Available online at **www.ijmrhs.com**

ISSN No: 2319-5886

International Journal of Medical Research & Health Sciences, 2021, 10(12): 88-97

Distribution of Alveolar Bone Defects Associated with Periodontitis Patients: A Demographic Study

Shivani Sachdeva[1*], Harish Saluja[2], Ameet Mani[1], Tanupriya Sonkar[3], Sayali Patil[4] and Vikram R. Pagar Patil[5]

[1]Department of Periodontology, Pravara Institute of Medical Sciences, RDC, Loni, Maharashtra, India

[2]Department of Oral and Maxillofacial Surgery, Pravara Institute of Medical Sciences, RDC, Loni, Maharashtra, India

[3]Department of Prosthodontics, Pravara Institute of Medical Sciences, RDC, Loni, Maharashtra, India

[4]Department of Periodontology, SMBT Dental College & Hospital, Maharashtra, India

[5]Department of Orthodontics, SMBT Dental College & Hospital, Maharashtra, India

[*]Corresponding e-mail: dr.shivani19@gmail.com

ABSTRACT

Aim: *Periodontal disease is one of the most widespread diseases of mankind. It is a chronic destructive infectious disease that involves the resorption of bone supporting the teeth. The purpose of this study was to analyze the prevalence and distribution of different forms of bone defects among different demographics in the Indian population.* ***Material and Methods:*** *The study population comprised forty-four patients of different age groups with moderate and severe periodontitis chronic periodontitis. A total sample of 1041 teeth was explored surgically and classified into suprabony, intrabony, inter radicular, and other bone defects. This study focuses on the differences in the distribution of various bone defects between different groups of age and gender.* ***Results:*** *Among 1041 teeth the prevalence of bone defects was 97%. Craters and intrabony defects were almost equal for age group 31-40 years and 41-50 years. But in the age group 51-60 years, craters comprised 33.3% and intrabony defects comprised 66.7%. Males had two times more 3-wall defects than females.* ***Conclusion:*** *The present study reveals that there is a need for applying epidemiological principles to periodontal bone defects to better understand the natural history of periodontal disease and eradicate the factors responsible for their commencement and progression. The following research article has been presented at the 2nd international congress of the world academy of growth factors and stem cells in dentistry (WAGRO) 25th -27th October 2018.*

Keywords: Demographics, Bone defects, Periodontitis, Prevalence, Inter-radicular defects

Abbreviations: SB: Suprabony Defect, IB: Infrabony Defect, OB: Other Bone Defect, IR: Interradicular Defect, CR: Crater, IT: Intrabony, CB: Combination, BB: Bulbous Bone Contour, LD: Ledge, RA: Reversed Architecture, FN: Fenestration, DH: Dehiscence, TR: Trench, RM: Ramp

INTRODUCTION

Lord Kelvin said, "Until you can count it, weigh it, or express it in a quantitative fashion, you have scarcely begun to think about the problem in a scientific fashion". Differences in the localization of bone defects do exist and that might be related to the associated loss of tooth support, to the site-specificity of periodontal destruction, and to the possibility that ecological niches (deep pockets and furcation involvement) associated with some osseous lesions may represent site-specific risk factors or indicators for disease progression [1-3].

Different studies depict that there are discrepancies in the distribution of defects between different groups for age, sex, and socioeconomic status. An increasing frequency of periodontal intrabony defects with age has been observed in many studies [4]. There were also variations between the occurrences of bone defects in males and females.

The present study is a descriptive cross-sectional epidemiological study that aims to pertain the epidemiological principles to evaluate the distribution of alveolar bone defects, explored surgically under direct illumination within the age range of 30-60 years, amongst both genders. The question of exploring the secrets behind the peculiar behaviour of the alveolar bone carries special significance to the dental profession, as periodontal disease is a major public dental health problem and knowledge of the osseous defects is useful to arrive at a diagnosis, to assess prognosis, and to plan the treatment.

MATERIALS AND METHODS

Source Data

A prospective descriptive cross-sectional study was carried out in the Department of Periodontology at Pravara Institute of Medical Sciences after taking ethical approval from the institutional ethical committee. The sample size was calculated and the prevalence and distribution of bone defects in 44 patients within the age range of 30-60 years comprising of twenty-one males and twenty-three females having moderate to severe chronic periodontitis were selected.

Inclusion Criteria

- Patients with a minimum of 10 natural teeth [5]
- Persistent gingival bleeding on probing after phase I therapy [5]
- Patients having intra-bony and inter-radicular defects [5]
- Patients having moderate and severe chronic periodontitis and having clinical attachment loss ≥ 3 mm and probing pocket depth of ≥ 5 mm [5]

Exclusion Criteria

- Patient with any systemic disease and who had undergone any type of periodontal surgery
- Patients with aggressive periodontitis
- Smokers

Method of Collecting Data

A given sample of 1041 teeth was explored. The patients were examined and diagnosis of moderate and severe chronic periodontitis was made after the detailed clinical and standardized radiological examination. Informed consent was obtained from all patient-participants.

Method of Segregation of Study Sample

After taking a detailed case history, the study sample was segregated into different groups according to age and gender which are depicted below:

A. Age

- 31-40 years
- 41-50 years
- 51-60 years

B. Gender

- Male
- Female

Procedure

The non-surgical treatment consisting of plaque control instructions, scaling and root planning under local anesthesia was carried out. Re-evaluation of the initial therapy was performed 6-8 weeks later and then patients were considered for periodontal surgical treatment. Periodontal surgery was performed and the osseous defects were explored under good illumination.

Classification and Description of Periodontal Bone Defects

The periodontal bone defects were classified as Suprabony (SB) defects, Intrabony (IB) defects (Craters and Intrabony defects), Other Bone defects (OB), and Interradicular (IR) defects [6]. The classification system was specially designed for the study and also for the designation of different bone defects; the general and specific criteria were followed. When a combination of more than one type of defect existed, all of them were recorded.

Collection, Comparison, and Statistical Analysis

All the raw data was assembled in the master chart by counting the SB, IB, OB, and IR defects for the study population. The data from the master chart was tabulated and segregated into groups of age and gender. The graphical representation of prevalence and distribution of bone defects for different demographics. Comparison of data by proportions and percentages was carried out under subheadings (**Part A and B**).

Tests for Statistical Significance

Statistical software 'Graph Pad Prism version 5' was used for the analysis of data. The sampling technique was simple stratified random sampling. The percentage and distribution of different defects were evaluated for significance using the Chi-square test and Fisher exact test.

It constituted evaluation of prevalence and distribution of SB, IB, OB, and IR defects among 3 different groups for age (31-40 years, 41-50 years and 50-60 years). To find the prevalence of different defects within the same age group, it was presumed that every group for age had 100% of defects. This enabled us in making a comparison of the percentage of defects within the same age group (absolute intragroup comparison). It not only explored the occurrences of dominant and minor defects but also helped in evaluating the pattern of variation among different groups (relative intergroup comparison). Although, it did not allow us to perform absolute intergroup comparison as there was sample size variability. Henceforth, the percentages of SB, IB, and OB defects were calculated and compared with each other, considering SB+IB+OB=100%, in each group for age. On similar grounds and following the same principles, percentages were calculated for both genders.

Percentage of Defects

The prevalence and distribution of SB, IB (CR and IT), OB, and IR were evaluated in each group for age and gender.

Number of defects/Total number of (SB+IB+OB) defects present in particular group × 100

RESULTS

The prevalence of defects in 1041 teeth was 97%. These 1010 defects were the absolute defects which comprised of SB, IB, and OB defects. Out of these 1010 defects, 184 defects were associated with one tooth, while 826 defects were associated with more than one tooth. Defects associated with one tooth were IT, RA, DH, and TR defects. And the defects associated with more than one tooth were SB, CR, BB and LD, and RM. Among the absolute bone defects fenestration was not observed.

In the present study, IR defects were counted separately because they depict the stage in the progress of disease and its severity. Therefore, they have been classified as relative defects in the present study. Total, 404 multi-rooted teeth were explored and out of that, 254 IR defects were observed comprising of Grade I, II, and III furcation involvement. Grade IV furcation involvement was not observed among the relative IR defects. The prevalence of IR defects among 404 multi-rooted teeth examined was 62.8%. Among these 404 teeth, 250 multi-rooted teeth did not have IR defects while 154 teeth were associated with IR defects. Hence, the prevalence of teeth with relative defects was 38.1%.

Age

The prevalence and distribution of absolute defects (SB, IB, and OB defects) were evaluated for 3 different groups of age as depicted in Table 1.

Table 1 Prevalence and distribution of absolute defects (SB, IB and OB) according to age

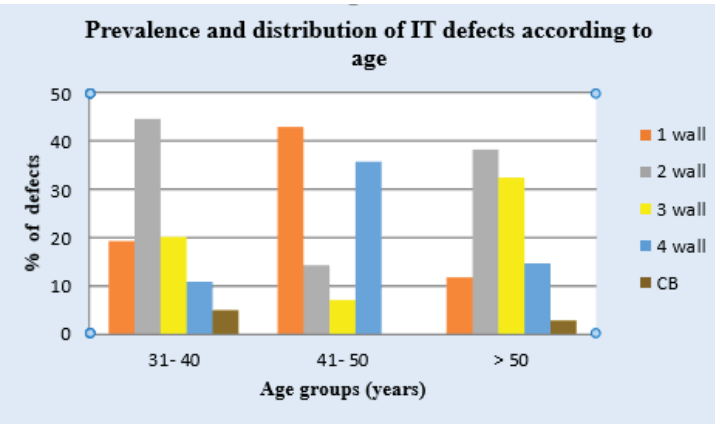
Age Groups	Teeth	SB	%	IB						OB	%	DF	%
				CR	%	IT	%	T	%				
31-40	803	503	65.1	116	15	119	15.4	235	30.4	35	4.5	773	100
41-50	104	69	67	14	13.6	14	13.6	28	27.2	6	5.8	103	100
51-60	134	71	52.9	17	12.7	34	25.4	51	38.1	12	9	134	100
Total	1041	643	63.7	147	14.5	167	16.5	314	31.1	53	5.2	1010	100
χ^2=9.876; d(f)=4; p-value=0.0426 (p<0.05), Statistically significant													

The statistical evaluation for the prevalence of SB, IB, and OB defects in 3 different groups for age was found to be statistically significant, using the chi-square test at 95% confidence interval. Though the differences in percentages of SB, IB, and OB defects for age groups 31-40 years and 41-50 years were minimal, the statistical evaluation was done to compare the prevalence in these 2 groups for age, and the results were found to be statistically not significant (χ^2=0.6914; p-value=0.7077, which is >0.05). Table 2 depicts the prevalence of defects in the age group 31-40 years, CR is 49.6% and IT formed 50.4% defects. The statistical evaluation for the prevalence of two IB defects i.e. CR and IT showed a p-value of>0.05. Hence, the difference in the results among 3 different groups for age was found to be statistically not significant.

Table 2 Prevalence and distribution of IB defects according to age

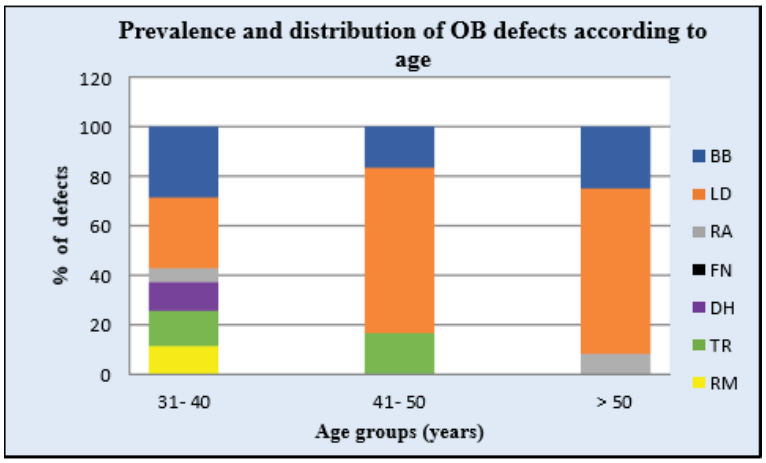
Age group	Infrabony defects				Total
	Crater		Intrabony		
	T	%	T	%	
31-40	116	49.6	119	50.4	235
41-50	14	50	14	50	28
≥ 50	17	33.3	34	66.7	51
Total	147	46.81	167	53.18	314
χ^2=4.449; d(f)=2; p-value=0.1081 (p>0.05)					

The prevalence and distribution of various IT defect i.e. 1-, 2-, 3-, 4- wall and CB defects in different age groups showed a p-value of <0.05. Hence, the differences in results in 3 different age groups for various IT defects were found to be statistically significant depicted in Graph 1.



Graph 1 Prevalence and distribution of IT defects according to age

The prevalence and distribution of OB defects have been depicted in Graph 2 and showed p-value>0.05. Hence, the differences in the results in 3 different groups for age were statistically not significant.



Graph 2 Prevalence and distribution of OB defects according to age

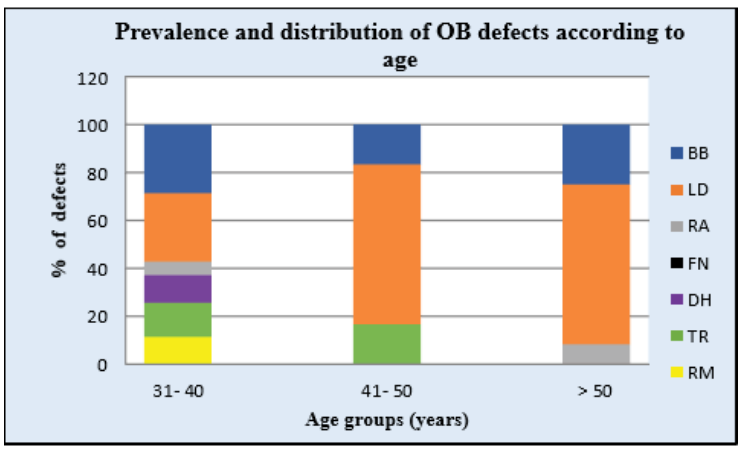
The statistical evaluation for the prevalence of IR defects showed a p-value ≤ 0.001. Hence, the differences in the results in 3 different groups for age were found to be statistically highly significant tabulated in Table 3.

Table 3 Prevalence and distribution of relative defects (IR) according to age

Age (years)	GR I		GR II		GR III		GR IV		Total	
	T	%	T	%	T	%	T	%	T	%
31- 40	103	63.2	56	34.4	4	2.5	0	0	163	100
41- 50	25	58.1	14	32.6	4	9.3	0	0	43	100
>50	11	22.9	24	50	13	27.1	0	0	48	100
Total	139	54.7	94	37	21	8.3	0	0	254	100
χ^2=41.10; d(f)= 4; p-value= <0.001, Highly significant										

Gender

The prevalence and distribution of absolute defects (SB, IB, and OB defects) were evaluated for different sexes. In males, the total defects explored were 451. In females, the total defects explored were 559. The distribution is depicted in Graph 3.

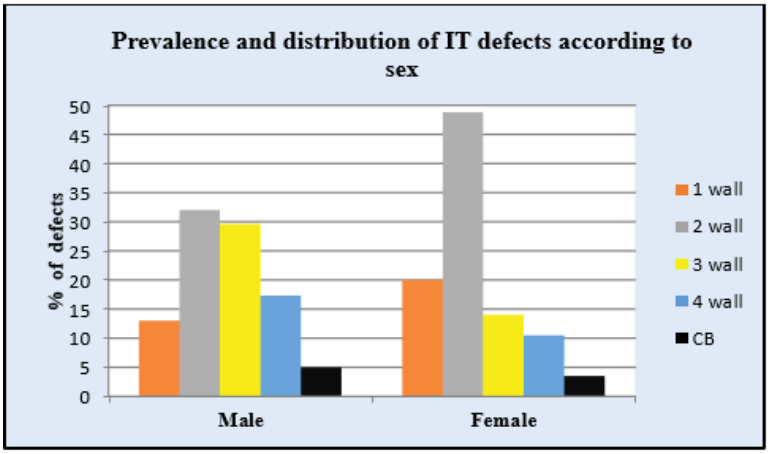


Graph 3 Prevalence and distribution of absolute defects (SB, IB, and OB) according to sex

The statistical evaluation for the prevalence of SB, IB, and OB defects showed a p-value>0.05. Hence, the differences in groups for sex were found to be statistically not significant, using the chi-square test at a 95% confidence interval.

The prevalence and distribution of IB defects were evaluated for sex. In males, 58 defects (41.7%) were CR, while 81 defects (58.2%) were IT defects. In females, 89 defects (50.9%) were CR, while 86 defects (49.1%) were IT defects. The statistical evaluation for the prevalence of two IB defects i.e. CR and IT showed a p-value as >0.05. Hence, the differences in groups for sex were found to be statistically not significant, using Fisher's exact test at a 95% confidence interval.

The prevalence and distribution of IT defect in different groups for sex was calculated and is shown in graphical representation Graph 4. Though the differences were found to be statistically not significant, they were significant clinically.



Graph 4 Prevalence and distribution of IT defects according to sex

The prevalence and distribution of OB defects according to sex was calculated. In males, OB defects i.e. BB, LD, RA, FN, DH, TR and RM were evaluated to be 8 (33.3%), 12 (50%), 2 (8.3%), 0, 0, 1 (4.2%) and 1 (4.2%), respectively. While in females, defects evaluated were 6 (20.7%), 10 (34.5%), 1 (3.5%), 0, 4 (13.8%), 5 (17.2%) and 3 (10.3%) for BB, LD, RA, FN, DH, TR and RM, respectively.

The prevalence and distribution of different IR defects were calculated for different groups of sex. In males, prevalence and distribution were 64 (49.6%), 51 (39.5%), and 14 (10.9%), while in females they were 75 (60%), 43 (34.4%), and 7 (5.6%) for Grade I, II and III IR defects, respectively. It was also found that prevalence and distribution for Grade II and III IR defects increased for males than females, while in females Grade I IR defects were increased. Hence, the severity of IR defects was found more for males than females. The differences were clinically significant but statistically not significant.

DISCUSSION

The greatest of American epidemiologists stated that "Epidemiology is something more than the total of its facts. It includes their orderly arrangement into chains of inference which extends more or less beyond the bounds of direct observation. Such of these chains are well and truly laid and guide in the investigation to the facts of the future. Those that are ill laid, fetter progress". [7].

Hence, in the present study different variables like age, sex, socioeconomic status, arch, and segments were assessed for differences in the prevalence and distribution defects. The paper in the assessment of arch and segments has already been published while SES is not included in this current article. It was found that the statistically significant differences in defects were associated with age, while between differences were statistically not significant for gender.

In the present study, both clinical and radiographical analysis helped in the diagnosis of moderate and severe chronic periodontitis patients. To overcome the limitations of other methods surgical inspection was done in the present study, which is considered to be the gold standard for the evaluation of periodontal bone defects [8].

In the present study, defects were explored, classified5, and their distribution was assessed. We have classified the defect into Suprabony defects (SB), Intrabony defects (IB), other bone defects, and Inter-radicular defects (IR). It was carried out on 44 subjects in the age range of 30-60 years and the average age of patients was 36.8 years. A total number of 1041 teeth was surgically explored from 21 males and 23 females for evaluating the prevalence and distribution of bone defects in patients having moderate and severe chronic periodontitis.

The data was qualitative and not ordinal; hence, chi-square and fisher's exact test were applicable in the present study. These tests were also enhanced to test whether the distribution of attributes in different groups was due to sampling variation or not.

Age

Destructive periodontal disease has been so consistently associated with aging that many authors in the past came to see it as an inevitable consequence of growing older. In the present study, patients were segregated into different age groups 31-40 years, 41-50 years, and 50-60 years. This was done to evaluate the prevalence and distribution of defects among different stages in life. It was also done to assess the variations in patterns of defects for different age groups [9].

In the age group 31-40 years, 773 absolute defects were found within 803 teeth. While in 41-50 years, 103 absolute defects were associated with 104 teeth, and in the age group 50-60 years, 134 absolute defects were found in 134 teeth examined. In the present study, it was observed that absolute defects increased with aging and the differences were statistically significant among 3 different age groups.

These were similar to the findings of Saari J, et al., that there was the tendency of the defects to increase with age [10].

It was seen, both clinically as well as statistically, that the prevalence of SB defects for age groups 31-40 years and 41-50 years were similar but it decreased in the age group 50-60 years. While IB defects were similar for age groups 31-40 years and 41-50 years but they increased for age groups 50-60 years. Also, OB defects consistently increased with aging.

It can be seen that in age groups 31-40 years and 41-50 years, the CR and IT defects were found to be almost equal, while in the age group 50-60 years, IT defects were found to be more than CR. It was also observed that CR decreased with aging, while IT defects increased with age. Hence, the differences were clinically significant but statistically not significant.

IT defects increased with aging, this finding of the present study was in agreement with the finding of Nielson IM, et al., [11]. They found that the difference in the prevalence of defects among the different age groups was statistically significant and intrabony defects occurred more frequently in the older age group (45-55 years and >60 years). They also observed that 37% of individuals older than 60 years had at least one IT defect, whereas this was found in only 18% of patients between the age group of 30-44 years, which depicts a drastic increase in IT defects.

Also, skulls of the age 60 years tended to have on average more intrabony defects than skulls of the younger age group. These findings of Lorato were by our study. But the present study has contrasting findings from a study by Papapanou where angular bone defects increased till 50 years and thereafter drop was seen [12,13]. While in the present study, no drop in IT defects was appreciated in the age group 50-60 years, rather they increased after 50 years. The possible explanation could be the difference in the study design as this study was carried out by examining intraoral X-rays, where we are bound to find the decreased incidence of intrabony defects due to overlapping of facial and lingual/ palatal cortical plate while in the present study there was a direct surgical exploration of defects [14-17].

The possible explanation of increased IT defects in the age group 50-60 years can be explained, as the individual mean bone level i.e. the distance between the CEJ and the coronal border of the alveolar bone, increased with increasing age [13]. Also, as the reduction in alveolar bone height with age occurred there was an increase in the thickness of alveolar bone, which could have led to the formation of more intrabony defects.

It was inferred that in the age group 31-40 years and 50-60 years, 2-wall and 3-wall were the dominant defects. While in 41-50 years, 1-wall and 4-wall were the dominant defects. The least prevalent defect was the CB defect for all the age groups. The differences were clinically as well as statistically significant.

The prevalence and distribution of OB defects showed that LD increased with aging, while DH and RM decreased with aging. For BB, RA, and TR no such trend could be determined. The differences were clinically significant but statistically not significant. There was an observed decrease of DH with age, this finding was consistent with the trend reported by Rupprecht RD., et al., [18]. This observation may be due to increased tooth loss with age that results in fewer teeth being at risk. Fenestration was not found in the present study which might be related to the possible conversion of fenestration from young subjects to dehiscence in older subjects.

In the present study, it was observed, that the severity of IR defects increased with age. Among, the IR defects in 31-40 years and 41-50 years Grade I>Grade II>Grade III. While in the age group 50-60 years, Grade II>Grade III>Grade I. The differences were clinically as well as statistically highly significant. This corresponded with studies by Lorato, Svadstrom, et al., [19,20]. The possible explanation for this finding could be that with increasing age the oral hygiene deteriorates and more severe bone loss occurs in the inter-radicular bone between two roots of multi-rooted teeth [19,21] Hence, it can be inferred that as the age increases, the severity of IR defects increases i.e. Grade II and III IR defect increases.

Gender

The differences in occurrences of defects were assessed for both males and females to evaluate the variations, if present, in patterns of bone defects among two different sexes. In males, the absolute defects found were 451, in a sample of 454 teeth, this formed 99.4% of occurrences. While in females absolute defects found were 559, in a sample of 587 teeth explored, accounting for 95.2% of occurrences. This showed that males had a higher prevalence of absolute defects than females.

The differences in SB, IB, and OB defects among the two gender was neither clinically nor statistically significant. The findings of Nielson, et al., were similar to the findings in the present study, that there was no statistically significant difference between the prevalence and distribution of defects in males and females [11]. But the slight difference in occurrences could be explained by the long-known difference in periodontal status between men and women which are usually attributed to women's better oral hygiene practices.

It was ascertained that in males the prevalence of IT defects was more than craters. While in females craters and IT defects occurred equally. The present study accords with the findings of Wouters FR, et al., those interproximal intrabony defects occurred more frequently in men than women but they found differences to be statistically significant [22].

It was also inferred that 2-wall and 3-wall defects were found to be more for males, while 1-wall and 2-wall defects were found to be more for females. The CB defect was least prevalent both for males and females. Males had two times more 3-wall defects than females. Though the differences were found to be statistically not significant, they were significant clinically.

BB, LD, and RA were found more in males than females, while DH, TR, and RM were found more in females than males. In the OB defects, males had 50% of LD and 33% of BB, while females had 34% of LD and 20% of BB. Though the differences were statistically not significant they were clinically significant. This finding was similar to the findings of Horning GM, et al., where buccal alveolar bone enlargements were common in males than females [23]. Dehiscence occurred exclusively in females and was not evident in males, the present finding accords with the finding of Rupprecht RD., et al., [18].

The order of prevalence of IR defects in descending order was Grade I>Grade II>Grade III both for males and females. It was also found that prevalence and distribution for Grade II and Grade III IR defects increased for males than females, while in females Grade I IR defects were increased. Hence, the severity of IR defects was more for males than females. The differences were clinically significant but statistically not significant. This finding was by the study by Svadstrom [20]. They also had no significant sex difference in inter-radicular bone defects but the severity of advanced furcation involvement was more for men.

Limitations

The limitations of the present study were sample size variability for the parameters of age groups. Also, the study holds for moderate and severe chronic periodontitis patients when probing pocket depth was ≤ 4 mm, because patients

with pocket depth ≤ 4 mm were not included, irrespective, of the presence of defects. And subjectivity might have been there as a single examiner has classified bone defects and there might be variability in the designation of defects.

CONCLUSION

Future Perspective

Also, future research relating the periodontal bone defects with aging can be better studied under longitudinal study. For today's periodontists and patients, regeneration of the periodontium lost by periodontitis is an ultimate goal. The high prevalence, as well as great variation and complexity of bone defects, support the view that treatment procedures with predictable success rates are of great significance in periodontal therapy.

DECLARATIONS

Conflicts of Interest

The authors declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

REFERENCES

[1] Vrotsos, John A., et al. "Prevalence and distribution of bone defects in moderate and advanced adult periodontitis." *Journal of Clinical Periodontology,* Vol. 26, No. 1, 1999, pp. 44-48.

[2] Sachdeva, Shivani, et al. "Prevalence and distribution of bone defects associated with moderate and severe periodontitis patients." *Clinical Epidemiology and Global Health,* Vol. 8, No. 3, 2020, pp. 712-17.

[3] Papapanou, Panos N., and Maurizio S. Tonetti. "Diagnosis and epidemiology of periodontal osseous lesions." *Periodontology 2000,* Vol. 22, No. 1, 2000, pp. 8-21.

[4] Persson, Rigmor E., et al. "Horizontal alveolar bone loss and vertical bone defects in an adult patient population." *Journal of Periodontology,* Vol. 69, No. 3, 1998, pp. 348-56.

[5] Carranza FA, Takei H. "The surgical phase of therapy. In: Newman, Takei, H. H. Takei, and P. Klokkevold. Carranza. Carranza's clinical periodontology." 2003.

[6] Sachdeva, Shivani, et al. "Newer morphological classification system-The insight in periodontics'." *EC Dental Science* Vol. 18, No. 6, 2019, pp. 1197-206.

[7] Greene, John C. "Epidemiology and indexing of periodontal disease." *The Journal of Periodontology,* Vol. 30, No. 2, 1959, pp. 133-39.

[8] Eickholz, Peter, et al. "Digital radiography of interproximal bone loss; validity of different filters." *Journal of Clinical Periodontology,* Vol. 26, No. 5, 1999, pp. 294-300.

[9] Persson, Rigmor E., et al. "Horizontal alveolar bone loss and vertical bone defects in an adult patient population." *Journal of Periodontology,* Vol. 69, No. 3, 1998, pp. 348-56.

[10] Saari, James T., William C. Hurt, and Norman L. Biggs. "Periodontal bony defects on the dry skull." *The Journal of Periodontology,* Vol. 39, No. 5, 1968, pp. 278-83.

[11] Nielsen, I. M., L. Glavind, and T. Karhing. "Interproximal periodontal intrabony defects: Prevalence, localization and etiological factors." *Journal of Clinical Periodontology,* Vol. 7, No. 3, 1980, pp. 187-98.

[12] Larato, Dominick C. "Intrabony defects in the dry human skull." *Journal of Periodontology,* Vol. 41, No. 9, 1970, pp. 496-98.

[13] Papapanou, Panos N., Jan L. Wennstrom, and Kerstin Grondahl. "Periodontal status in relation to age and tooth type: A cross-sectional radiographic study." *Journal of Clinical Periodontology,* Vol. 15, No. 7, 1988, pp. 469-78.

[14] Hou, G. L., et al. "Radiographic alveolar bone loss in untreated Taiwan Chinese subjects with adult periodontitis measured by the digital scanning radiographic image analysis method." *Dentomaxillofacial Radiology,* Vol. 32,

No. 2, 2003, pp. 104-08.

[15] Muller, Hans-Peter, and Martin Ulbrich. "Alveolar bone levels in adults as assessed on panoramic radiographs. (I) Prevalence, extent, and severity of even and angular bone loss." *Clinical Oral Investigations,* Vol. 9, No. 2, 2005, pp. 98-104.

[16] Goldman, Henry M., and Richard E. Stallard. "Limitations of the radiograph in the diagnosis of osseous defects in periodontal disease." *Journal of Periodontology,* Vol. 44, No. 10, 1973, pp. 626-28.

[17] Eickholz, Peter, et al. "Validity of radiographic measurement of interproximal bone loss." *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology,* Vol. 85, No. 1, 1998, pp. 99-106.

[18] Rupprecht, Robert D., et al. "Prevalence of dehiscences and fenestrations in modern American skulls." *Journal of Periodontology,* Vol. 72, No. 6, 2001, pp. 722-29.

[19] Larato, Dominick C. "Furcation involvements: Incidence and distribution." *Journal of Periodontology,* Vol. 41, No. 9, 1970, pp. 499-501.

[20] Svärdström, Gram, and Jan L. Wennström. "Prevalence of furcation involvements in patients referred for periodontal treatment." *Journal of Clinical Periodontology,* Vol. 23, No. 12, 1996, pp. 1093-99.

[21] Gupta, Om P. "Epidemiological study of periodontal disease in Trivandrum India." *Journal of Dental Research*. Vol. 43, No. 5, 1964.

[22] Wouters, Francis R., et al. "Prevalence of interproximal periodontal intrabony defects in an adult population in Sweden: A radiographic study." *Journal of Clinical Periodontology,* Vol. 16, No. 3, 1989, pp. 144-49.

[23] Rosenberg MM, Ross SE. "Management of osseous defects. In: James W. Clark. Clinical dentistry: Periodontal and oral surgery." *Harper and Row Publishers Inc*, 1977.