Resonance frequency analysis of initial implant stability in grafted bone

Thesis

Submitted to the faculty of Oral and Dental Medicine,

Cairo University

As a partial fulfilment of the requirements of Master

Degree in Oral Surgery

By

Shady Ahmed Abd El-Hamid El-Sadek

B.D.S (October 6 University) 2004

Faculty of Oral and Dental Medicine

Cairo University

2014

Supervisors

Dr. Maha M. Hakam

Professor of Oral and Maxillofacial Surgery

Faculty of Oral and Dental Medicine, Cairo University.

Dr. Sameh T. Mekhemer

Professor of Oral and Maxillofacial Surgery

Faculty of Oral and Dental Medicine, Cairo University.

THE JURY

Dr. Maha M. Hakam

Professor of Oral and Maxillofacial Surgery

Faculty of Oral and Dental Medicine, Cairo University.

Dr. Sameh T. Mekhemer

Professor of Oral and Maxillofacial Surgery

Faculty of Oral and Dental Medicine, Cairo University.

Dr.Tamer Abd El bary

Professor of Oral and Maxillofacial Surgery

Faculty of Oral and Dental Medicine, Suez Canal University

Dr. Salah Yassin

Professor of Oral and Maxillofacial Surgery

Faculty of Oral and Dental Medicine, Cairo University

List of contents

1	Introduction and review of literature	Pg. 9-38
2	Aim of the study	Pg. 39
3	Patients and Methods	Pg. 40-66
4	Results	Pg. 67-74
5	Discussion	Pg. 75-81
6	Summary	Pg. 82-83
7	Conclusion	Pg.84
8	References	Pg. 85-100

List of Figures

Fig.	Pages	Description
1	37	Diagram showing Osstell ISQ
2	38	Diagram showing the mounting of the smart peg into the implant
3	38	Diagram showing the Osstell probe during the measurement of the implant initial stability
4	46	Photograph showing the Keystone (Dynablast) grafting material
5	46	Photograph of Dynablast putty material in the sterile container
6	54	Copy of the patient form used in the study
7	55	Clinical photograph showing the second lower Rt molar
8	55	3D CBCT view showing the grafted post extraction socket
9	56	Coronal CBCT view showing the grafted post extraction socket
10	56	Clinical photograph showing the extraction socket
11	57	Clinical photograph showing Dynablast within the socket
12	57	Clinical photograph showing the figure of 8 suture over the graft using [3/0] silk suture material
13	58	Clinical photograph showing surgical motor (NSK) used in the procedure
14	59	Clinical photograph of Osstell ISQ device used in measuring the initial stability of the implant placed
15	60	Clinical photograph showing the implant system surgical kit
16	60	Clinical photograph of the Superline implant used

List of Figures

17	61	Clinical photograph of the preoperative field after flap reflection
18	61	Clinical photograph of the pilot drill osteotomy
19	62	Clinical photograph showing the wrench used in implant insertion
20	62	Clinical photograph of the implant after insertion
21	63	Clinical photograph of the smart peg mount
22	63	Clinical photograph of the smart peg being inserted onto the implant
23	64	Clinical photograph showing Osstell probe during initial implant stability measuring
24	64	Clinical photograph of Osstell reading
25	65	Radiograph showing a coronal CBCT immediately after first molar implant placement
26	65	Radiograph showing coronal CBCT immediately after second molar implant placement
27	66	3D CBCT radiograph showing both implants immediately after insertion
28	68	Column chart representing mean ISQ readings in group A, B
29	69	Column chart showing case distribution (Number of implants) according to implant size
30	71	Column chart showing mean ISQ readings according to implant size
31	72	Scatter plot showing correlation between ISQ readings and implant size

List of Tables

Table	Page	Description
1	11	Misch bone density classification scheme
2	12	CT determination of bone density
3	67	ISQ readings taken by Osstell for each case
4	68	ISQ readings in groups A, B and statistical significance of the difference using unpaired Student's test
5	70	Range, mean and standard deviation of ISQ readings

List of Acronyms

1	CT	Computed tomography.
2	DFDBA	Demineralized freeze dried bone allograft.
3	e-PTFE	Expanded polytetrafluoroethylene.
4	FDBA	Freezed dried bone allograft.
5	BMP	Bone morphogenic proteins.
6	DBM	Demineralized bone matrix.
7	PBBM	Porous bovine bone material.
8	GTR	Guided tissue regeneration.
9	HA	Hydroxy apatite.
10	TCP	Tri-calcium phosphate.
11	RFA	Resonance frequency analysis.
12	BIC	Bone-implant contact.
13	PTV	Periotest value.
14	ISQ	Implant stability quotient.
15	MD	Mesio-distal.
16	BL	Bucco-ligual.
17	Bid	Bisnide (twice daily).
18	Tid	Ternide (3 times daily).
19	IAN	Inferior alveolar nerve.
20	IL	Immediate loading.
21	DL	Delayed loading.
22	CBCT	Cone beam computed tomography.

Introduction and review of literature

The close relationship between the tooth and the alveolar process continues throughout life. Wolf's law (1892) states that the bone re-models in relationship to forces applied [(1)]. Every time the function of bone is modified, a definite change occurs in the internal architecture and external configuration [(2)].

Bone needs stimulation to maintain form and density. teeth transmit compressive and tensile forces to the surrounding bone. When a tooth is lost, the lack of stimulation to the residual bone caused a de-crease in trabeculae and bone density in this area, with loss in external width, then the height, of the bone volume [(3)]. There is a 25% decrease in width of bone during the first year after tooth loss and an overall (4mm) decrease in height during the first year after extraction [(4)].

In a longitudinal 25 years study of edentulous patients, lateral cephalograms demonstrated continued bone loss during this time span; a fourfold greater loss, was observed in the mandible [(5)]. However, be-cause initially the mandible height is twice that of the maxilla, maxillary bone loss is also significant in the long-term edentulous patients. Sever-al esthetic consequences result from the loss of alveolar bone.

A decrease in facial height from a collapsed vertical dimension causes several facial changes. The loss of labiomental and keeping of the vertical lines in the area create a harsh appearance.

As the vertical dimension progressively decreases, the occlusion evolves toward a pseudo class II, resulting in a chin forward rotation creating a prognathic facial appearance [6].

Available bone is practically important in implant dentistry and describes the external architecture or volume of the edentulous area considered for implants. The internal structure of bone is described in terms of quality and density, which reflects a number of biomechanical properties, such as strength and modulus of elasticity.

The density of available bone in an edentulous site is a determining factor in treatment planning; implant design, surgical approach, healing time, and initial progressive bone loading during prosthetic reconstruction.

In 1988, Misch [7,8] proposed five density groups independent of the regions of the jaws, based on microscopic cortical and trabecular bone characteristics. Dense or porous cortical bone is found on the outer surface of bone includes the crest of an edentulous ridge [2, 25-36]. In combination, these four increasing macroscopic densities constitute four bone categories described by Misch (D1, D2, D3, D4 and D5) as seen in table (1).

- D1 bone is primarily dense cortical bone.
- D2 bone has dense-to-porous cortical bone on the crest and, within the bone, has coarse trabecular bone.
- D3 bone types have a thinner porous cortical crest and fine trabecular bone.

- D4 has almost no crestal bone cortical bone. The fine trabecular bone composes almost all of the total volume.
- D5 bone is very soft with incomplete mineralization and large inter-trabecular spaces.

Bone Density	Description	Tactile Analog	Typical Anatomical Location
D1	Dense cortical	Oak or maple wood	Anterior mandible
D2	Porous cortical and coarse trabecular	White pine or spruce wood	Anterior mandible Posterior mandible Anterior maxilla
D3	Porous cortical (thin) and fine trabecular	Balsa wood	Anterior maxilla Posterior maxilla Posterior mandible
D4	Fine trabecular	styrofoam	Posterior maxilla

Table (1) Misch bone density classification scheme.

The initial treatment plan often begins with radiographs precisely determining bone density by tomographic radiographs especially computed tomography and lately cone beam computed tomography [18-21].

Each C.T. axial image has 260,000 pixels, and each pixel has a C.T. number (Hounsfield Unit) related to the density of the tissues within the pixel. In general, the higher the C.T. number, the denser the tissues.

Bone Density	Hounsfield Units
D1	>1250 Hounsfield units
D2	850 to 1250 Hounsfield units
D3	350 to 850 Hounsfield units
D4	150 to 350 Hounsfield units
D5	<150 Hounsfield units

Table (2) CT Determination of Bone Density[19].

The initial bone density not only provides mechanical immobilisation of the implant during healing, but also after healing permits distribution and transmission of stress from the prosthesis to the implant-bone interface.

Misch noted in 1990 that the bone density influences the amount in contact with the implant surface not only in the first stage surgery, but also at the second stage uncover and early prosthetic loading [2].

One of the things that affect the decision of implant placement during treatment plan as mentioned before is the quality and quantity of available bone; which is significantly affected after tooth extraction. If performed inadequately, the resulting deformity can be a considerable obstacle to the aesthetic, phonetics, and functional results.

Ridge preservation:

Some of the techniques are based on the principle of guided tissue/bone regeneration, while many procedures have been suggested includes [22]:

1. Minimally traumatic tooth extraction.
2. Timing of extraction.
3. Debridement and decortication of the socket.
4. Coverage of the socket by soft tissue.
5. Bone or bone substitute grafts only.
6. Membranes only.
7. Bone grafts and membranes together.
8. Space fillers.
9. Implants as ridge preservers.

Placing a graft material into the socket has been one proposed method of preserving the natural tissue contours at extraction sites to maintain external resorption of the ridge and maximise bone formation within the socket for possible reconstruction with implant supported prosthesis [23].

According to Misch, some of the keys to ensure successfully grafting bone into extraction sites include atraumatic tooth removal, asepsis and complete removal of granulomatous tissue, evaluating both the remaining bony walls and defect size following extraction, ensuring adequate blood supply to the grafting site, graft containment with soft tissue closure, choosing the appropriate grafting material and allowing for adequate time for healing (24).

Several of these keys are interrelated; one key affects another and may form a cascade toward failure or success. these materials include: A**utografts**, i.e. the bone is harvested from the same individual's body and transferred to the site of restoration e.g. iliac crest, chin bone.

Allograft, i.e. the material is produced from another member of the same species e.g. demineralised freeze dried bone allograft (DFDBA). **Xenografts**, i.e. the material is harvested from a different species than the recipient e.g. bovine-derived used in humans. **Alloplastic** i.e. the material is derived totally from synthesised components e.g. hydroxyapatite (resorbable and non-resorbable), tricalcium phosphate, bioactive glass, silica calcium phosphate composite.

Also Barrier membranes (resorbable and non-resorbable) have been used alone or in conjunction with osseous grafts for alveolar ridge preservation e.g. e-PTFE membranes (13-15). For the bone graft to be so called ideal it should posses characteristics such as:

1. Biologically compatible.
2. Non-supportive for local pathogens or cross infection.
3. Osteogenic (facilitate bone cells growth).

4. Osteoinductive (stimulates non-differentiated mesenchymal cells to form bone cells).
5. Osteoconductive (serves as a scaffold for in-growth of capillaries, peri-vascular tissue and osteoproginator cells from the recipient bed).
6. Should match the physical and chemical composition of natural bone trabeculae.
7. Should be resorbable and osteotropic (enhance bone formation by its chemical or structural characteristics).
8. Should provide calcium and phosphate sources.
9. Should be microporous and easy to handle.
10. Exit in unlimited supply without the need for violation of distant donor.
11. Should be completely hosted by bone of the same or superior quality and quantity as quick as possible.
12. Maintain the mechanical stability and volume during the initial healing phase and then subsequently resorbs completely and becomes replaced by newly formed bone.

Autogenous grafts:

Autografts is for long considered the gold standard of grafting material and is currently the only available osteogenic graft available to clinical practitioners. Grafted autogenous bone heals into growing bone through the process of osteogenesis, osteoinduction and osteoconduc-