

Retrospective review of implantoprosthesis complications: analysis of associated risk factors

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Summary

Retrospective review of implantoprosthesis complications: analysis of associated risk factors.

The purpose of this retrospective review is to identify types and frequency of complications associated to implants and risk factors associated to implant complications.

The sample group consisted of 340 patients who received 1150 implants. For the purpose of obtaining statistically reliable deductions for medical interpretations one implant per patient was hazardously selected to be analysed. The results mentioned below are based on 340 patients and 340 implants.

Our study shows that the total frequency of implant complications after dental implants placement is 18.82% (64/340). This datum can seem relevant however it takes into account all complications – minor com-

plications included – such as repeated occlusal adjustments or loose prostheses recementation. These complications would be considered by some specialists as insignificant or not severe; however they are significant since they represent an inconvenience both for patient and specialist.

Key words: dental implants, osseointegration, peri-implantitis, implant complications.

Sommario

Studio retrospettivo sulle complicazioni implantoprotesiche: analisi dei fattori di rischio associati.

Obiettivo di questo studio retrospettivo è stato identificare i tipi e le frequenze delle complicanze riconducibili agli impianti ed i fattori di rischio associati alle complicanze implantari.

Il gruppo campione è stato composto da 340 pazienti che hanno ricevuto 1.150 impianti. Per produrre deduzioni statisticamente valide per le interpretazioni mediche è stato selezionato un impianto a caso per paziente per le analisi. I risultati che seguono sono basati su 340 pazienti e 340 impianti.

Sulla base del nostro studio, la frequenza globale delle complicanze implantari dopo il posizionamento degli impianti dentari è risultata essere del 18,82% (64/340). Il dato può sembrare rilevante, ma tiene conto di tutte le complicanze anche quelle minori, come gli aggiustamenti occlusali ripetuti o la ricementazione delle protesi allentate, complicanze che sarebbero invece considerate da molti medici insignificanti o non gravi; esse sono tuttavia significative in quanto non rientrando nelle visite programmate costituiscono un inconveniente sia per il paziente che per il medico.

Parole chiave: impianti dentali, osteoingrazione, perimplantie, complicazioni implantoprotesiche.

Introduction

Over the last ten years dental implantology has underwent a major technological development becoming a more reliable and predictable therapeutic solution to total, partial and monodental edentulism; it is chosen more frequently than the traditional rehabilitation process. However, limits and prosthesis problems – associated to the implant therapy – exist; a number of long term studies focused on the incidence and nature of clinical complications of implantoprosthesis although literature offers little information with regard to this subject.

Back in 1987 Brånemark classified implantoprosthesis complications as follows: bony (failed bone anchorage, mucoperiosteal perforation, surgical trauma); soft tis-

sues complications (gingival problems, proliferative gingivitis, fistula); biomechanical (mechanical complications, devices, prosthesis or screws breakdowns, etc.) (Brånemark, 1987).

In 2003 Goodacre revised the current classification which was included in the literature since 1981. Complications of single implantoprosthesis elements and of implant-supported prostheses were classified as follows: surgical, biological (implant loss, perimplantar bone loss), mechanical, aesthetic/phonetic (Goodacre, 2003).

In 2004 Lang defined complications as undesirable events which imply further time – both for patient and operator – once the prosthetic treatment is concluded (Lang, 2004).

The purpose of this retrospective review is to identify types and frequency of complications associated to implants and risk factors associated to implant complications.

Materials and methods

Review plan

This study was carried out on all patients seen by specialist odontologists between April 1992 and July 2002 at the Institute of Odontostomatologic Sciences, Università Politecnica delle Marche, University Hospital Ancona Torrette, Italy. Patients who had all received implant interventions and implantoprosthesis rehabilitations from private dental practice in various towns (mainly in the Marche region, but also in other regions such as Puglia, Abruzzo, Umbria, Emilia Romagna) were selected for this retrospective review. Only patients who were treated by private dentists with a professional experience in the implantoprosthesis field of less than 15 years were excluded from the study.

Predictable variables

Predictable variables of complications – namely either expositions or risk factors – are the following:

1. Demographic variables

These variables include sex and age at the time of implant.

2. Variables depending on the patient health

Patient health has been classified according to the American Society of Anesthesiologists (ASA) in five levels. ASA I includes a patient in good health conditions whereas ASA V is a dying patient. Presence of particular conditions, such as diabetes and hepatic disorders, or immunodepression, associated to insufficient scar healing process, was noted as well. Smoking at the time of implant was also noted.

3. Anatomical variables

These variables included: (1) the implant location, both maxillary and mandibular, anterior or posterior; (2) bone quality (types from 1 to 4); (3) the implant vicinity to the natural tooth or to other implants. Bone quality harvested by osteotomy was assessed at the

time of surgical intervention on the basis of bony material collected by drill grooves of 3.5 mm. Type 1 bone was defined as a compact bone, almost bloodless, which completely filled the drill grooves. Bone quality was classified as type 4 when little or no bony material was found on the drill grooves. Bone type 2 and 3 was intermediate. Relationship between implant and other dental alveolar structures was identified according to the following categories: edentulous, 1 natural tooth, 2 natural teeth, 1 implant, 2 implants, 1 natural tooth and 1 implant.

4. Variables associated to the implant

These variables included the implant diameter (from 3 to 5 mm); the implant length (from 6 to 13 mm); the right measure (2 or 3 mm); coating (uncoated, titanium plasma-sprayed or TPS, hydroxyapatite-coated or HA) and monophasic or biphasic. Pillar diameter (0.15 or 25 degrees) and angle were also recorded.

5. Prosthetic variables

Prosthetic variables were divided in two categories: removable (overdenture) or fixed (fixed partial crown or prosthesis).

6. Reconstructive variables

The use of a reconstructive procedure is indicated in the patient chart if the recipient site improved at least by means of one of the following procedures: 1 barrier membrane, internal and external sinus lift, split crest, onlay graft, inlay graft, autologous or eterologous bone graft, guided bone regeneration (GBR). The reconstructive procedure timing was assessed and classified following the implant stages. It was specifically noted if reconstructive procedures and implant surgeries were carried out simultaneously or separately.

7. Other variables

The use of peri-operative antibiotics, implantologist and prosthodontist identity were documented as well.

Survival analysis

The following information was recorded: implant, support, and restoration dates; date of first complication (when applicable).

The main outcomes variable was the presence or lack of further complications following the implant placement. The date of first implant complication was recorded, successively complication was classified in one of the following three groups: inflammatory, surgical or prosthetic.

Inflammatory complications included the following conditions:

1. Implant mobility.

2. Persistent pain seven days after surgical intervention so that an additional pharmacological therapy is needed.

3. Infections, such as the presence of pus formation, fistula, sinusitis or documented diagnosis of infections demanding antibiotics treatment or other therapeutic agents (i.e., chlorhexidine gluconata).

4. Peri-implantitis, namely the vertical loss of peri-implantar bone, radiographically visible.
5. Poor scar healing after implant surgery, with following partial bone, graft material or implant uncoverage.
6. Gingival recession demanding a graft procedure of free gum.

Inflammatory complications were further classified in major and minor complications. Major complication occurs more than twice or concludes with an implant failure. Minor complication occurs only once or twice and the implant loss was not at risk.

Prosthetic complications included:

1. Fractured or loose abutment.
2. Need for occlusal and/or prosthetic adaptation, two weeks after definitive restoration.
3. Need for loose fixed prostheses recementation within two weeks.

Surgical complications included:

1. Accidental implant placement in a sinus, inferior meatus or submandibular space.
2. Paresthesia, intended as a subjective disorder of numbness and 'pins and needles' of the patient for at least 7 days after surgical treatment.

Most of the complications mentioned above can be considered clinically minor and easy to treat. However one guideline followed when listing the complications is represented by patients seeing the specialist in an unplanned visit for assessment and treatment.

Unplanned visits are easy and regard solvable problems but represent an inconvenience both for patient and specialist.

Some of the complications mentioned above are not typical of dental implants but occur in the conventional restorative dental treatments and in alveolus-dental surgical procedures.

The list of complications mentioned above was developed so as to study the global purpose of minor or major challengers when implants are used for replacing lacking dentition.

Data analysis

Complications frequency and descriptive statistics were calculated by means of the statistical software (Version 8.0; SAS Institute, Cary, NC). Descriptive statistics assessed all the review variables. In order to identify the risk factors of complications in implant-prostheses the "Cox proportional Hazard" regression model was used. Potential risk factors of complications were identified following the bivariate regression model "Cox proportional Hazard" and were considered variable candidates if $P < .15$. Variables satisfying this model were included in the multivariate model "Cox proportional Hazard" so as to identify those variables which are statistically associated ($P < .05$) to complications.

Results

The sample group consisted of 340 patients who received 1150 implants. For the purpose of obtaining statistically reliable deductions for medical interpretations one implant per patient was hazardously selected to be analysed. The results mentioned below are based on 340 patients and 340 implants. The descriptive statistics of the sample group are summed up in table I. It must be noted that 68.82% of patients were women. The average age was 45.5+16.9 years. The majority of patients were in good health (94.11% were classified as ASA I or II). At the time of implant placement 10.88% of patients was smoking. The majority of implants were placed on type III bone (40%). Implants were placed in only one visit in less than 20% of patients. Approximately one third of implants was associated to reconstructive procedures.

Total frequency of implants complications seen by specialists which were not recorded was 18.82% (64/340) (Figure 1). More than half – 68.75% (48/64) – were major complications. Bivariate analysis showed that smoking ($P = .01$), implant stage ($P = .002$), prosthesis type ($P = .02$) and use of reconstructive procedures ($P = .014$) are associated to an increased risk of complications (Table IIa).

The multivariate model was built by using the possible variables such as age and sex (Table III). With respect to smoking the hazard ratio was 2.52 ($P = .0049$; 95% CI: 1.07-4.36) suggesting that smokers are 2.5 times more at risk of complications than non smoking patients.

Total frequency of inflammatory complications was 15.29% (52/340) (Figure 2). The majority of inflammatory complications were associated to implant mobility (3.53%, 12/340), infections (4.11%, 14/340), pain (4.41%, 15/340), peri-implantitis (2.35%, 8/340).

The bivariate analysis showed that smoking ($P = .0012$), implant location (jaw or mandible, $P = .12$), implants placed during 1 or 2 surgical stages ($P = .0004$), use of reconstructive procedures ($P = .0019$) and bone quality ($P = .044$) are potential risk factors of inflammatory complications (Table IIb).

The multivariate model included the variables mentioned above, as well as age and sex. For normal smoking the hazard ratio was 3.35 ($P = .0002$; 95% CI, 1.64 a 6.34). The hazard ratio adapted for implants placed in 1 or 2 stages was 3.23 ($P = .0004$; 95% CI, 1.54 a 5.86), with implants placed in one treatment associated to a higher risk of inflammatory complications. The use of reconstructive procedures and poor quality bones increased possible inflammatory complications.

Total frequency of prosthesis complications was 2.35% (8/340, Figure 1). The bivariate Cox model showed that the implant position (anterior vs posterior, $P = .00$), prosthesis type (removable vs fixed, $P = .0001$), implant proximity ($P = .009$), abutment angle ($P = .023$), jaw vs mandible ($P = .049$) were statistically associated to prosthesis complications (Table IIc).

The total frequency of surgical complications was 1.18% (4/340) (Figure 1). The bivariate regression Cox proportional hazard model showed that age ($P = .08$), jaw vs mandible ($P = .035$), use of reconstructive proce-

Table I - Statistical description of the sample group of patients (n=340).

Variables	Values
<i>Demographic</i>	
Average age*	45.5±16.9
Proportion Males/Females	140/200 (41.18%/68.82%)
<i>Health</i>	
ASA condition	
ASA I	200 (58.82%)
ASA II	120 (35.29%)
ASA III	20 (5.88%)
Particular medical conditions	27 (7.94%)
Smoking	67(19.71%)
<i>Anatomical</i>	
Jaw/mandible	223/117 (65.59%/34.41%)
Anterior/posterior	126/214 (37.06%/62.94%)
Proximity to local anatomical structures	
No tooth	51 (15%)
1 adjacent tooth	100 (29.41%)
between 2 natural teeth	78 (22.94%)
1 adjacent implant	50 (14.71%)
2 adjacent implants	35 (10.29%)
1 tooth + 1 implant	26 (7.65%)
Bone quality	
Type I	28 (8.24%)
Type II	52 (15.29%)
Type III	136 (40%)
Type IV	124 (36.47%)
<i>Regarding the implant</i>	
Implant diameter	
from 3 to 3.5 mm	178 (52.35%)
from 4 to 4.5 mm	120 (35.29%)
5 mm	36 (10.59%)
6 mm	6 (1.76%)
Implant length	
4-6 mm	5 (1.47%)
8 mm	32 (9.41%)
10-11 mm	266 (78.24%)
13-14 mm	37 (10.88%)
Surface	
Uncoated	115 (33.82%)
Plasma sprayed titanium	217 (72.65%)
Hydroxyapatite	8 (2.35%)
Biological width	
2 mm	299 (88.7%)
3 mm	41 (11.3%)
Stage	
One surgical stage	62 (18.24%)
Two surgical stages	278 (81.76%)
<i>Regarding the abutment</i>	
Diameter	
from 3 to 4 mm	66 (25.3%)
from 5 to 5.5 mm	236 (55.2%)
from 6 to 6.5 mm	182 (19.5%)
Angle	
0 degree	262 (77.06%)
15 degrees	78 (22.94%)
<i>Regarding the prosthesis</i>	
crowns	302 (88.82%)
removable	38 (12.06%)
<i>Presurgical</i>	
use of reconstructive procedures	112 (32.94%)

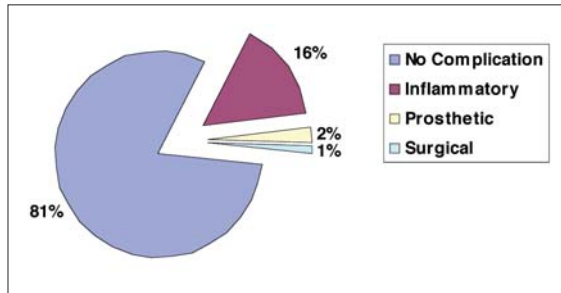


Figure 1 - Percentage identification and number of complications (n=340 implants per 340 patients). Complications percentage is 18.82% (64/340).

dures (P=.065), bone quality (P=.084), the ratio A/P (P=.05) were associated to surgical complications (Table II). A multivariate model with respect to prosthesis and surgical complications was not created on account of its scarcity.

Discussion

The purpose of this review is to identify the types, complications frequency associated to implant placement and risk factors associated to implant complications.

A prospective study over 4 years on 168 patients – who received 432 implants for replacing posterior dentition – showed a loose abutment frequency of 0.74%, a frequency of abutment breakdown of 0.5% and a crown replacement frequency of 3.71% on account of failing cement or breakdown of porcelain (Muftu, 1998).

Chaffe NR (2002) reported the number of restorations requested so as to provide mandible overdenture on satisfactory implants: a sample group of 58 patients was considered, patients were seen 327 times for checking adaptations, 59% of these visits were unplanned.

Our study shows that the total frequency of implant complications after dental implants placement is 18.82%. This datum can seem relevant however it takes into account all complications – minor complica-

Table II - Bivariate analysis of potential risk factors associated to implant complications.

Variables	Hazard ratio	95% CI	P value
<i>a. Regarding total complications (n=64)</i>			
Average age	1.01	0.95-1.02	.52
Sex	0.4	0.63-1.40	.78
Smoking	2.44	1.10-3.96	.01*
Surgical stages (1 vs 2)	0.46	0.15-0.85	.002*
Prosthesis type (removable or fixed))	1.31	1.02-1.63	.03*
Use of reconstructive procedures (yes or no)	1.65	1.02-2.29	0.14*
<i>b. Regarding the inflammatory complications (n=52)</i>			
Average age	1	0.98-1.02	.089
Sex	0.97	0.63-1.72	.96
Smoking	2.82	1.21-5.34	.0012*
Jaw vs mandible	0.65	0.38-1.09	.10*
Surgical stages (1 vs 2)	3.08	1.57-5.70	.0004*
Use of reconstructive procedures (yes vs no)	2.23	0.98-4.33	.0019*
Bone quality	1.68	0.44-2.98	.044*
<i>c. Regarding the prosthesis complications (n=8)</i>			
Average age	1.004	0.97-1.04	.94
Sex	1.24	0.45-2.89	.79
Position A/P	0.23	0.043-0.60	.005*
Jaw vs mandible	2.14	0.80-6.36	.049*
Proximity to local anatomical structures	0.53	0.36-0.77	.009*
Abutment angle	2.02	1.02-3.83	.023*
Prosthesis type (removable or fixed)	5.81	2.76-19.12	.0001*
<i>d. Regarding surgical complications (n=4)</i>			
Average age	1.002	0.99-1.21	.08*
Sex	0.58	0.08-2.44	.37
Jaw vs mandible	3.14	0.80-9.36	.035*
Use of reconstructive procedures (yes vs no)	4.91	0.88-13.26	.065*
Bone quality	1.28	0.24-2.48	.084*
Position A/P	0.23	0.043-0.60	.05*
Proximity to local anatomical structures	0.73	0.36-1.77	.065*
Dependent on operator	0.53	0.15-1.38	.92

Regression model Cox proportional hazards; * Statistically significant.

Table III - Multivariate Cox model (adapted): analysis of potential factors associated to implant complications.

Exposition	Hazard ratio	95% CI	P value
Smoking (smokers vs non smokers)	2.52	1.07-4.36	.0049*
Reconstructive procedures (yes vs no)	1.39	1.03-1.97	.0017*
Surgical stages (1 vs 2)	2.68	1.42-4.58	.0011*
Sex (female vs male)	0.92	0.58-1.44	.78
Prosthesis type (removable vs fixed)	1.88	0.92-4.21	.081

* Statistically significant.

tions included – such as repeated occlusal adjustments or loose prostheses recementation; these complications would be considered by some specialists as insignificant or not severe; however they are significant since they represent an inconvenience both for patient and specialist (they are considered unplanned visits).

With respect to total complications, the multivariate regression model Cox proportional hazard shows that smokers, the use of reconstructive procedures and one-stage implants are statistically associated to an increased risk of total implant complications.

Inflammatory complications were 15.29% and followed prosthesis and surgical complications from 2.35% to 1.18%. Specific types and frequency of inflammatory complications included removability (4.12%), infections (3.23%), pain (2.94), peri-implantitis (2.06%), late scar healing (1.76%) and gingival recession (1.18%). The multivariate model identified the same variables of risk factors as for inflammatory complications: smoking ($P=.0002$, hazard ratio 3.35), use of reconstructive procedures ($P=.049$, hazard ratio 1.47), one-stage surgery implants ($P=.0004$, hazard ratio 3.23).

Previous studies associated smoking, poor oral hygiene, inexperienced operators, adherent gum lack, loose abutment screws to inflammatory complications (Engquist, 1988; Smith, 1989; Zarb, 1990; Naert, 1991; Naert, 1992; Bain, 1993; Jemt, 1993; Veyant, 1994; Weyant, 1994; Avivi-Arber, 1996; Haas, 1996; Lindquist, 1996; Lazzara, 1996; Allen, 1997).

The majority of previous studies associated prosthesis complications to excessive load, site (anterior vs posterior), insufficient number of implants supporting the prosthesis, abutment material, implant diameter inferior to 3.5 mm. The multivariate regression model Cox Proportional hazard shows that the implants location in the jaw ($P=.035$, hazard ratio 3.14) and the use of reconstructive procedures ($P=.065$, hazard ratio 4.91) are statistically associated to an increased risk of surgical complications. Previous studies associated surgical complications to surgical experience, severe damage to the jaw and mandible bone, pressure on the nerve due to post surgical oedema, high temperature during implant placement and scar formation (Albrektsson, 1988; Van Stenberghe, 1990; Jemt, 1991; Johns, 1992; Higuchi, 1995; Wismeijer, 1997).

Conclusion

This wide definition of complications results in the frequent impossibility to compare the incidence of compli-

cations observed in the current study with other reviews included in the literature. In general, discrepancies between current findings and other studies can depend on the different populations, use of multivariate analysis, exclusion of some predictable variables from this model, subject selection (bias), different definition of some complications, etc.

The current retrospective review identified smoking, one-stage surgery implants, use of reconstructive procedures and placement of the implants in the jaw as factors which increase the risk of implant complications. Therefore the odontologist should correctly inform and explain patients that complications risks increase after implantoprosthesis treatment. If the patient is a smoker implants should be placed in the jaw vs mandible and regenerative procedures are needed; if one-stage surgery implants are placed the patient, if possible, should choose other alternative therapies, certainly less risky.

References

1. Albrektsson TA. A multicenter report on osseointegrated oral implants. *Prosthet Dent* 1988; 60:75-84.
2. Allen PF, McMillan AS, Smith DG. Complications and maintenance requirements of implant-supported prostheses provided in a UK dental hospital. *Br Dent J* 1997; 182: 298-302.
3. Avivi-Arber L, Zarb GA. Clinical effectiveness of implant-supported single tooth replacement: The Toronto study. *Int J Oral Maxillofac Implants* 1996; 11:311-321.
4. Bain CA, Moy PK Association between the failure of dental implants and cigarette smoking. *Int J Oral Maxillofac Implants* 1993; 8:609-615.
5. Brånemark A, Albrektsson T, Blomberg S, Carlsson GE. Edentulousness -an oral handicap. Patient reactions to treatment with jawbone-anchored prostheses. *J Oral Rehabil* 1987 Nov; 14(6):503-11.
6. Chaffee NR, Felton DA, Cooper LF, Palmqvist U, Smith R Prosthetic complications in an implant-retained mandibular overdenture population: Initial analysis of a prospective study. *J Prosthet Dent* 2002; 78:40-44.
7. Engquist B, Bergendal T, Kallus T, Linden U. A retrospective multicenter evaluation of osseointegrated implants supporting overdenture. *Int Oral Maxillofac Implants* 1988; 3:129-134.
8. Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JY. Clinical complications in fixed prosthodontics. *J Prosthet Dent* 2003 Jul; 90(1):31-41.
9. Haas R, Haimbock VV, Mailath G, Watzek G. The relationship of smoking on peri-implant tissue: A retrospective study. *J Prosthet Dent* 1996; 76:592-596.

10. Higuchi KW, Folmer T, Kultje C. Implant survival rates in partially edentulous patients: A 3-year prospective multicenter study. *Int J Oral Maxillofac Surg* 1995; 53:64-68.
11. Jemt T, Laney WR, Harris D, et al. Osseointegrated implants for single tooth replacement: A 1-year report from a multi-center prospective study. *Int J Oral Maxillofac Implants* 1991; 6:29-36.
12. Jemt T, Pettersson P. A 3-year follow-up study on single implant treatment. *J Dent* 1993; 21:203-208.
13. Johns RB, Jemt T, Heath MR, Hutton JE, McKenna S, McNamara DC, et al. A multicenter study of overdentures supported by Brånemark implants. *Int J Oral Maxillofac Implants* 1992; 7:513-522.
14. Lang NP, Berglundh T, Heitz-Mayfield LJ, Pjetursson BE, Salvi GE, Sanz M. Consensus statements and recommended clinical procedures regarding implant survival and complications. *Int J Oral Maxillofac Implants* 2004; 19 Suppl:150-4.
15. Lazzara R, Siddiqui AA, Binon P, et al. Retrospective analysis of 3i endosseous dental implants placed over a 5-year period *Clin Oral Implants Res* 1996; 7:73-83.
16. Lindquist UV, Carlsson GE, Jemt T. A prospective 15 year follow-up study of mandibular fixed prostheses supported by osseointegrated implants: Clinical results and marginal bone loss. *Clin Oral Implants* 1996; 7:329-336.
17. Muftu A, Chapman RJ. Replacing posterior teeth with free standing implants: Four-year prosthodontic results of a prospective study. *J Am Dent Assoc* 1998; 129: 1097-1102.
18. Naert I, Quirynen M, Theuniers G, van Steenberghe D. Prosthetic aspects of osseointegrated fixtures supporting overdentures: A 4-year report. *J Prosthet Dent* 1991; 65: 671-680.
19. Naert I, Quirynen M, van Steenberghe D, Darius P. A six year prosthodontic study of 509 consecutively inserted implants for the treatment of partial edentulism. *Prosthet Dent* 1992; 67:236-245.
20. Smith DE, Zarb GA. Criteria for success of osseointegrated endosseous implants. *Prosthet Dent* 1989; 62:567-572.
21. Tolman DE, Laney WR. Tissue-integrated dental prostheses: The first 78 months of experience at the Mayo Clinic *Mayo Clin Proc* 1993; 63:323-331.
22. Van Steenberghe D, Lekholm U, Bolender C, et al. Applicability of osseointegrated oral implants in the rehabilitation of partial edentulism: A prospective multicenter study on 558 fixtures. *Int J Oral Maxillofac Implants* 1990; 5:272-281.
23. Veyant RJ. Characteristics associated with the loss and peri-implant tissue health of endosseous dental implants. *Int J Oral Maxillofac Implants* 1994; 9:95-102.
24. Weyant R. Characteristics associated with the loss and peri-implant tissue health of endosseous dental implants. *Int J Oral Maxillofac Implants* 1994; 9:95-102.
25. Wismeijer D, van Waas MA, Vermeeren JI, Kalk W: Patient's perception of sensory disturbances of the mental nerve before and after implant surgery: A prospective study of 110 patients. *Br J Oral Maxillofac Surg* 1997; 35:254-259.
26. Zarb ZA, Schmitt A. The longitudinal clinical effectiveness of osseointegrated dental implants: The Toronto study. Part III: Problems and complications encountered. *J Prosthet Dent* 1990; 64:185-194.