconstruction of the anophthalmic socket. Each has their own benefits, and the decision as to which procedure is a best need to be customized.

During evisceration, the contents of the eye are removed, leaving behind a pocket of sclera. The pouch of sclera is filled with an orbital implant or sphere. The sphere may be made of polymethylmethaarylate (PMMA) or hydroxyapatite material. This orbital sphere or implant remains permanently behind the soft tissues of the orbit, Tenon's and conjunctiva (Hersh, 1988). The tissues are allowed to heal for 6-8 weeks prior to the fitting of the ocular prosthesis. Because muscles that control eye movement remain attached to the sclera, and as a result evisceration generally gives better movement to the ocular prosthesis (artificial eye) than most types of enucleation procedures.

Evisceration involves complete removal of the ocular contents through an opening in the cornea or sclera, leaving the optic nerve and sclera along with attached extraocular muscles. The first evisceration was recorded in 1817 when an iridectomy for acute glaucoma was complicated by an expulsive haemorrhage forcing James Bear, an ophthalmic surgeon to remove the contents of the globe.

Evisceration was considered in cases such as endopthalmitis unresponsive to antibiotics and improvement of cosmesis in a blind eye but it is contraindicated in cases of

suspected intraocular malignancy and may not relieve the pain associated with blind eye since ciliary nerves remain intact.

Enucleation involves the removal of the entire globe with preservation of the eye muscles (Hersh, 1988). These muscles can be placed around an orbital implant to facilitate movement of the prosthetic eye. Under certain rare conditions e.g in cases of extensive orbital malignancy and severe infection, an implant cannot be used.

There are advantages and disadvantages of evisceration comparing to enucleation. An advantage of evisceration gives a better cosmetic result with good superior motility of the prosthesis (Bailey, 1988). There are fewer tendencies toward the development of enopthalmos and deep supratarsal sulcus formation. Also orbital volume can be maintained close to the original state and in cases of endopthalmitis, evisceration avoids further contamination of the orbit and spreads of infection into subarachnoid space.

1.5 Orbital Implants

In managing anopthalmic socket, two major components are important; an orbital implant to maintain the volume of the eye socket and an artificial eye or prosthesis. A variety of materials have been used for the orbital implant including gold, silver, cartilage, bone, fat, cork, titanium mesh, acrylics and silicone in an attempt to find the most biocompatible, least reactive implant over the last 100 years. A variety of shapes and sizes have also been tried to try and provide some motility to the socket.

The first-generation implants were a major improvement for those wearing an artificial eye, but they were unable to deliver a natural movement to the artificial eye. This lack of movement was a major obstacle to restoring a natural appearance, which made the adjustment to wearing an artificial eye much more difficult.

The first-generation implants also tend to drift (migrate) in the orbit and were often rejected by the body, making further surgery necessary. These problems inspired researchers to seek a better orbital implant.

When an eye is removed, an orbital implant is used to replace the volume in the orbit (bony cavity surrounding the eye) that was previously occupied by the eye. This small, spherical implant maintains the natural structure of the orbit and provides support for the artificial eye without being visible.

While artificial eyes have been made for thousands of years, the first orbital implant was developed only about 100 years ago. These small spheres of glass or gold were later replaced by plastic or silicone spheres. The basic design of these first-generation orbital implants changed little and minimally over the years until the development of the Bio-eye Orbital Implant in 1985.

The first step in the quest for an ideal implant, however, began with a focus on the less significant but more manageable problem of reducing the complications common to existing synthetic implants. The basic strategy was to develop an orbital implant that incorporated all of the design features that the literature review had shown to be common features of the most successful implant designs.

The ideal features of orbital implants should include the following factors;

a. Maintain natural lid shape
    - The implant must provide a means, such as the ability to receive a motility/support peg, to support the weight of the artificial eye to prevent damage to the delicate muscles of the lower lids over time.
b. Light weight
    - The implant must be light in weight.
c. Porosity
    - The implant must allow vascular orbital tissues to invade its structure to:
        a. Lock it into place and prevent migration,
        b. Allow it to overcome infections from within the implant via the vascular bed infiltrating the implant
        c. Support "healing from within" of any defect in the conjunctival-Tenon's closure.
d. True integration
    - The implant must be directly integrated (e.g., via a peg) with the artificial eye to allow direct transfer of all available movement from the rectus muscles to the artificial eye.
e. Natural biocompatibility
    - The implant must be a natural material and readily accepted by the tissues of the orbit to prevent "synthetic implant syndrome" i.e., pseudocapsule formation around the implant. This pseudocapsule is the body's way of walling off a foreign material. Presence of this pseudocapsule will cause

rejection of implants and not allowing fibrovasular ingrowth towards the implant.

1.6 Types of Orbital Implants

Orbital implants replace the volume lost by the eviscerated or enucleated eye. There are two major groups of orbital implants.

1. Integrated.
2. Non integrated.

1.6.1 Non Integrated Orbital Implants

Non integrated implants contain no unique apparatus for attachments to the extraocular muscles and do not allow ingrowth of organic tissue into their organic substance. These types of implants have no direct attachment to the ocular prosthesis.

Materials used as non-integrated implants include glass, rubber, silicone, steel, gold, silver, acrylic and polymethylmethacrylate (PMMA). As compared without any implants, these materials provide both volume replacement and improved cosmesis.

1.6.2 Integrated Orbital Implants

A. Hydroxyapatite

This type of orbital implant is commonly used during enucleation surgery. It is formed from a salt of calcium phosphate that is present in the mineralized portion of human bone. It is reported to be non-toxic, nonallergenic, and biocompatible. Its porous structure allows integration of fibrovascular tissues into the stroma of the implant.

Sires and associates postulate the pore orientation in the hydoxyappatite sphere may influence the degree of vascularization and that poor vascularization might result in implant extrusion.

Fibrovascular ingrowth and density changes have been assessed by a variety of radiographic techniques but contrast-enhanced magnetic resonance imaging with surface coil appears to be the modality of choice.

These radiograpichs techniques have been demonstrated by Jamell and coworkers how magnetic resonance imaging with contrast enhancement shows early peripheral vascularization of the implant, with vascularization of the central core.

B. Porous Polyethylene

Porous polyethylene is another integrated implant material. This spherical implant was approved for clinical use in reconstructive surgery in 1985. Like hydroxyapatite, porous polyethylene allows fibrovascular ingrowth although not as quick as hydroxyapatite.

Histopathological evaluation revealed that the fibrovascular ingrowth extended to the central core of the implant. Advantages of the porous polyethylene device are that it does not require donor sclera or other type of wrapping material.

Porous polyethylene implants are smooth and malleable, which makes implantation easier. The device can be implanted in the standard fashion followed by attachment of the extraocluar muscles at points approximating the spiral of Tillaux. One major disadvantages of this material was the lack of an integrating device for the ocular prosthesis

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C. Synthetic Hydroxyapatite

Synthetic hydroxyapatite has been noted to maintain all of the functional characteristics of traditional hydroxyapatite, but at half the cost. Jordan et al reported on 60 patients who had this implants, there was only one wound dehiscence and minor problems common to traditional hydroxyapatite implants. Synthetic hydroxyapatite implants appear to be a cost effective alternative to traditional hydroxyapatite implants.

D. Proplast

Proplast is an inert, porous, alloplastic material originally used in orthopaedic procedures. It allows fibrovascular ingrowth and attachment of extraocular muscles and has been used as a subperiosteal implant and an orbital implant.

Neuhaus et al noted that there were no cases of implant migration or extrusion during 2 years in the first four patients and 1 year in an additional six patients.

E. Other Implants

Many substances have been considered for use in orbital implants. Polytetrafluoroethylene that was previously investigated for use as wrapping material for hydroxyapatite implants has recently been investigated for use in spherical orbital implants in a rabbit model.

1.7 Hydroxyapatite Orbital Implants

The first orbital implant made of hydroxyapatite was implanted in 1985, by Dr. Arthur Perry, after several years of preliminary research but hydroxyapatite was first used in animal studies as an ocular implant in 1983 (Ashworth J.L , 1996). In August 1989, the FDA released the first HA ocular implant, now known as the Bio-eye HA ocular implant. These spheres are completely porous throughout their structure and have an average pore size of 0.5 mm. Natural porous HA is very much like human cancellous bone.

The advantages of using natural porous hydroxyapatite as an ocular implant include:

1. Decreased lower -lid sag due to the peg's support of the weight of the artificial eye.
2. Potential for direct coupling with the artificial eye to make the artificial eyes move in conjunction with normal eye.
3. Decreased migration.
4. Decreased extrusion.
5. Resistance to infection.

Hydroxyapatite , the major chemical component of bone , has the chemical composition $Ca^{10}(PO_4)_6(OH)^2$. Hydroxyapatite is an inert, biocompatible, non-toxic and non-allergenic bio ceramic, making it an ideal choice for an ocular implant. The hydroxyapatite intergrated implant to be used in this procedure is composed of calcium phosphate obtained from a femoral head of bovine bone. At the core of this implant, there are interconnecting pores about 500 μm in diameter (Ashworth J.L, 1996). These interconnecting pores allow for vascular tissue in-growth and anchorage to ocular socket.

The hydroxyapatite implant provides for natural motility, has a lower extrusion rate than other eye prosthetic materials and resulting in lower risk of infection. Few sides' effects of this hydroxyapatite have been reported including conjunctival thinning implant exposure and socket infection.

The natural hydroxyapatite orbital implant achieved its success because it is highly biocompatible and completely porous. Hydroxyapatite is a complex calcium phosphate, which is the same mineral that comprises the hard portion (mineral portion) of human

bone, and is therefore readily accepted by the tissues of the orbit. Additionally, natural hydroxyapatite is derived from a specific genus of marine coral whose exoskeleton is completely porous: each pore connects with every other pore (Ashworth J.L, 1996).

This is an extremely important characteristic for long-term success. Synthetic orbital implants silicon; polyethylene, porous polyethylene (like Medpor) and aluminum oxide (like Bioceramics) have been unable to duplicate the complete interconnective characteristic of natural hydroxyapatite. Natural HA also matches the 500-μm pore size characteristic of human cancellous bone (Piecuch, 1982) in which, by volume, is 50% hard tissue and 50% soft tissue. When placed into the orbit, natural HA becomes fully incorporated with the fibrovascular tissues of the orbit, and when attached to the rectus muscles, can deliver all available socket motility directly to the artificial eye.

Additionally, the natural hydroxyapatite orbital implant has the longest successful track record of any known implant material that can successfully accommodate a motility/support peg, which directly connects the artificial eye to the implant. The complete interconnected porosity filled with fibrovascular ingrowth makes this possible. The motility and support peg, supports the weight of the prosthesis while simultaneously ensuring transfer of any socket movement directly to the prosthesis.

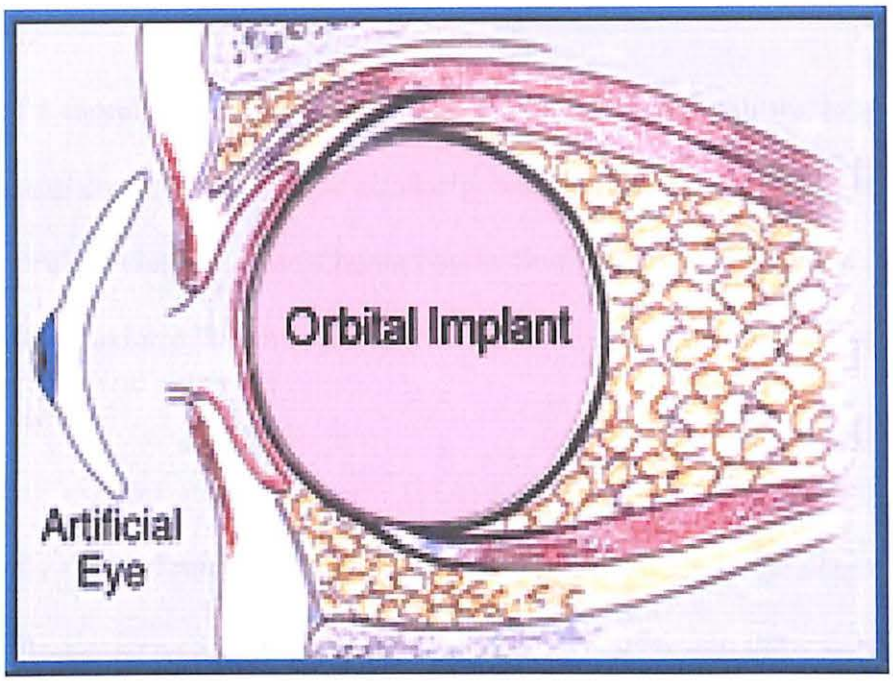

Figure 1.1 showed saggital section of globe with orbital implants

Some years earlier, it had been discovered that certain species of marine coral have a skeleton with microarchitecture almost identical to that of human cancellous bone. Fortunately, these species also have a chemical makeup that allows them to be converted to hydroxyapatite (HA), which is the mineral that makes up the hard portion of bone.

This remarkable coincidence enables converted coral implants to be invisible to the immune system, preventing the implant from producing a foreign body reaction that has been a complication of implants for over 100 years. Both X-ray diffraction and SEM microscopy have shown naturally derived HA to be virtually identical to the mineral portion of cancellous bone in terms of both porosity and chemical make-up. Consequently, soft tissue readily infiltrate the material, muscles can be attached to it, and, if exposed, the material tends to "heal" itself using the body's natural mechanisms for wound closure and infection resistance (Ashworth J.L, 1996).

The goal of a more natural appearance was finally achieved with the help of a natural material: ocean coral. A remarkable similarity was noticed between the porous structure of certain coral species and that of human bone. Soon after this discovery, a method was developed to transform the mineral in coral to match that of human bone, known as hydroxyapatite.

This naturally derived material has both the porous structure and the chemical structure of bone. Thus, the tissues of the body will accept, even grow into these naturally derived hydroxyapatite implants, and they essentially become a "living" part of the body. This is in contrast to artificially made hydroxyapatite, or the porous materials like porous polyethylene (Medpor) or aluminum oxide (Bioceramic) that do not have these properties.

The benefits of natural movement and fewer long-term problems have made the hydroxyapatite orbital implant the implant of choice among leading ophthalmic and oculoplastic surgeons worldwide. It is the most widely used orbital implant that becomes a living part of the body.

Chronic infection of hydroxyapatite implants can occur late, in the absence of large conjunctival defects, or other obvious risk factors. While exposure of the implant to pathogens through a breach in the conjunctiva may have been a factor, it appeared that the infection may have arisen in an avascular portion of the implant prior to the conjunctival breakdown in one or more of these cases.

The hydroxyapatite orbital implant is surgically placed within the orbit at the time the eye is removed, and the tissues are closed over the implant. The implant will not be seen. A temporary conformer (a clear plastic spacer) is then placed on top of the tissues covering the implant and under the eyelids to maintain the space for the future artificial eye.

Fibrovascular tissue ingrowth from adjacent orbital tissue into spherical porous polyethylene orbital implants is well established and has been demonstrated using several techniques (histopathologic findings, technetium isotope scanning, computed tomography, and magnetic resonance imaging). Vascularization usually occurs from the periphery of the implant toward the center of the sphere and aids integration of the implant into host tissues. This is believed to reduce infection, extrusion, and exposure of the implant.

Today, over 80,000 people worldwide have benefited from the Bio-eye orbital implant, the natural orbital implant, which is known as the Bio-eye Hydroxyapatite Orbital Implant. In addition to natural eye movement, the Bio-eye orbital implant offers many less-obvious benefits. It reduces implant migration and extrusion, which are common with the other implants.

There are also porous implants of porous polyethylene, (Medpor), and of aluminum oxide, (Bioceramic). These are not natural materials of the body and do not have the same, completely porous, micro architecture as human bone or as the hydroxyapatite orbital implant.

Porous polyethylene orbital implants are increasingly popular and used commonly as sheets, blocks, or spheres for volume replacement in the anophthalmic socket and for orbital wall repair in orbital wall fractures. Synthetic orbital implants are generally less expensive than natural coral implants and are also biocompatible and nontoxic, with interconnecting pores and channels.

The Bioceramic orbital implant (aluminum oxide, Al_2O_3, alumina) represents a new generation of porous orbital implant. It is structurally strong, free of contaminants and easy to work with. It has a more extensive uniform pore structure (with excellent pore interconnectivity) than either the Bio-Eye.

The implant is coated with the body's own protein on implantation allowing it to become immunologically camouflaged. The US Food and Drug Administration approved the implant in April 2000 and by Health and Welfare Canada in February 2001.

1.8 Ocular Prosthesis

An artificial eye, or ocular prosthesis, is the items that need to be esthethically pleasing since it is seen by other people and is used to restore the natural appearance of the eye and surrounding tissues. It reflects the post surgical changes to the socket (the space behind the eyelids in which the artificial eye rests). Artificial eyes are usually made of plastic, acrylic, or glass.

The artificial eye shell or ocular prosthesis is composed of methyl methacrylate (MMA). MMA is a plastic that is molded to fit between patient's eyelids and over the hydroxyapatite implant. The natural features of the eye such as the iris, blood vessels and any tints or shading in the sclera are painted onto the shell. The MMA is transparent; zinc oxide is added to produce the white background of the sclera.

Besides providing cosmetic benefits, the artificial eye supports the eyelids, preventing drooping and allowing for normal opening and closing of the eyelids. The artificial eye shell also prevents the eyelashes from turning in and provides proper lubrication of the eye tissues.

Confusion often exists in terminology with respect to orbital implant and ocular prosthesis. An ocular or orbital implant is placed in the deep tissues of the bony socket and is permanent. An ocular prosthesis (artificial eye) is like a giant contact lens, on which an eye is carefully painted to match the remaining good eye. The prosthesis can be removed and polished on a regular basis. Approximately six weeks after either enucleation or evisceration, an ocularist will make an impression of the patient's socket to create an ocular prosthesis or artificial eye. The ocularist will make prosthesis with eye color and shape to match the remaining eye.

Then the oculoplastics surgeon will create a detailed artificial eye; often astonishing in its lifelike appearance that exactly matches your natural eye. The artificial eye fits over the tissues that cover the implant and under the eyelids, and will move as the implant moves or "tracks" along with the natural eye.

Desired movement is achieved, can perform a simple procedure to connect the artificial eye to the implant, by means of a peg. In this optional procedure, a hole is placed in the implant and a peg is inserted into the hole. Titanium is now the material of choice used for the pegging system.

Once the peg is placed in the implant, a month of healing is suggested before the ocularist modifies the back of the artificial eye to accept the head of the peg, thus forming a direct link to the artificial eye. The artificial eye can be worn as usual during the period.

The peg placement procedure can only be performed after the implant has had time to fill with vascular tissues from the orbit, usually about six months after implantation. A bone scan or magnetic resonance imaging (MRI) test should be performed to confirm whether the implant has had adequate vascular ingrowth and is ready to accept a peg. These tests, as well as the peg placement procedure, are usually painless.

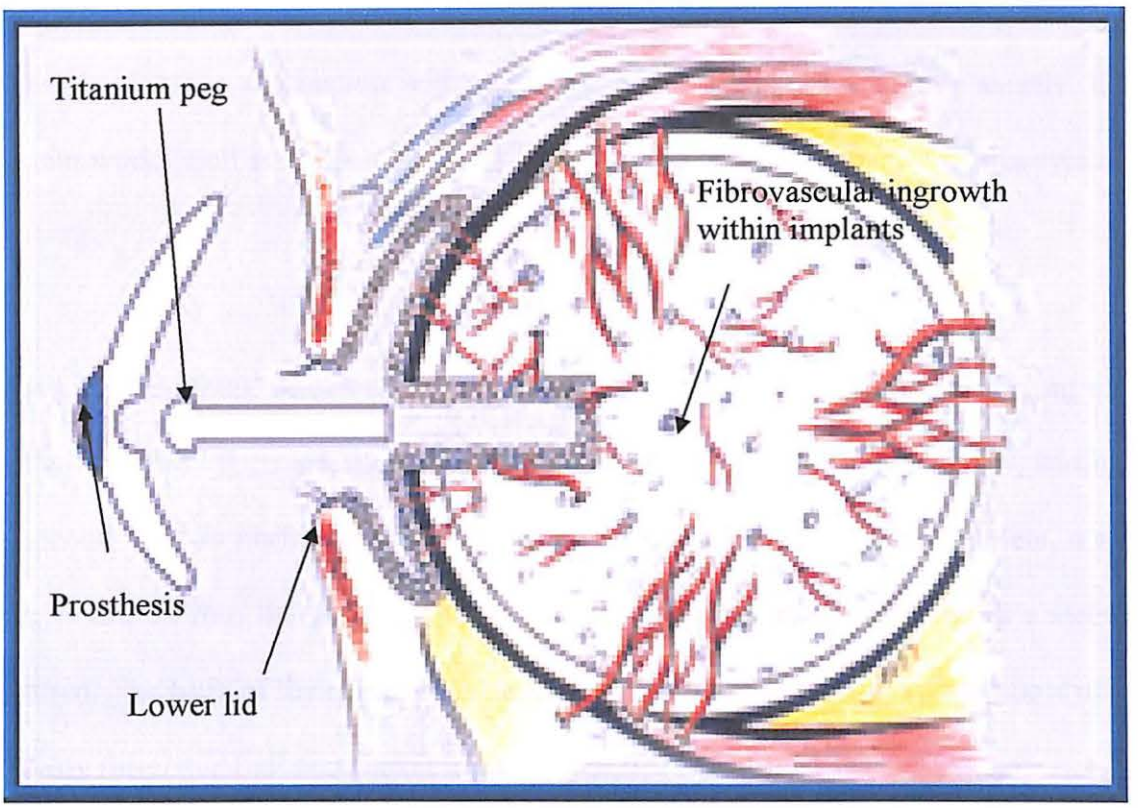

Figure 1.2 showed saggital section eye globe with orbital implants and pegging

Pegging will allow coupling of the Bioceramic implant to the overlying prosthetic eye and as a result, an increased range of movement as well as simultaneous movement of the artificial eye with the normal eye. The small dart-like tracking movements that occur give the artificial eye a more life-like appearance. Although pegging increases the movement, potential problems (most of which are minor) can occur in up to 1/3 of patients. To peg or not to peg is up to the surgeon and patient.

The most common type of peg system used at this time involves a Titanium peg and sleeve system. Earlier models of the peg and sleeve were polycarbonate; however titanium has proven to be more bioinert. This coating allows fibroblasts to gain a stronger attachment to the sleeve as compared to uncoated titanium (i.e. retention

strength is improved). A Bioceramic sleeve (made of the same aluminum oxide material as the implant) in association with a titanium peg will also be available shortly. Either system works well and replaces the older polycarbonate or polymethylmethacrylate peg systems.

Approximatelly, six weeks after surgery, an ocular prosthesis is placed in front of the orbital implant. Then six months after the initial surgery, a bone scan or gadolinium enhanced MRI is performed to document healing. When healing is complete, a small hole is drilled into the hydroxyapatite implant and a peg with or withoiut a sleeve is inserted. The back of the ocular prosthesis can engage this peg, imparting almost normal motility through a ball and socket joint.

1.9 Inflammation

Inflammation is fundamentally a protective response that is to rid the organism from initial cause of cell injury and the consequences of such injury. Without inflammation, infections would go unchecked, wound would never heal and injured organs might remain permanent festering sores.

Fibrosis may lead to disfiguring scars and fibrous bands that cause limits the mobility of joints. The inflammatory response occurs in the vascularized connective tissue, including plasma, circulating cells, blood vessel and cellular or extracellular constituents of connective tissue.

The circulating cells include neutrophils, monocytes, eosinophils, lymphocytes, basophils and platelets. The connective tissue cells are the mast cells that intimately surround blood vessels, the connective tissue fibroblasts and occasional resident macrophages and lumphocytes. The extracellular matrix consists of the structural fibrous proteins, adhesive glycoproteins and proteoglycans. The basement membrane is a specialized component of the extracellular matrix consisting of adhesive glycoproteins and proteoglycans.

Inflammation is divided into acute and chronic patterns. Acute inflammation is of relatively short duration, lasting for minutes, several hours or a few days and its main characteristics are the exudation of fluid and plasma proteins and the emigration of leukocytes predominantly neutrophils. Whereas chronic inflammation longer duration and associated histologically with the presence of lymphocytes and macrophages, the prolifearation of blood vessels, fibrosis and tissue necrosis.

1.9.1 Acute Inflammation

Acute inflammation is the immediate and early response to an injurious agent. Acute inflammation has three major components;

a. Alterations in vascular calibre that lead to an increase in blood flow.
b. Structural changes in the microvasculatures that permit the plasma proteins and leukocytes to leave the circulation.
c. Emigration of the leukocytes from the microcirculation and their accumulation in the focus of injury.

Exudates are an inflammatory extravascular fluid that has a high protein concentration much cellular debris and a specific gravity above 1.012. Transudate is a fluid with low protein content and a specific gravity of less than 1.012. It is essentially an ultrafiltrate of blood plasma and results from hydrostatic imbalance across the vascular endothelium.

1.9.2 Chronic Inflammation

Chronic inflammation is considered inflammation of prolonged duration (weeks or months) in which active inflammation; tissue destruction and attempts at repair are proceeding simultaneously. Although it may follow acute inflammation, chronic inflammation frequently begins insidiously as a low grade, smoldering, and often-asymptomatic response.

Chronic inflammation arises under the following settings:

a. Persistent infections by certains microorganisms.
b. Prolonged exposure to potentially toxic agents either exogenous or endogenous.
c. Autoimmunity which is immune reaction is set up against the individual's own tissues.

Histological features of chronic inflammation are characterized by:

a. Infiltration with mononuclear cells that include macrophages, lymphocytes and plasma cells – a reflection of a persistent reaction to injury.