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Indices in implantology- A proposed classification

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Abstract

Dental implant therapy is a financially and esthetic demanding process. Therefore, it is imperative for dental implants to be a success. Conventional methods used for evaluation of peri-implant health include peri-implant probing depths (PD), some form of recording for gingival inflammation, plaque accumulation, radiographic evaluation, peri-implant crevicular fluid (PICF) evaluation, and recording implant stability. All methods are helpful but possess inherent limitations especially regarding implant health prognostication. No standard indices similar to those used for the evaluation of periodontal conditions have been defined for the characterization of peri-implant tissues. Periodontal parameters are not strictly applicable to the features of tissues encountered around implant fixtures. There is no working classification for indices based on its relationship with peri-implant hard and soft tissue analysis. Hence, an attempt is made to compile currently available literature on the indices in oral implantology for defining success criteria, planning of the implant, at diagnostic stage, esthetics evaluation, maintenance of the peri implant site.

Keywords: Peri-implantitis, Indices, Implant maintenance, Radiomorphometric analysis, PES, WES, mPI, mBI.

Introduction

Disease prevention and health promotion are the core functions of health professional. Prevention of a disease primarily mandates knowledge of the etiology, risk factors, the distribution pattern, and associated factors. Epidemiological studies hence become the foundation for such information through quantification and measurement. Indices are powerful tools for any epidemiologist, a researcher, or a clinician. They are a means to quantify a clinical observation, thereby reducing the subjectivity in reporting a finding. Dental indices provide a quantitative method for measuring, scoring, and analyzing dental conditions in individuals and groups.

Dental implant therapy is a time consuming, and financially demanding process. Therefore, it is imperative for dental implants to be a success. Conventional methods used for evaluation of peri-implant health include periimplant probe depths (PD), some form of recording for gingival inflammation, plaque accumulation, radiographic evaluation, peri-implant crevicular fluid (PICF) evaluation, and recording implant stability. [1] [2] [3] All methods are helpful but possess inherent limitations especially regarding implant health prognostication. No standard indices similar to those used for the evaluation of periodontal conditions have been defined for the characterization of periimplant tissues. Periodontal parameters are not strictly applicable to the features of tissues encountered around implant fixtures.[4] It seems reasonable to define parameters applicable to the periimplant area which are based on periodontal indices. Hence, the criteria have been modified for the implant site and various modified indices have been proposed.

The prevalence of peri-implantitis has historically been measured using the extent and severity of loss of attachment and ⁄ or probing pocket depth in millimeters and represents an accretion of the manifestations of past disease with little or no indication of present disease activity. To best assess present disease activity, it is necessary to use descriptive methods of quantifying disease incidence that lend themselves a quantitative evaluation and electronic data processing through indices. An index is a tool that serves to monitor patient maintenance at recall visits as well as evaluating patient satisfaction regarding dental implant esthetics and function.

There is no working classification for indices based on its relationship with peri-implant hard and soft tissue analysis. Hence, an attempt is made to compile all the indices in implantology. Minimizing the incidence of implant loss by regular monitoring of the patient and preventing the recurrence of disease progression in treated peri implant site that is the main therapeutic goal of implant maintenance therapy.

Point of Divergence: Peri-Implantitis Vs. Periodontitis

Periodontal and peri-implant tissues are extremely different, and the most evident difference is the presence of a ligament around a tooth compared to the ankylosed state of an implant. In a study, at a microscopic level author demonstrated the presence of a hemidesmosomal attachment at the epithelium–implant surface in contrast to the fibrous junctional epithelium of the Periodontium. [5]

Several animal studies in the early 90s have compared the initiation and progression of periimplant disease and then compared that to periodontal disease. In one of the pioneer studies using a canine model, showed that tissue destruction proceeds more slowly around implants than around natural teeth. [6]

Contrary study using a dog model induced peri-implantitis showed that signs of tissue destruction were more pronounced in dental implants than in natural teeth using both clinical signs and radiographs extended into the bone marrow, but those around natural teeth did not. [7]

Another study using a similar model, induced peri-implantitis and periodontitis around ankylosed teeth and control teeth, demonstrated that bone loss around implants was significantly greater than that observed around ankylosed teeth. [8]

The results of these early animal studies have been confirmed by studies on human subjects.

A study done on 275 implants in 50 subjects concluded that, over a period of 30 months post-loading, the peri-

implant mucosa demonstrated a significantly greater likelihood of having elevated inflammation and plaque when compared to the gingiva around natural teeth. [9]

Another study compared the peri-implant disease initiation on 15 healthy subjects and measured a significant increase in plaque and gingival indices, MMP-8 at implant crevicular fluid, but no differences in levels of IL-1β, and detection of putative periodontal pathogens between implant and natural tooth sites. Hence, introduced subsequent plaque control for implant maintenance. [10]

Table 1: Depicts the characteristic contrasting features between a natural teeth and dental implant

Sn.	Parameters	Natural Tooth	Implant
1.	Composition	Calcium and phosphorus (hydroxyapatite)	Primarily titanium and titanium-based alloy
2.	Nature	Living	Non-living
3.	Gingival Sulcus Depth	Shallow	Depends upon abutment length and restoration margin
4.	Junctional Epithelium	On enamel	On titanium
5.	Connectivity Issue	Perpendicular to tooth surfaces	Parallel and circular fibers; no attachment to implant or bone
6.	Gingival Fibers	Complex array inserted into cementum above crestal bone	No organized collagen fiber attachment
7.	Crest Of Bone	1 to 2 mm apical to cementoenamel junction	According to implant design
8.	Nerve Supply	Present	Absent
9.	Proprioception	Highly sensitive	No ligament receptors
10.	Physical Characteristics	Physiologic mobility caused by viscoelastic properties of the ligament	Rigid connection to bone, as if ankylosed
11.	Adaptive Characteristics	Width of ligament can alter to allow more mobility with increased occlusal forces	No adaptive capacity to allow mobility; orthodontic movement impossible
12.	Connection	Cementum, bone, periodontium	Osseointegration, bone functional ankylosis ligament
13.	Junctional Epithelium	Lamina lucida and lucida, lamina dense zones	Lamina, lamina densa, and sublamina lucida zones
14.	Connective Tissue	Thirteen groups: perpendicular to tooth surfaces Decreased collagen, increased fibroblasts	Two groups: parallel and circular fibers Increased collagen, decreased fibroblasts
15.	Biological Width	2.04 to 2.91 mm	3.08 mm
16.	Vascularity	Greater, supraperiosteal and periodontal ligament	Less, periosteal
17.	Probing Depth	3 mm in health	2.5 to 5.00 mm
18.	Bleeding On Probing	More reliable	Less reliable

Peri-Implant Diagnostic Parameters

Conventional methods used for evaluation of peri-implant health include periimplant probing depths (PD),

some form of recording for gingival inflammation, plaque accumulation, radiographic evaluation, peri-implant crevicular fluid (PICF) evaluation, and recording implant stability. All methods are helpful but possess inherent limitations especially regarding implant health prognostication. The following are various diagnostic parameters to assess peri implant health.

1. Plaque and Mucosal Assessment
2. Bleeding on Probing (BOP)
3. Peri-Implant Probing Depth
4. Width of Peri-Implant Keratinized Mucosa
5. Peri-Implant Sulcus Fluid Analysis (PISF)
6. Suppuration
7. Occlusal Evaluation
8. Radiographic Evaluation
9. Evaluation of Implant Stability/Mobility
10. Set of indices

Plaque and Mucosal Assessment

No standard indices similar to those used for the evaluation of periodontal conditions have been defined for the characterization of periimplant tissues. Periodontal parameters are not strictly applicable to the features of tissues encountered around implant fixtures. It seems reasonable to define parameters applicable to the periimplant area which are based on periodontal indices such as the Plaque Index, Sulcus Bleeding Index and Gingival Index. Such parameters were developed to assess plaque by the criteria of a modified Plaque Index (mPlI). The bleeding tendency of the marginal periimplant tissues was evaluated using a modified Sulcus Bleeding Index (mBI) by Mombelli et al. [4]

Bleeding On Probing (BOP)

Absence of bleeding on probing has been reported to represent periodontal health with a negative predictive value of 98.5%. Periodontal probing is commonly used for assessing both the status of gingival health and connective tissue attachment around teeth. The role of probing around endosseous implants explained by Lang et al. in 1994, that demonstrated healthy peri-implant sites were characterized by the absence of bleeding (0%), whereas both peri-implant mucositis and peri-implantitis sites showed substantially increased BOP (67% and 91%, resp.).[11] Later, Luterbacher and coworkers reported that BOP alone yields higher diagnostic accuracy at implant sites compared with tooth sites. [12]

BOP has been used to assess peri-implant tissue conditions around implants. However, no correlation was found between BOP and histologic, microbiologic, or radiographic changes around implants. It was hypothesized that bleeding could have been caused by inappropriate force transmission from the periodontal probe tip to the peri-implant soft tissues. [13]

Width of Peri-Implant Keratinized Mucosa

Clinical and experimental studies have failed to support the concept of an “adequate width” of keratinized tissue adjacent to natural teeth for the maintenance of periodontal health. Implant research has also focused on the necessity of the presence of keratinized mucosa around oral implants.[14][15] The presence of good oral hygiene, the nature of the mucosa may have little influence on the long-term survival of implants. However, suboptimal oral hygiene may lead to greater tissue damage around implants within alveolar mucosa than around implants within keratinized tissue. Prospective longitudinal controlled clinical trials will have to be performed to further elucidate the potential role of a sealing effect of keratinized mucosa on long-term peri-implant health.

Peri-Implant Sulcus Fluid Analysis (PISF)

Several biochemical mediators in the PISF have been identified as potential host markers for peri-implant

disease activity and progression and their analysis offers a non-invasive means of evaluating the role of host response in peri-implant disease. To date, only a few studies have reported on the association between signs of peri-implant inflammation and increased levels of inflammatory mediators in the peri-implant sulcus fluid (PISF).[16-20] Collectively, these data document an important implication of catabolic inflammatory mediators in periimplant tissue breakdown and indicate a potential value of biochemical markers for monitoring the host response during the supportive phase of implant therapy.

Suppuration

Peri-implantitis is often associated with bleeding, suppuration, increased probing depth, mobility, and bone loss; therefore, suppuration is a definite indicator of the disease activity and indicates the need for anti-infective therapy.[21]

Occlusal Evaluation

The occlusal status of the implant and its prosthesis has to be evaluated on a routine basis. Any signs of occlusal disharmonies, such as premature contacts or interferences, should be identified and corrected to prevent occlusal overload which can in turn cause a host of problems, including loosening of abutment screws, implant failure, and prosthetic failure.[22]

Radiographic Evaluation

A mean crestal bone loss ≥1.5mm during the first year after loading and ≥0.2mm/year thereafter has been proposed as one of the major success criteria. Hence, long-term preservation of peri-implant crestal bone height is extremely crucial. Preventive maintenance appointments should be scheduled every 3 to 4 months and a periapical/vertical bitewing radiograph at 6 to 8 months should be compared with the baseline to assess crestal bone changes, which occur often during the first year of loading. These two previous radiographs should be compared with another vertical bitewing radiograph at 1year. If no changes or unfavorable clinical signs are apparent, subsequent radiographic examinations may be scheduled every 3 years. However, if crestal changes are evident, radiographs must be taken and reviewed every 6 to 8 months until the bone is stable for two consecutive periods, besides stress reduction and hygiene modification. [23]

Evaluation of Implant Stability/Mobility

Unlike a tooth, for which mobility is not a primary factor for longevity, mobility is a primary determining factor for implant health. Rigid fixation is usually the first clinical criterion evaluated for a dental implant. The techniques to assess rigid fixation are similar to those used for natural tooth mobility, with an end of two rigid instrument with approx. 500gm force. The amplitude of tooth mobility may be rated from 0 to 4 on an implant mobility scale given by Misch. Though the recording of implant mobility may be specific but it is not a sensitive clinical parameter in detecting loss of osseointegration, this parameter more likely detects the final stage of osseo-disintegration and, therefore, represents a late implant loss. [24] An electronic device (Periotest) and Resonance frequency analysis (RFA) has been developed to measure primary implant stability and to monitor implant stability over time. This method not only evaluates the stiffness of the bone-implant interface but also allows the detection of any increase or decrease in implant stability that otherwise could not be clinically perceived. [25]

Indices in Implantology

With time, the emphasis for long-term success of implant has changed from a focus on the surgical phase of treatment to obtaining osseointegration and, now, recently, towards the long-term maintenance health of

the peri-implant hard and soft tissues. The long term success of this therapy runs in parallel to its maintenance protocol. Patient education and motivation is important at each recall visit. Implant indices can serve as a powerful tool for the dentists to monitor the state of health or regulating the progression of disease at implant site as well as it can provide individual assessment to help patient to recognize and reinforce the maintenance. An index is a tool that serve to monitor patient maintenance at recall visits as well as evaluating patient satisfaction regarding dental implant esthetics and function. No standard indices similar to those used for the evaluation of periodontal conditions have been defined for the characterization of periimplant tissues. An attempt is made to compile currently available literature on the indices in oral implantology for defining success criteria, planning of the implant, at diagnostic stage, esthetics evaluation, maintenance of the peri implant site.

Radiomorphometric analysis at diagnostic stage, quantifies the bone mineral density of the edentulous sites and exerts a strong relationship of these indices with their potential indicator of osteoporotic state anticipating the stability of dental implant. Analysis of esthetic scores mostly using photographic record, gives a good reproducible tool for evaluating the esthetic appearance of the soft tissue around single-tooth implant crown prosthesis and can be a useful tool for monitoring long-term soft-tissue alterations around implant. Assessing periodontal or periimplant soft tissue healing scores is utmost important in order to maintain a positive architecture that is a major importance to satisfy the growing esthetic demands of patients. At maintenance stage, no standard indices similar to those used for the evaluation of periodontal conditions have been defined for the characterization of periimplant tissues rather modifications in these have been studied due to implant and its peculiar attachment with the surrounding bone.

Table 2: Proposed Classification of Indices In Implantology

At diagnostic stage	Panoramic Indices	Author, Year
	Panoramic Mandibular Index (PMI) [27]	Benson BW, Prihoda TJ, Glass BJ, 1991
	Mandibular Cortex Index (MCI) [26]	Klemetti E, Kolmakov S, Kröger H., 1994
	Mental Index (MI) [28]	Ledgerton D, Horner K, Devlin H, Worthington H., 1999
	Antegonial Index (AI) [28]	Ledgerton D, Horner K, Devlin H, Worthington H., 1999
	Gonial Index (GI) [28]	Ledgerton D, Horner K, Devlin H, Worthington H., 1999
At healing stage	Healing Index (HI) [29]	Landry, R.G.; Turnbull, R.S.; Howley, T, 1988
	Early Wound-Healing Index (EHI) [30]	Wachtel H et al, 2003
	Wound Healing Index (WHI) [31]	Huang LH, Neiva RE, Wang HL, 2005
	Early Wound Healing Score (EHS) [32]	Marini L. et al, 2018
	Gingival Healing Index (GHI) [33]	Trombelli L. et al, 2018
Evaluation of implant esthetics		
	Papilla Index [34]	Jemt (1997)

Mucosa aesthetics indices	Pink Esthetic Score [35]	Furhauser et al. (2005)
	Implant Esthetic Score [36]	Testori et al. (2005)
	Subjective Aesthetic Score [37]	Evans & Chen (2008)
	Modified Jemt Papilla Index [38]	Schropp & Isidor (2008)
	Smile esthetic index (SEI) [39]	Rotundo R (2015)
Reconstruction aesthetics	Guidelines for the assessment of clinical quality and professional performance proposed by the Californian Dental Association (1977) [40]	De Bruyn et al. (2000)
Mucosa and reconstruction aesthetics	Chang Index [41]	Chang et al. (1999)
	Implant Crown Esthetic Index [42]	Meijer et al. (2005)
	Levin Index [43]	Levin et al. (2005)
	Rompen Index [44]	Rompen et al. (2007)
	Pink and White Esthetic Score (PES/ WES) [45]	Belser et al. (2009)
	Esthetic Outcome Objective Score [46]	Dueled et al. (2009)
	Root coverage esthetic index [47]	Cairo F (2009)
	Complete Esthetic Index [48]	Juodzbalys G (2010)
At maintenance and follow up stage	Modified Plaque Index [49]	Mombelli A, Van Oosten MA, Schürch Jr E, Lang NP., 1987
	Lindquist Plaque Index [50]	Lindquist LW, Rockler B, Carlsson GE, 1988
	Modified Bleeding Index [49]	Mombelli A, Van Oosten MA, Schürch Jr E, Lang NP.,1987
	Mazza Bleeding Index [51]	Mazza JE, Newman MG, Sims TN, 1981
	Gingival Index [52]	Apse P, Zarb GA, Schmitt A, Lewis DW, 1992
Peri-implant marginal mucosal index	Clinical Mobility Scale [52]	Apse P, Zarb GA, Schmitt A, Lewis DW, 1992

Conclusion

To best assess present disease activity, it is necessary to use descriptive methods of quantifying disease incidence that lend themselves a quantitative evaluation and electronic data processing through indices. The literature above provided almost all the possible indices available related to the implant at diagnostic, healing, functional esthetic and maintenance stages with its own merits and limitations. Assessing various parameters like bone mineral density, pink(mucosal)/ white(crown proportion of adjacent tooth and implant), smile esthetics, soft tissue recession around implant, soft tissue seal around implant, osseointegration, hygiene maintenance, gingival status, bleeding status, mobility and others. Periimplant indices serves as a powerful tool for quantifying the disease incidence to best assess the present disease

activity and it can suggest the long term success of implant therapy. However, the success criterion has to be established with various longitudinal studies. Research efforts are currently under way to relate biologic parameters to morphologic changes in peri-implant structures. However, reliable prognostic indicators for peri-implant hard and soft tissue changes are still lacking. With further research in terms of radiographic, morphologic and histologic studies, a predictive diagnostic indices can become a routine recommendation in clinical practice in near future.

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