Original Article

Evaluation of the correlation between interleukin 1β levels in peri-implant crevicular fluid as an adjunctive diagnostic marker with clinical and radiographic parameters for assessing the peri-implant health status

ABSTRACT

Background: Interleukin-1β (IL-1β) is one of the most important cytokines that seems to have an important role in the inflammatory process in gingival and peri-implant tissues. As peri-implant crevicular fluid (PICF) provides with a more swift and objective measure of the disease activity, the present study was conducted to evaluate IL-1β level in PICF as a biochemical marker and to investigate its correlation with clinical parameters and radiological parameters.

Materials and Methods: After evaluating all the patients following inclusion and exclusion criteria, 60 patients were selected for the study. After 3–4 months of implants placement, the implants were exposed following standard surgical procedure. PICF sample from implant site was taken 3 days after suture removal with gingival former still in place followed by measurement of clinical and radiological parameters.

Results: There was significant increase in IL-1β levels in both the follow-ups from baseline with variable and minimal change in the clinical parameters and radiological parameters as well, which shows that IL-1β levels change significantly even when there is a minimal gingival inflammation.

Conclusion: Therefore, IL-1β level in PICF can be used as an adjunctive diagnostic marker to clinical and radiographic parameters for assessing the peri-implant health status.

Keywords: Dental implant, interleukin-1β, peri-implant crevicular fluid

BACKGROUND

The use of endosseous implants to treat completely and partially edentulous patients has become a standard of care in dentistry as patients are more contended with implant-supported prosthodontic rehabilitation as far as esthetics, restoration of the function, mucosal comfort, and stability are concerned compared to conventional prosthesis. High success and predictability also contribute to its wide acceptance, despite the facts failures do occur, and implant-supported prostheses may require substantial periodontal and prosthodontic maintenance over time.[1]

It has become increasingly evident that following osseointegration and loading, implants that begin to fail develop peri-implant inflammation similar to periodontitis.[2]

The consensus report of the First European Workshop on Periodontology proposed peri-implant diseases into two

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entities as peri-implant mucositis and peri-implantitis.[3] Peri-implant mucositis was defined as a reversible inflammatory reaction in the soft tissues surrounding a functioning implant, whereas peri-implantitis was described as inflammatory reactions associated with loss of supporting bone around an implant in function. Host response to the presence of various microbial pathogens in the oral biofilm or plaque around implant-supported prosthesis found to be similar to the changes in periodontal status of tooth. Because of this similarity in the inflammatory response around the endosseous implants resulting in loss of attachment, peri-implant diseases are being termed into two different types: peri-implant mucositis and peri-implantitis according to the clinical presentation of bleeding on probing (BOP), purulence, pocketing, breakdown of the peri-implant epithelial seal, and progressive bone loss. Peri-implant mucositis defined as reversible inflammatory reaction in soft tissue surrounding an implant, and peri-implantitis is defined as "inflammatory process affecting the soft and hard tissues surrounding an osseointegrated implant resulting in rapid loss of supporting bone and associated with bleeding and suppuration." However peri-implant diseases are not considered as implant failure because there are treatments that may be used in an attempt to restrict the disease progression.[4,5]

The peri-implant diseases prevalence has been reported with the considerable variations among the studies reported. Zitzmann and Berglundh[6] showed that the frequency of peri-implantitis varied between 28 and 56% of the participants; and in 12 and 43% of individual implants. In a systematic review by Berglundh *et al*.,[7] the biologic and technical complications in oral implant therapy were summarized by reviewing a large number of longitudinal prospective studies. Implant loss was most frequently described (reported in about 100% of studies), with biological complications were considered in 40–60%, and technical complications in 60–80% of the studies.

As the criteria for evaluating disease activity around dental implants are mainly based on clinical and radiographic methods, they often reflect extensive inflammatory changes. The tissue appearance may not be a good clinical measure for monitoring early peri-implant health changes. The radiographic evidence of bone loss is also detectable only after a significant demineralization has taken place. Furthermore, the evaluation of clinical and radiographic changes is often subjective. Ideally, the presence of peri-implantitis should be detected objectively and during the early inflammatory phase to minimize the tissue damage and increase the potential for therapeutic success.[8]

A number of diagnostic tests have been used by clinicians to supplement clinical signs with objective tests that include microbiologic monitoring, proteolytic enzyme markers from bacteria (e.g., collagenase and glycosidases), markers of tissue damage, and markers of repair and regeneration. Recently, gingival crevicular fluid (GCF)/peri-implant crevicular fluid (PICF) analysis has been the focus of intense investigation.[9]

PICF is an osmotically mediated inflammatory exudate originating from the vessels of the gingival plexus that contains host-derived enzymes, inflammatory mediators as cytokines, and tissue breakdown products. Various studies have indicated that enzymatic activity of putative pathogens, host-derived enzymes, tissue breakdown products, and inflammatory mediators are present in GCF/PICF. These may be useful not only in detecting the presence of periodontal/peri-implant disease but also in predicting impending disease activity.[10]

IL-1β in co-operation with other inflammatory markers and growth factors such as acute-phase proteins and immunoglobulin G against Porphyromonas gingivalis, platelet derived growth factor (PDGF), prostaglandin E2 (PgE2) and aspartate aminotransferase has an important role in regulating and amplifying the inflammatory response in periodontal and peri-implant tissues.[6,11]

Based on the fact that periodontitis and peri-implantitis are similar in clinical manifestations and microbial profile, it seems that the IL-1β stimulated during peri-implantitis may also be the same cytokine that is released during periodontitis and may cause destruction of the supporting peri-implant tissues.

Thus, this study was carried out to evaluate IL-1β as an important biochemical marker in PICF to evaluate the tissue destruction around dental implants/natural tooth and to correlate it with the clinical and radiological parameters around implants tooth.

MATERIALS AND METHODS

All patients reporting to the Outdoor Patient Department of Periodontology of the institute were evaluated after obtaining ethical clearance from I.D.S.T ehical committe with ref. no. IDST/IERBC/2016-19/27 dated 23.11.2016 with inclusion criteria of presence of partially edentulous site and presence of adequate bone volume and vertical interarch space to accommodate an implant with prosthesis of appropriate size as determined by clinical inspection and preoperative radiographs, and excluded if they had medical history that would complicate the outcome of the study, dental history of bruxism, parafunctional habit, and/or lack of stable posterior occlusion, habit of smoking or alcohol consumption, any

osteodegenerative disorder, pregnant or lactating females, and patients allergic to drugs.

After evaluating all the patients following inclusion and exclusion criteria, 60 patients were selected for the study. All the patients were informed and explained about the nature and course of treatment and an informed consent were obtained from them before starting the treatment.

All the implant sites in the selected patients were treated following the standard protocols for two-stage implant placement [Figure 1a–c]. After 3–4 months of implants placement, the implants were exposed following standard surgical procedure. The implant was sufficiently exposed to allow removal of cover screw. Gingival former was placed/screwed and soft tissue was trimmed (if necessary) [Figure 1d] and sutured back around the gingival former. Sutures were removed after 7 days. PICF sample with PICF collection kit [Figure 2a] from implant site was taken 3 days after suture removal with gingival former still in place and sent for IL-1β analysis [Figure 2b and c]. Also the following clinical and radiological parameters were recorded on the same day of PICF collection. All these readings were considered as baseline records.

All the selected implant sites were recorded and evaluated for modified plaque index (mPI), simplified gingival index (SGI), modified sulcular bleeding index (mSBI), probing depths at four sites (mesiobuccal, mid-buccal, distobuccal, and mid-palatal).

After recording the mPI, PICF collection was done [Figure 3a, c, e] and then SGI, mSBI, and probing depths [Figure 4a–c] were recorded to avoid contamination of PICF with blood that is induced during probing.

a. Before the collection of crevicular fluid, the implant site/area was first isolated with cotton rolls and the area was dried.
b. After carefully removing the supragingival plaque, a standardized volume of 3 µl PICF from the implant site was collected using calibrated, volumetric microcapillary pipettes positioned extracrevicularly on the margin of the gingiva around the gingival former or implant-supported crown [Figure 3a, c, e].

Sample was then immediately transferred to an eppendorf-tube containing phosphate-buffered solution (PBS) (100 µl) [Figure 3b, d, f] and frozen at −80°C.

Radiographic parameters

Intraoral periapical radiographs were taken using the long cone paralleling technique and were transferred to a digital software and analyzed for crestal bone level changes at baseline, 3 month, and 6 month compared with the bone level at the time of implant placement [Figure 5a–d].

Following the baseline recording of PICF collection and clinical and radiographic evaluation, impressions were taken following the standard protocols and implant-supported prosthesis was delivered/inserted within 7 days.

All the recordings (PICF sampling, clinical, and radiographic parameters) from implant site were repeated after 3 and 6 month from baseline using the same protocols/methods.

Lab procedure for PICF analysis of IL-1β level

Lab procedure for detecting the level of IL-1β in the PICF collected involves the enzyme-linked immunosorbent assaying (ELISA) technique. The technique involves the

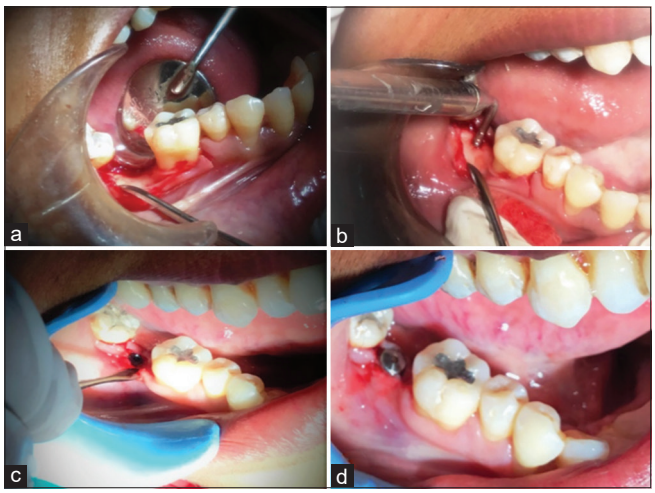

Figure 1: Surgical phase (a) flap reflection (b) placement of guide pin (c) placement of dental implant, and (d) implant with healing screw

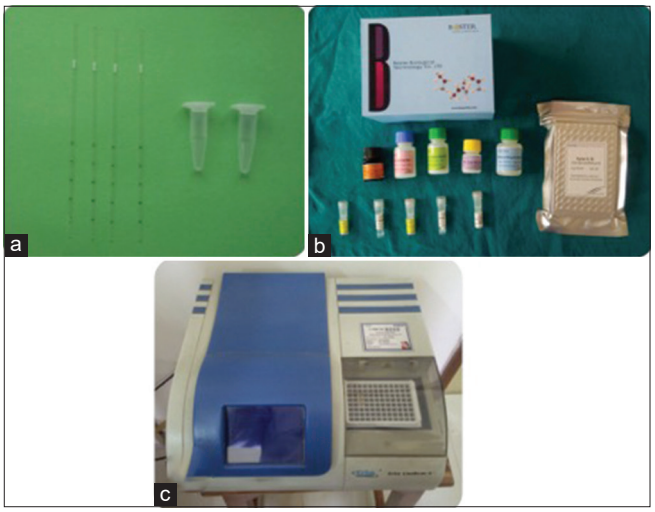

Figure 2: Armamentarium (a) microcapillary pipettes and eppendorf-tubes (b) ELISA kit, and (c) ELISA reader

immobilization of an antigen to a solid surface and then complexed with an antibody that is linked to an enzyme. Then, detection is accomplished by assessing the conjugated enzyme activity via incubation with a substrate to produce a measureable product. The most crucial element of the detection strategy is a highly specific antibody–antigen interaction. Reagents used (provided with the ELISA kit) were standard solution, PBS, avidine biotin peroxidase (ABC), tetra methyl benzydine (TMB), and biotinylated antibody.

Assay procedure

The ABC working solution and TMB color-developing agent were kept warm at 37°C for 30 min before starting the procedure. Human IL-1β standard solution was kept pre-coated in the 96 wells test plate. Diluent buffer (0.1 ml) was added into the control well and 0.1 ml of each diluted samples was added in the rest of the wells. The plate was sealed and incubated at 37°C for 90 min [Figure 6a].

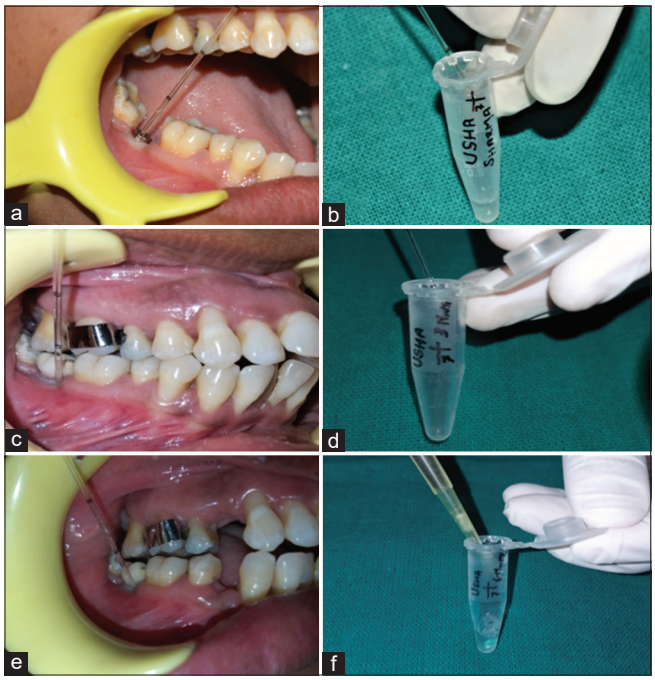

Figure 3: PICF collection and transfer (a) Collection of PICF from implant site at baseline (b) PICF transfer to eppendorf tube with buffer at baseline (c) Collection of PICF from implant site at 3 months (d) PICF transfer to eppendorf tube with buffer at 3 months (e) Collection of PICF from implant site at 6-months, and (f) PICF transfer to eppendorf tube with buffer at 6-months

Cover was removed after incubation and plate contents were discarded without letting the wells completely dry. Biotinylated antibody working solution (0.1ml) was added into each well and sealed plate was incubated at 37°C for 60 min. After incubation, plate was washed-off three times with 0.01 M PBS, and each time, let the washing buffer stay in the wells for 1 min. Then, 0.1 ml of ABC working solution was added into each well and covered plate again incubated at 37°C for 30 min [Figure 6b]. TMB color-developing agent (90 µl) was added into each well and incubate at 37°C for 15–20 min. Then, 0.1 ml of TMB stop solution was added into each well and the color changes immediately [Figure 6c and d]. The test wells were then kept in the ELISA reader for the detection and analysis of IL-1β level in test samples.

Method for radiographic calibration

The digitalized radiographic image was assessed for changes in the mesial and distal crestal bone level around placed implants. A horizontal line was made at the implant shoulder that was placed equicrestal at the time of implant placement. This horizontal line was taken as the reference for evaluating the mesial and distal bone level changes. Then, the digitalized radiographic image was calibrated by the length of the implant placed (from reference line to the tip of the implant). The calibrated radiographic images were further used to determine the mesial and distal bone level by evaluating the distance between the reference line and bone crestal height. This was measured by drawing vertical lines from the reference line to the mesial and distal bone crestal height adjoining the implant surface. Baseline, 3 month, and 6 month measurements of these vertical lines were compared to determine the changes in the bone height on both mesial and distal surfaces.

All the baseline, 3 month, and 6 month parameters were be recorded in a tabulated proforma and statistically analyzed to find the correlation between biochemical, clinical, and radiological parameters.

Descriptive statistics was performed by calculating mean and standard deviation for the continuous variables. Categorical variables are presented as absolute numbers

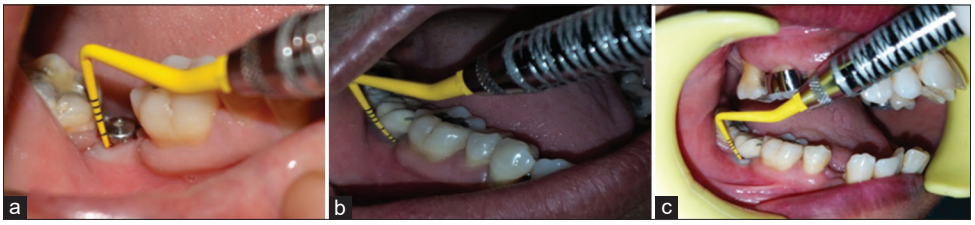

Figure 4: Clinical parameters (a) probing at baseline (b) probing at 3 month, and (c) probing at 6 month

and percentage. Nominal categorical data between the groups were compared using Chi-square goodness-to-fit test.

The software used for the statistical analysis was Statistical Package for Social Sciences version 21.0 and Epi-info version 3.0.

RESULTS

Mean mPI [Table 1] changes significantly from baseline to 3 month and baseline to 6 month and non-significantly from 3 month to 6 month, whereas mean SGI [Table 1] changes significantly from baseline to 6 month and 3 month to 6 month and non-significantly from baseline to 3 month. Changes in mean mSBI [Table 1] were significant from 3 month to 6 month and non-significantly from baseline to 3 and 6 month.

Mean probing depth (PD [Table 1] changes significantly from baseline to 6 month and 3 to 6 month and non-significantly from baseline to 3 month and mean bone loss (BL) [Table 1] increased significantly from baseline to 3 and 6 month and 3 month to 6 month.

IL-1β levels [Table 1] in PICF increased significantly from baseline to 3 and 6 month and 3 month to 6 month.

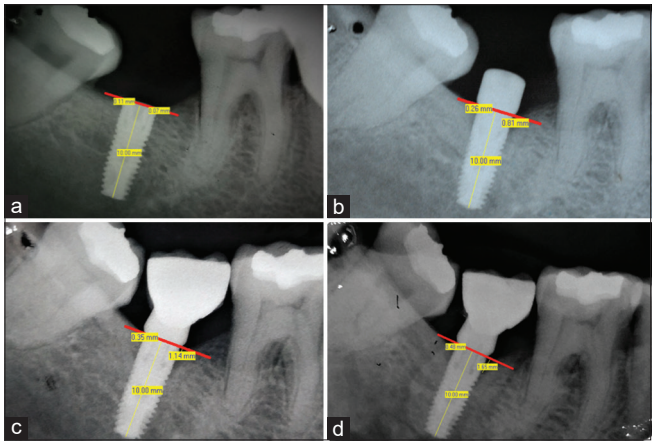

Figure 5: Radiographic parameters (a) bone level at mesial and distal sites at placement of dental implant (b) changes in bone level at mesial and distal sites at baseline (c) changes in bone level at mesial and distal sites at 3 month, and (d) changes in bone level at mesial and distal sites at 6 month

Correlation of mPI with other parameters

There was no significant correlation between the mean mPI and the other parameters from baseline to 3 and 6 months, respectively, and 3 month to 6 month was found, other than the mean IL-1β level that was significantly correlated [Table 2].

Correlation of SGI with other parameters

There was no significant correlation of mean SGI with mean mSBI and mean PD from baseline to 3 month was found, but mean BL level was only weakly correlated. Mean IL-1 level was significantly correlated during baseline to 3 months of the study [Table 3].

There was no significant correlation between mean SGI and mean PD, mean SBI, mean BL, and mean IL-1β level from baseline to 6 month was found [Table 3].

There was no significant correlation between mean SGI and mean PD, mean SBI, and mean BL from 3 to 6 months was found other than with the IL-1β level where significantly positive correlation was found [Table 4].

Correlation of mSBI with other parameters

There was no significant correlation of mean mSBI with the mean PD, mean BL, and mean IL-1β levels from baseline to 3 month was found [Table 4].

There was no significant correlation of mean mSBI with mean PD and mean BL from baseline to 6 month was found but mean IL-1β level was significantly correlated.

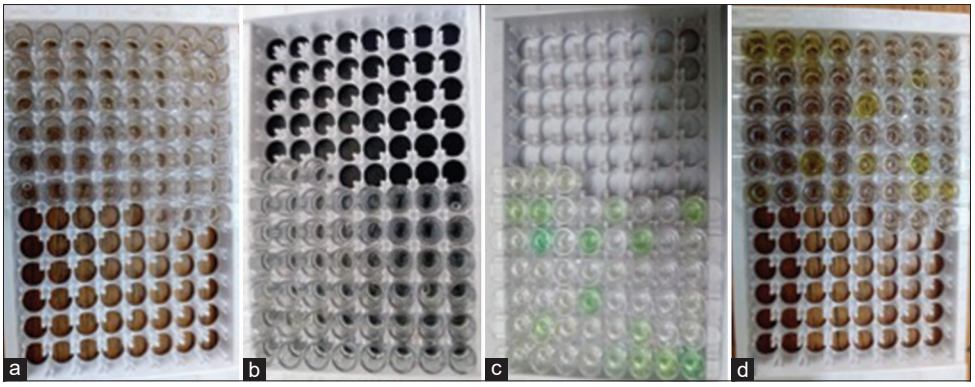

Figure 6: Assessment of IL-1β level in PICF by ELISA. (a) Test plate with standard solution coated test wells and 0.1ml of diluted samples with buffer as diluent. (b) ABC Working solution added in each well. (c) Test Plate with TMB color developing agent and stop solution added. (d) Test wells ready for ELISA reader for detection and analysis of IL -1β

Table 1: Clinical parameters at different time interval and inter-interval comparison

Time interval	mPI			SGI			mSBI			PD			BL			IL-1β		
	mean	Difference from baseline	*P*	mean	Difference from baseline	*P*	mean	Difference from baseline	*P*	mean	Difference from baseline	*P*	mean	Difference from baseline	*P*	mean	Difference from baseline	*P*
Baseline	1.42			1.38			1.20			2.60			0.64			28.40		
3 months	1.66	-0.24	0.038*	1.40	-0.02	1.000	1.05	0.14	0.664	2.68	-0.08	1.000	0.80	-0.16	<0.001*	42.93	-14.53	<0.001*
6 months	1.69	-0.27	0.004*	1.62	-0.24	0.038*	1.33	-0.14	0.488	3.15	-0.55	0.045*	1.01	-0.37	<0.001*	120.40	-92.00	<0.001*
3-6 months		-0.03	1.000		-0.22	0.042*		-0.28	0.033*		-0.47	0.043*		-0.21	0.001*		-77.47	<0.001*

mPI=modified plaque index, SGI=simplified gingival index, mSBI=modified sulcular bleeding index, PD=probing depth, BL=bone loss, IL-1β=interleukin-1β. *P* value ≤0.05 significant

Table 2: Correlation of MPI with other parameters

	(MPI) Baseline to 3 months	(MPI) Baseline to 6 months	(MPI) Baseline to 3-6 months
	Pearson's correlation	Pearson's correlation	Pearson's correlation
	P	*P*	*P*
Difference in mGI	0.041	0.159	0.093
	0.885	0.573	0.741
Difference in mSBI	0.310	0.446	0.071
	0.261	0.096	0.802
Difference in mPD from	0.169	0.099	0.385
	0.546	0.725	0.156
Difference in mBL	-0.276	0.091	0.120
	0.319	0.748	0.670
Difference in IL-1β	-0.063	0.600	0.522
	0.825	0.018*	0.038*

mPI=modified plaque index, mSBI=modified sulcular bleeding index, mPD=mean probing depth, mBL=mean bone loss, IL-1β=interleukin-1β. *P* value ≤0.05 significant

Table 3: Correlation of SGI with other parameters

	(SGI) Baseline to 3 months	(SGI) Baseline to 6 months	(SGI) Baseline to 3-6 months
	Pearson's correlation	Pearson's correlation	Pearson's correlation
	P	*P*	*P*
Difference in mSBI	0.288	0.126	0.028
	0.298	0.656	0.921
Difference in mPD	0.351	0.449	0.086
	0.199	0.093	0.760
Difference in mBL	0.690	0.074	0.245
	0.004*	0.793	0.378
Difference in IL-1β	0.517	0.042	0.490
	0.048*	0.883	0.039*

SGI=simplified gingival index, mSBI=modified sulcular bleeding index, mPD=mean probing depth , mBL=mean bone loss, IL-1β=interleukin-1β. *P* value ≤0.05 significant

Table 4: Correlation of mSBI with other parameters

	(mSBI) Baseline to 3 months	(mSBI) Baseline to 6 months	(mSBI) Baseline to 3-6 months
	Pearson's correlation	Pearson's correlation	Pearson's correlation
	P	*P*	*P*
Difference in mPD	0.318	0.141	0.600
	0.249	0.617	0.018*
Difference in mBL	0.513	0.135	0.423
	0.051	0.631	0.042*
Difference in IL-1β	0.351	0.695	0.478
	0.199	0.004*	0.046*

mSBI=modified sulcular bleeding index, mPD=mean probing depth , mBL=mean bone loss, IL-1β=interleukin-1β. *P* value ≤0.05 significant

Significantly positive correlation of mSBI with the mean PD, mean BL, and mean level of IL-1β from 3 to 6 months was found.

Correlation of PD with other parameters [Table 5]

There was no significant correlation with the mean BL at all three intervals were found, whereas mean IL-1β

levels were significantly correlated with the mean PD at any intervals.

Correlation of BI with other parameters [Table 6]

There was a significantly positive correlation with mean IL-1β levels were found at all three intervals.

DISCUSSION

In the present study, the mean mPI and SGI scores increased non-significantly from 3 month to 6 month implying that the oral hygiene condition was maintained over a follow-up period. The same score increased significantly from the baseline to 3 month and 6 month implicating the compromised maintenance of the oral hygiene post-prosthesis insertion. The absence of any statistically significant correlation between the clinical and radiographical parameters with the mPI and SGI suggests on the independence of the hard and soft tissue condition around implant from the expected relationship of these factors [Tables 2 and 3].[12] The gingival index and changes in the crestal bone level were only weakly correlated suggesting the difficulties in recording soft tissue condition around implants as the non-keratinized peri-implant mucosa appears as reddened gingiva than the keratinized tissue around natural teeth,[13] with the residual scaring from the surgical procedures of implant placement surgeries added to the difficulties in the assessment of clinical parameters.[9,14,15]

Comparison of the mean SBI results shows non-significant increase from the baseline with the absence of any correlation between other clinical and radiographic parameters during same period. These findings are in accordance with the longitudinal study by Apse *et al.*[16] in 1991 and Lekholm *et al.*[17] in 1986. The scores of mean SBI show significant increase during 3 month to 6 month, although BOP had a high negative predictive value for monitoring peri-implant health status.[18,13] Kajale*et al.*[9] in 2014 reported BOP may be more directly related to the tightness of the mucosa around the abutment, and probing may result in tissue penetration with subsequent bleeding occurring at otherwise healthy site. Non-keratinized soft tissue adherence without any fibrous attachment into metallic surface with the varied thickness of gingival bio-type contributes to the increased tissue penetration and subsequent bleeding while probing. In the experimental study by Ericsson and Lindhe[14] in 1993, higher scores of BOP from the healthy implant sites compared with the healthy natural dentition were reported,[13] correspondingly Meyer *et al.*[19] in 2017 observed higher proportions of bleeding sites in peri-implant mucosa compared with that observed in gingiva in the comparative human study. Therefore, for peri-implant tissues, the presence of BOP is non- suggestive for the peri-implant gingival inflammation and peri-implantitis as with the gingival and periodontal tissues in natural dentition.

Table 5: Correlation of probing depth (PD) with other parameters

	(PD) Baseline to 3 months	(PD) Baseline to 6months	(PD) Baseline to 3-6 months
	Pearson Correlation	Pearson Correlation	Pearson Correlation
	P	*P*	*P*
Difference in mBL	0.275	0.324	0.152
	0.321	0.238	0.590
Difference in IL-1β	0.489	0.629	0.419
	0.042*	0.011*	0.047*

**P* value ≤0.05 significant

Table 6: Correlation of bone loss with other parameters

	(BL) Baseline to 3 months	(BL) Baseline to 6 months	(BL) Baseline to 3-6 months
	Pearson's correlation	Pearson's correlation	Pearson's correlation
	P	*P*	*P*
Difference in IL-1β	0.799	0.438	0.521
	0.001*	0.043*	0.028*

BL=bone loss, IL-1β=interleukin-1β. **P* value ≤0.05 significant

Comparisons of PD between the three visits were found to be statistically significant with the mean PD significantly increasing up to 3.15 mm from 2.60 mm at 6 month of recall. This increase in mean PD was within physiological limits as many studies have indicated that successful implants allow probe penetration of approximately 3–3.5 mm. Mombelli *et al.*[20] in 1993 reported that a mean PD of 8.5 mm for unsuccessful implants and a mean PD of 3.9 mm for successful implants.[13] One potential explanation was given by Listgarten *et al.*[21] in 1991 for the increased peri-implant PD measurements. They stated that the most collagen fibers in the supracrestal connective tissue compartment have been demonstrated to run in a parallel direction to the implant axis; hence, it was concluded that peri-implant PD measurements are more sensitive to force variation than the corresponding measurements around teeth.[13]

Radiographic changes in the mean BL was found to be significantly increasing at both the recalls from baseline. The changes in the crestal bone level were 0.64 mm at baseline with the mean BL up to 1.01 mm at 6 month interval that was comparable to one of the studies, in which the mean crestal BL at 6 month was found to be 1.2 mm on mesial and distal surface of implant.[15] The changes in the marginal bone level were also found to be similar to the study by Harby *et al.*[22] in 2016 where marginal bone level changes were checked immediately postoperatively, on the third, sixth, and

on the ninth months intervals. The statistically significant increase in the crestal bone loss around implants was within the physiological limits of 2 mm during the first year in function. the finding was in accordance to the proceedings by world workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions in 2018.[23]

Present study showed that PICF consistently had lower levels of IL-1β at baseline. The low values at the baseline may be because of the presence of the healing abutment that caused minimal peri-implant mucosal irritation. These findings may be supported by a previous study that compared components of PICF.[9] The statistically significant increase in the values at the 3 month and 6 month recall can be attributed to the sub-marginal placement of the implant supported crown margins.[20] One more possibility for such high values at the 6 month recall may be because of the effect of occlusal loading of the prosthesis. Nevertheless, both the 3 and 6 month values of IL-1β in peri-implant mucosa were well within the range of healthy implants as seen by Kao *et al.*[10] and Ataoglu *et al.*[24]

While analyzing the correlation between the different parameters, non-significant correlation exists between clinical and radiological parameters between all three time intervals. This non-significant correlation was also stated by Chaytor *et al.*[12] and found the absence of any statistically significant correlations between marginal alveolar bone level change and plaque index, amount of keratinized mucosa, and other clinical parameters. The gingival index and the PD were only somewhat weakly correlated with bone level changes. Lekholm and colleagues[17] in 1986 found no correlation between BOP and histologic, microbiologic, or radiographic changes around implants.[13] Becker *et al.*[25] stated in their study that the evidence of implant radiolucencies together with the mobility and the increased PDs as the secondary factor is a good indicator of implant failure.

Finally, the correlation of biochemical parameters with clinical parameters using the Pearson's correlation coefficient revealed significant correlation between the above parameters at the baseline and both follow-ups. This is in agreement with the outcomes of the study done by Yaghobee *et al.*[11]

In 2014, Salvi and Lang[13] state that it is reasonable to use number of clinical parameters along with radiographic and biochemical parameters to discriminate between peri-implant health and disease. It was made evident from this study that indicates the use of a number of clinical, biochemical, and radiographic parameters in the evaluation of peri-implant tissue status. In 2018, Schwarz *et al.*[26] stated through the systematic reviews that the assessment of proinflammatory cytokines (mainly IL-1β) levels in the PICF is of beneficial to differentiate between peri-implant health and disease. While Heitz-Mayfield *et al.*[27] in 2018 stated the significance of IL-1β level in PICF from TNF-α and TGF-β_2 levels that did not change during the experimental period, whereas IL-1β yielded a significant increase after 3 weeks of abolished oral hygiene and was reversed to pre-experimental levels after reinstitution of oral hygiene measures.

The clinical, radiographic and biochemical parameters in the present study were within the healthy range. The correlation was significant between biochemical parameter with all the other parameters and this outcome could have been the reason for the meaningful evaluating the peri-implant health status even in the cases of sub-clinical inflammation.

Hence, this suggests us that IL-1β can be a useful adjunctive biochemical marker along with the clinical and radiological parameters for assessing the peri-implant health status.

CONCLUSION

The present study was conducted to investigate the correlation of IL-1β level in PICF with the clinical parameters (mPI, SGI, mSBI, and PD) and radiological parameters. There was significant correlation between IL-1β level and clinical and radiological parameters at all time intervals. Therefore, IL-1β level in PICF can be used as an adjunctive diagnostic marker to clinical and radiographic parameters for assessing the peri-implant health status.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed

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Conflicts of interest

There are no conflicts of interest.

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