Ligaplants: A Revolutionary Concept In Implant Dentistry

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Abstract:
Periodontitis is the inflammation of hard and soft tissues surrounding the tooth and if left untreated may lead to a tooth loss. Replacement of the missing tooth with an implant has gained popularity among patients. The advent of periodontal tissue engineering has brought about a revolution not only in the field of periodontology but also in the field of implant dentistry at large. Currently, the development of a periodontal ligament (PDL) attachment around dental implants has now become an important new therapeutic tool to replace lost teeth. PDL houses various vital cells that are important in the dynamic relationship between the tooth and the bone. Ligaplants are now an available option to improve the biological performance and to prolong the life of the prosthesis.

Keywords:- Dental implants, Periodontal ligament, Tissue engineering

INTRODUCTION:
The boom in implant dentistry is attributed to a combination of various reasons: prolonged life span of ageing individuals, failures associated with removable and fixed protheses, advantages, and predictable outcomes associated with the use of implants.[1] Before placement of the implant, local bone defects and general poor bone quality necessitate bone reconstruction. Besides this, localized bone loss around the implant fixture represents the clinical challenge, especially in the case of gingival recession, which requires further surgical interventions.[2] With the loss of natural teeth, periodontal ligament (PDL) cells are lost as well. Therefore, these cells cannot participate in wound healing around endosseous implants, which are inserted for the replacement of lost teeth. Thus, at present, optimal healing around implants is considered to be intimate bone-to-implant contact, called Osseointegration.[3]
Currently, osseointegrated implants are generally agreed to be the most acceptable implants because of their high longterm clinical survival rate. These problems could be resolved, if implant with PDL could be developed, which could be achieved by ligaplants, a combination of the PDL cells with implant biomaterial.[4] Because osseointegrated implants are “ankylosed” and do not have the same mobility as natural teeth with a PDL, efforts have been made for years to compensate for this obvious difference by “shock-absorbing systems” built into the implant or its suprastructure.[5]

Ligaplants are a new treatment modality, which are being clinically tried in-vivo and in-vitro. Moreover, in animal studies, they have shown good results, although in-vivo results are yet to be correlated. Several successful experiments have been conducted to devise “implant-supported by the periodontium” that can maintain form function and potential proprioceptive responses similar to a natural tooth. Based on this strong evidence, the possibility of the future clinical use of such implant can be strongly stated which would revolutionize the implant dentistry and favoured by the patients as well.

Properties Of Ligaplants:-

1. It acts as a shock absorber, giving the toothsome movement in the socket
2. It also provides proprioception
3. The PDL also has an important interaction with the adjacent bone, playing the role of the periosteum, at the bone side facing the root
4. It contains vital cells such as osteoclasts, osteoblasts, fibroblasts, cementoblasts, cementoclasts, and most importantly, the undifferentiated mesenchymal stem cells
5. These cells are all important in the dynamic relationship between the tooth and the bone.[6]

Procedure For Obtaining Ligaplants:-

Tooth transplantation with double PDL stimulation is one of the best examples of its healing capacity. Fourteen days before transplantation, the donor tooth is extracted and immediately replanted in its original alveolus. This deliberate trauma triggers a healing process within the PDL, which includes cell proliferation and differentiation. The in vivo cell culture reaches its peak of activity after 14 days, after which the transplantation of the tooth can be performed with millions of cells full activity attached to its root by new Sharpey’s fibres.[4]

Using this model in its biological and clinical aspect, we now use it similar cell culture around an artificial root using tissue engineering techniques as follows.

1) Preparation of temperature-responsive culture dishes

N-isopropylacylamide monomer in 2-propanol solution was spread onto polystyrene culture dishes. Then the dishes were subjected to electron beam irradiation with an Area Beam Electron Processing System. The temperature-responsive polymer-grafted (poly Nisopropylacrylamide) dishes were rinsed with cold water to remove ungrafted monomer and sterilized with ethylene oxide.[5]

2) Cells and cell culture

Human periodontal ligament cells were isolated from an extracted tooth. After extraction, periodontal tissue was scraped from the middle third of the root with a scalpel blade. The harvested tissue was placed into culturedishes containing Dulbecco’s modified Eagle’s minimal essential medium, supplemented with 10% fetal bovine serum and 100 units/mL of penicillin/streptomycin. Then, those outgrowth cells were cultured in a humidified atmosphere of 5% CO₂ at 37°C for 48 hours to allow attachment of the cells to the dishes. The dishes were washed to eliminate debris and the medium was changed three times per week. To harvest the cell sheet, human periodontal ligament cells were plated on temperature-responsive culture dishes (35 mm indiameter) at a cell density of 1x10⁵ and cultured at 37°C supplemented with 50 mg/mL ascorbic acid 2-phosphate, 10 nM dexamethasone and 10 nM β-glycerophosphate that function as an osteodifferentiation medium.[4,5]

3) Culture of PDL cells in a Bioreactor
A titanium pin which coated with hydroxyapatite (HAP) was placed in a hollow plastic cylinder leaving a gap of 3mm around the pin. Culture medium was continuously pumped through the gap. Single cells suspension, obtained from human, were seeded first into plastic vessels under a flow of growth medium for 18 days.\(^4\,5\)

**Risk Factors of Ligaplants:**

A cushion of sufficient thickness favours the formation of PDL and on the other, the prolonged cell culturing may favour the appearance of non-PDL cell types. In order to preserve the cell differentiation state and to obtain adequate cell stimulation, the bioreactor has been constructed with the aim to resemble the PDL situation during cell growth; cells are positioned in a narrow space between the ligaplant and surrounding hollow cylinder. It was thereby anticipated that the PDL phenotype would be favoured implicating a tight attachment of cells to the implant. So, the preparation of the ligaplants should have minute mechanical movements of the medium flow and space between the implants and the culture should be optimal and the duration of the surface treatment should also be optimal to obtain the successful ligaplants which brings big improvements to the implant system.\(^4\)

**Advantages Of Ligaplants:**

1. It alleviates problems like gingival recession and bone defects of missing tooth.
2. Mimics natural insertion of natural tooth roots in alveolar process.
3. Ligaplants become firmly integrated without interlocking direct bone contact, despite the initial fitting being loose in order to spare PDL cell cushion.
4. Bone formation was induced and movements of ligaplants inside the bone suggests an intact communication between bone and implant surface.\(^8\)

**Disadvantages Of Ligaplants:**

1. The culturing of ligaplants should be through with caution. i.e., the temperature, the cells that are used for culturing, the duration of the culturing, and others. If some problem evokes during the culturing, the ligaplants may fail as other non-periodontal cells may develop
2. Besides, the cost of this implant is high due to limited facilities
3. The factors affecting the host to accept the implant or the growth of PDL in the socket is unpredictable, which fail implant.\(^8\)
4. The prolonged cell culturing may favor the appearance of non-PDL cell types.\(^4\)

**Clinical Importance:**

For reconstruction and regeneration of ligaplants, the important elements required are as follows:

1. Matrix or a scaffold
2. Signalling molecules
3. Cells.

Tissues prepared in the laboratory are cultivated with in-vitro technique. The cells are cultured on the biodegradable scaffolds or matrix with the help of signalling molecules, following which they are transplanted into the body. Whereas, when all the cultivated vital elements are placed in a tissue defect and undergo a natural healing process in the body giving rise to regeneration, it is called as in vivo technique. It induces intrinsic healing activity at the site of tissue defect using the three elements. This can be done by both in vitro and in vivo.\(^10\)

**The Success Of Ligaplants:**

The development of a regenerative PDL depends on sitespecific signalling, which in turn is mediated by an anatomic code, written in expression patterns of homeogene-coded transcription factors. Hence, the homeoproteins influence the synthesis of cell surface and signalling components, and signals from...
the cell surface feedback to modulate homeogene expression, whereby cell identities are established according to the anatomic site and tissue type.\textsuperscript{[6]}

**DISCUSSION:**

Nyman et al in 1982 suggested that, the cells of the periodontal ligament possess the ability to re-establish connective tissue attachment.\textsuperscript{[12]}

Nunez et al in 2012 further validated the regenerative potential of periodontal ligament derived cells in a proof of principle study. Several in vivo experiments have demonstrated the formation of cementum-like tissue with an intervening periodontal ligament, when the dental implants were placed in proximity to tooth roots. This caused the migration of cementoblast and PDL fibroblast precursor cells towards dental implants due to contact or proximity of the tooth-related cell populations to those implants.

Gault P et al in 2010 stated that, new tissue consistent with PDL developed on the surface of dental implants after implantation. This evidence demonstrates the application of ligament-anchored implants, which have potential advantages over osseointegrated oral implants.\textsuperscript{[4]}

Kiong AL et al in 2014 stated that, ligaplants as tooth replacement has decisive advantages as compared with osseosintegration devices, due to their periodontal tissue regeneration. The ligaplants surgery is moderately simple, because the implant isn’t tightly fitted to its site. Besides that, patient may not have to undergo bone grafting, inconvenience and discomfort with the ligaplants placement.\textsuperscript{[8]}

**CONCLUSION :-**

As with all emerging technologies, a successful future for ligaplant will only be achieved through research finding and testing. Current research in ligaplant is focusing on extending this initial observation to clarify and to further pursue the implications of this type of healing around dental implants with titanium surfaces evaluation of whether this phenomenon occurs around implants with other surfaces. Further research on humans with longterm followup could only validate the feasibility and success of ligaplants.

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