

Analysis of Mandibular Ridge Resorption in Completely Edentulous Patients Using Digital Panoramic Radiography

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Abstract:

Objectives: To determine variations of mandibular ridge resorption with period of edentulousness, age, gender and to evaluate the relative impact of these factors on the amount of resorption.

Methods: 60 completely edentulous subjects with age between 50 – 85 years, completely edentulous for more than 6 months were selected for the study. A standardized panoramic radiograph was made for all patients. Measurements were made digitally using RadiAnt Dicom viewer software and the amount of resorption was calculated using the Wical and Swoope method. Statistical analysis was done using t tests, ANOVA tests and regression analysis. Level of significance was set at 0.05.

Results: As age increased the amount of resorption increased (from 28.542% in younger age group to 34.205% in older age group). With increase in duration of edentulousness, as age increased, amount of resorption increased (p value = 0.000). With increase in age, as duration of edentulousness increased, amount of resorption increased (p value = 0.004). Resorption was found to be more in females than in males.

Conclusion: Resorption increased with increase in age, duration of edentulousness and was more in females than in males. Edentulous period had most significant impact on resorption followed by age and then gender.

Keywords: Complete denture, mandible, mental foramen, panoramic radiography, residual ridge resorption.

I. Introduction

Residual ridge is defined as the portion of the residual bone and its soft tissue covering that remains after the removal of teeth¹. Residual ridge resorption is a term which is used for the diminishing quantity and the quality of the residual ridge after the teeth are removed. It is a chronic, progressive, irreversible and disabling disease². Residual ridge resorption (RRR) is a continuous process, which is greater during the first few months after the tooth extraction than later (Kovacic et al. 2012)^{3, 4}. The rate of resorption is four times more pronounced in the mandible than in the maxilla (Tallgren 2003)³.

The aetiology of residual ridge resorption is said to be multifactorial. According to Atwood D A et al the factors related to the rate of resorption can be divided (Atwood et al⁵) into anatomic factors like size, shape and density of ridges, metabolic factors like nutritional and hormonal factors, functional factors like frequency, intensity, duration, and direction of forces applied to bone, and prosthetic factors like techniques, materials, concepts and principles incorporated in the fabrication of prostheses⁵. Systemic factors (Devlin et al⁶) include osteoporosis, hyperthyroidism, hyperparathyroidism and diabetes. Local factors include trauma involved during extraction, duration of edentulism, stress on the ridge, parafunction, antagonists etc. In addition to these factors, the majority of the authors establish the age and sex of the patient as important factors in the resorption of the residual alveolar ridge⁶.

The consequences of residual ridge resorption includes loss of sulcus depth and width, transformed facial aesthetics, altered vertical dimension of occlusion, and altered inter-arch relationship, all of which have some bearing on the success of the denture².

There are several methods devised to measure the ridge resorption like Cephalometric roentgenograms, Dento-contourographs, comparator used with the help of the casts, Photogrammetric method, measuring callipers, visual Analogue scale⁷ etc. The most widely used technique is the orthopantomographic method which was initially described by Wical and Swoope⁷. It is a simple and useful method to estimate the amount of RRR in a given patient at a particular time. Several authors^{8,9} after surveying anatomic specimens, have affirmed that the relationship of the foramen to the inferior border of the mandible remains relatively constant in spite of increasing age or resorption of the alveolar process above the foramen. Wical and Swoope suggested that the amount of bone below the foramen is a predictable proportion of total bone height (1:3). Hence this height may serve as the basis for estimating the original mandibular height in edentulous subjects. The amount of bone lost is best expressed as a proportion or fraction of the original height as such proportional estimations remain consistent in spite of varying sizes of mandibles and radiographic images⁸.

Panoramic radiographs (OPG) were used by several investigators¹⁰⁻¹² as they can be used to visualise a greater area of hard tissues, thus allowing a more accurate localization of the mental foramen in both the horizontal and vertical dimensions¹³. Advantages of using panoramic radiographs are that as panoramic radiographs are often part of the routine examination of patients, their use for research purposes does not involve the patient of any additional exposure or cost, and panoramic radiographs are also likely to be found in records going back several years; and hence constitutes a source of data for a retrospective study¹⁴.

Several studies have been done to evaluate the variations of mandibular ridge resorption with either age, gender or duration of edentulousness. However not many studies have been conducted to assess the impact of all the 3 factors and their inter relationship in amount of residual ridge resorption observed in completely edentulous subjects. Moreover no clear conclusions have been drawn from them due to their varied results.

It is of clinical significance to understand the rate and amount of resorption so as to predict the prognosis of the removable prosthesis with respect to the retention, stability and support, and also to predict the success of grafting procedures in extremely resorbed cases². Hence the present study was undertaken to determine variations of mandibular ridge resorption with period of edentulousness, age and gender and to evaluate the relative impact of these factors on the amount of resorption as it will be useful in appropriate treatment planning for the patients.

II. Materials And Methods

2.1. Ethical approval

The study protocol was approved by the Yenepoya University Ethics Committee, and the study was conducted in the department of Prosthodontics, Yenepoya dental college, Mangalore.

2.2. Armamentarium used

Digital OPG Machine
Standardized Digital OPG
RadiAnt Dicom viewer (Version 3.4.2) software

2.3. Source of data

This study was carried out on 60 completely edentulous subjects comprising both males and females, selected from the patients attending the department of Prosthodontics, Yenepoya University, Mangalore.

2.4. Selection Criteria

Inclusion Criteria

All subjects between the ages of 50-85 years who were completely edentulous for more than six months were included in the study.

Exclusion Criteria

- Patients who have undergone prosthetic surgical procedures like sulcus deepening or ridge augmentation
- Patients with maxillary and mandibular defects
- Patients with neurological deficits
- Patients with metabolic bone disease , cancers with bone metastasis
- Patients with significant renal impairment
- Patients under medications which affect bone metabolism such as estrogen.

2.5 Methodology

All the subjects were further subdivided into 12 groups based on their age, gender and duration of edentulousness (Table 1). After taking an informed consent, a standard panoramic radiograph (OPG) was made using the standardized Planmeca Promax machine on a standard Kodak C – Mat Green Sensitive 8 inch x 10 inch film. Exposure parameters were set at 68 kV, 5mA and 16 seconds. All images were made by the same operator according to standardization protocol for patient positioning. Only those OPGs in which anatomic landmarks such as mental foramen and the superior and inferior border of mandible were distinct on at least one side were selected. The following measurements were made (using RadiAnt Dicom viewer software): Distance between inferior border of mental foramen and inferior border of mandible (Fig 1), Distance between superior and inferior borders of mandible (Fig 2).

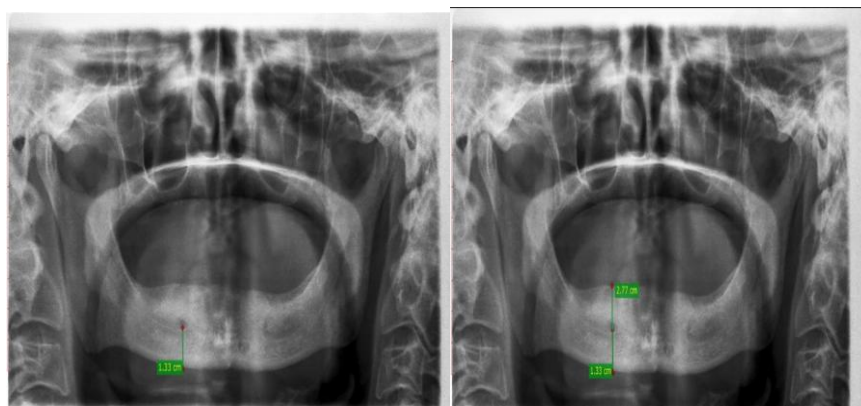


Fig 1

Fig 2

Fig 1: Measurement of distance from inferior border of mental foramen to inferior border of mandible

Fig 2: Measurement of distance between superior and inferior border of the mandible

The amount of resorption was calculated according to the formula given by Wical and Swoope⁷: $R = 3x - L$, where R is the amount of mandibular residual ridge resorption, x is the distance from inferior border of the mandible to the inferior border of mental foramen; L is the measured height of the mandibular residual ridge. The values obtained were recorded; and correlated with period of edentulousness, age and gender by statistical analysis using t tests, ANOVA, post hoc test of bonferroni and regression analysis. Level of significance was set at 0.05.

III. Results

With increase in the age of the subjects, resorption was found to increase and this difference was found to be statistically significant (p value is 0.008) (Table 2). With an increase in the duration of edentulousness, there was an increase in the amount of resorption in both the age groups which was found to be statistically significant for the period of edentulousness of 6M – 5Y (p value is 0.000) and 5 – 10Y (p value is 0.004), but was not significant for the period of 10 – 15Y (p value is 0.655) (Table 3)

With an increase in age, the amount of resorption was found to increase in all the three edentulous periods, and the difference was found to be statistically significant. (P value: 0.000)(Table 4) In males there was an increase in the amount of mean residual ridge resorption with increase in age which was found to be statistically significant (p value is 0.020) whereas in females, the increase in the amount of resorption with age was found to be statistically not significant (Table 5). In males and females, the mean amount of resorption was found to increase with an increase in the edentulous period, and this difference was found to be statistically significant (p value: 0.000) (Table 6). When the impact of the three factors on resorption was evaluated using regression analysis, duration of edentulousness was found to have the most impact with beta = 0.794, followed by age with beta = 0.351, and then gender with beta = 0.149. All these parameters were found to influence the resorption by 76.3 % (Table 7). It can be expressed in the equation as follows to predict approximately the amount of resorption

Amount of resorption (%) = $0.346 + 0.112 \times \text{Duration of edentulousness} + 0.372 \times \text{Age} - 2.473 \times \text{Gender}$ (1 if male, 0 if female) Here for gender, independent variable was created by coding 1 for males and 0 for females and it was found to be significant in the regression analysis (p = 0.032), and beta was found to be negative, which showed that males had lesser resorption when compared to females.

IV. Discussion

Gross resorption of the edentulous mandibular alveolar process resulting in excessive loss of denture bearing ridge is one of the most difficult restorative problems for the prosthodontist (Nahriet al¹⁵). Residual ridge resorption can be measured by different methods of which the most commonly used is the Wical and Swoope method⁷. Wical et al⁸ found the ratio between the total height of the mandible and the distance of mental foramen from inferior border of mandible (c/a) to be 2.90 ± 0.23 . Similar results were obtained in the studies by Bairam L R et al¹⁶, G. Pakota et al¹⁷, Naeem et al¹⁸. As the distance between the mental foramen and inferior border of mandible (x) is found to be constant and as the actual mandibular height is found to be 3 times the distance between foramen and inferior border, the amount of resorption can be calculated by using the formula $R = 3x - L$, where L is the measured height of the mandible⁸. The result of this study showed that the amount of mandibular ridge resorption increased with increase in age which was statistically significant. These findings are in agreement with a study done by Bianchi¹⁹ et al who suggested that the degree of alveolar bone loss increases with age which may be related, to the systemic conditions. The findings are also in agreement

with a study done by Bairam¹⁶ et al who found that the mean ratio of alveolar bone height tended to decrease with age. Similar results were also obtained in studies done by Jagadeesh⁷ et al, Imirzalioglu P²⁰ et al, and Al-Jabrah O³ et al. This can be explained by the fact that after the age of 40, the bone mineral density of the skeleton decreases, leading to the loss of approximately one third of the bone minerals by the age of 65²¹. Low bone density in the skeleton is accepted as a predisposing factor for rapid RRR in the mandible. Decreased physical activity, lowered secretion of oestrogen, diet, race and heredity may all play a role in age-related bone loss.

However contrasting results were obtained in the study by Atwood and coy⁵, Lopez – Roldan et al²², Hirai²³ et al who did not find any significant correlation between age and ridge resorption. The lack of correlation observed in these studies may be because of measuring rates of bone resorption in different age groups either immediately after extraction of teeth or shortly after. However, in studies that were conducted for many years, bone resorption continued throughout the whole period of observation and was found to have a positive correlation with age.

The results of this study showed that with an increase in the duration of edentulousness, there was an increase in the amount of resorption in both the age groups which was found to be statistically significant for the period of edentulousness of 6M – 5Y and 5 – 10Y, but was not significant for the period of 10 – 15Y. These findings are in agreement with a study done by Bairam et al¹⁶ who suggested that that the extent of bone loss does increase both with time after extraction and with age but may be statistically significant sometimes only when compared between 0-5 years and those 16 years and above after extraction in all age groups. The reason could possibly be that alveolar bone loss is more rapid in the first year after extraction and then after that there is a gradual decrease in the rate of resorption" resulting in a cumulative effect after a period of time. The results are also in agreement with the study done by Baat et al²⁴ who found that the mandibular alveolar bone resorption was greater in people who had been edentulous longer. In a study done by Zmyslowska et al²¹, the duration of mandibular edentulism was found to be closely associated with the degree of mandibular resorption. Similar results were also obtained in the studies done by Jagadeesh et al⁷ and Al Jabrah-O³ et al.

With an increase in age, the amount of resorption was found to increase in all the three edentulous periods, and the difference was found to be statistically significant. One possible reason was that bone resorption may have already started before extraction of the teeth, due to periodontal diseases which might have resulted in reduction in alveolar height while the teeth were still in the jaw, and this could have resulted in additional reduction in the height of the ridge after extraction of the teeth¹⁶.

It was found that resorption was more in females than in males. These findings are in agreement with several studies which had also reported that females have more alveolar RRR than males [Bianchi & Sanfilippo¹⁹ (2002), Lopez-Roldan et al²² (2009), Al-Jabrah³ (2011), Baat et al²⁴]. Kordatzis et al¹³ (2003) reported that the estimated average reduction in height for conventional CD was 1.63 mm in 5 years and that female gender was a risk factor for greater resorption. Solar et al²⁵, also revealed that female gender was an independent risk factor for more severe bone resorption. Rusiniak-Kubik et al²¹, reported an increase in mandibular residual ridge resorption in the course of the life of an edentulous patient and double the incidence of severe atrophy in females as compared with males. Increase in residual ridge resorption in females could be explained with the effect of the menopausal activity. After menopause, a deficiency of estrogen hormone was observed, which accelerated skeletal bone loss and resulted in rapid alveolar bone resorption²⁶. The mechanism of this phenomenon was confirmed in further experimental studies, which revealed that oestrogens induce apoptosis of osteoclasts. Hence oestrogen deficiency prolonged the life span of osteoclasts and, thereby contributed to more intense bone resorption²⁷.

The results of the study showed that, in females, as age increased the increase in amount of resorption was not found to be statistically significant which is in accordance with the study done by Narhi et al¹⁵, but is in contrast to the studies by Humphries et al²⁸, who stated that age of the subject was found to significantly affect RRR. This might be because of the age of the subjects included in the studies. The former studies included women of mostly in the post-menopausal age range whereas women of both premenopausal and postmenopausal age group were included in the latter studies.

In males as age increased there was an increase in the amount of resorption which was statistically significant. These findings are in agreement with the study done by Bairam et al¹⁶ who found that in males, the mean ratio of alveolar bone height tended to decrease with age. This may be because of the decrease in the bone mineral density with age, which predisposed to increase in amount of RRR.

The results of the study showed that, in females, with an increase in the period of edentulousness the amount of resorption increased which was found to be statistically significant. These findings are in agreement with the study done by Narhi et al¹⁵ who found that the amount of residual ridge resorption was significantly correlated with the number of years females were edentulous. The results can be explained by the fact that an increase in the amount of RRR has been found to occur after menopause and most of the subjects in the present study were past the usual age for menopause²⁹.

In males it was observed that with an increase in the period of edentulousness, the amount of resorption increased. These findings are in agreement with a study done by Bairamet al¹⁶ who suggested that that the amount of resorption increases with time after extraction.

The results of the present study showed that all the factors evaluated namely age, gender and duration of edentulousness had a significant impact on the amount of RRR with duration of edentulousness having the most impact. These findings suggests that attempts must be made to retain the teeth for the longest time possible as the amount of resorption would increase following teeth loss (Schwartz-Dabney & Dechow³⁰ 2002). Moreover, with increase in edentulous period, the reduction in height and width of the mandible occurs, which makes implant therapy more difficult. The results of a study by Crum and Rooney³¹ indicated that the use of the mandibular overdenture helped preserve alveolar bone in the mandible. They suggested that the discrete proprioceptive ability of the teeth under an overdenture acted as a signal against the physiological overload of the system and thus prevented bone resorption. . Similarly, Van Waaset al³² stated that retention of tooth roots, even if they are in poor condition, has a positive effect on the reduction of alveolar bone loss. Studies by Wright et al³³, Kordatzis et al¹³, concluded that implant-supported dentures showed a minimal reduction in the residual alveolar ridges compared to conventional dentures.

Tables

Table 1: Distribution of study subjects.

GROUPS	NO.OF SUBJECTS	AGE GROUP	GENDER	EDEDTULISM PERIOD
A	5	50-65	M	6M-5Y
B	5	50-65	F	6M-5Y
C	5	50-65	M	5-10Y
D	5	50-65	F	5-10Y
E	5	50-65	M	10-15Y
F	5	50-65	F	10-15Y
G	5	65-85	M	6M-5Y
H	5	65-85	F	6M-5Y
I	5	65-85	M	5-10Y
J	5	65-85	F	5-10Y
K	5	65-85	M	10-15Y
L	5	65-85	F	10-15Y

Table 2: Amount of mandibular ridge resorption with respect to age.

AGE	N	MEAN	STD. DEVIATION	T VALUE	P
50 – 65	30	28.542	8.5216	2.769	0.008
65 – 85	30	34.205	7.2681		(HS)

Table 3: Amount of mandibular ridge resorption with respect to duration of edentulousness in different age groups

	AGE	N	MEAN	STD DEVIATION	T VALUE	P
6M - 5Y	50 - 65	10	18.905	2.4445	7.081	0.000
	65 – 85	10	26.600	2.4152		
5 – 10Y	50 – 65	10	29.390	4.1351	3.292	0.004
	65 – 85	10	37.760	6.8958		
10 – 15Y	50 – 65	10	37.330	4.5949	0.454	0.655
	65 - 85	10	38.254	4.5064		

Table 4: Amount of mandibular ridge resorption with respect to age in different edentulous periods

	AGE	N	MEAN	STD DEVIATION	ANOVA F	P
50 – 65	6M - 5Y	10	18.905	2.4445	57.986	0.000
	5 – 10Y	10	29.390	4.1351		
	10 – 15Y	10	37.330	4.5949		
	Total	30	28.542	8.5216		
65 – 85	6M - 5Y	10	26.600	2.4152	17.682	0.000
	5 – 10Y	10	37.760	6.8958		
	10 – 15Y	10	38.254	4.5064		
	Total	30	34.205	7.2681		

Table 5: Amount of mandibular ridge resorption in males and females for different age groups

AGE	N	MEAN	STD DEVIATION	T VALUE	P
Female	50	29.793	9.3459	1.382	0.178
	– 65	15	33.763		
65					NS

- 85						
Male	50	15	27.290	7.7277		0.020
- 65		15	34.647	8.5211	2.477	Sig
- 85	65					

Table 6: Amount of mandibular ridge resorption in males and females for different edentulous periods.

GENDER		N	MEAN	STD DEVIATION	ANOVA F	P
Female	6M – 5Y	10	23.940	4.6297	34.125	0.000 HS
	5 – 10Y	10	31.200	4.3742		
	10 – 15Y	10	40.194	4.2092		
	Total	30	31.778	7.9882		
Male	6M – 5Y	10	21.565	4.4875	19.264	0.000 HS
	5 – 10Y	10	35.950	8.4796		
	10 – 15Y	10	35.390	3.3699		
	Total	30	30.968	8.8249		

Table 7: Overall Regression Analysis

MODEL	R SQUARE	ANOVA F	P
1	0.763 ^a	60.260	0.000 (HS)

a. Predictors: (Constant), Age, Duration of edentulousness (months), Gender.

Coefficients

MODEL	UNSTANDARDISED COEFFICIENTS		STANDARDISED COEFFICIENTS	T	P
	B	STD. ERROR	BETA		
1 (Constant)	0.346	4.430		0.078	0.938
Gender	-2.473	1.122	-0.149	-2.204	0.032
Duration Of Edentulousness (Months)	0.112	0.009	0.794	12.215	0.000
Age	0.372	0.072	0.351	5.184	0.000

a. Dependent Variable: Amount of Resorption(%)

V. Conclusion

Within the limitations of the present study and on the basis of the results obtained it can be concluded that

- With an increase in age, there is an increase in the amount of resorption
- With an increase in the duration of edentulousness, there is an increase in the amount of resorption.
- For a particular age group, as duration of edentulousness is increased, there is an increase in the amount of resorption.
- For a particular period of edentulousness, as age is increased, there is an increase in the amount of resorption.
- The amount of resorption in females is found to be more than that of male
- In males, as age increases, there is an increase in the amount of resorption.
- In males and females, as duration of edentulousness increases, there is an increase in the amount of resorption
- Duration of edentulousness has the most significant impact on resorption followed by age and then gender.

Applications of the present study

The results of the present study can be used for the appropriate treatment planning of the patient. For example, as it is found that RRR increases with duration of edentulousness, in a young patient, attempts must be made to preserve the bone by either retaining natural teeth or root to the longest time possible, or by the fabrication of tooth supported overdenture or early implant placement for implant- supported overdentures instead of the conventional complete denture therapy.

Limitations of the study:

One of the limitations of this study was small sample size which may not represent the group completely. In addition, the method used gives information about RRR localized in the region of mental foramen, thus RRR in other areas were not assessed. Moreover the evaluation of residual ridge resorption was

based mainly on panoramic radiography and clinical factors like occlusal contacts and chewing habits were not assessed.

Scope for further studies:

Further research on a larger sample and including other factors; such as other local and systemic factors, denture quality, oral parafunction and general health status will be useful for predicting the amount of mandibular ridge resorption in geriatric patients.

References

- [1] Ural C, Bereket C, Şener I, Aktan A.M, Akpınar Y.Z. Bone height measurement of maxillary and mandibular bone in panoramic radiographs of edentulous patients. *Journal of Clinical and Experimental Dentistry*. 2011; 3:5-9.
- [2] Kheur M, Matani J.D, Latifi M. Prediction of further residual ridge resorption by a simple biochemical and radiographic evaluation: A pilot study. *Journal of Orofacial Sciences*. 2012; 4:32-36.
- [3] Al-Jabrah O, Al-Shumalian Y. Association of complete denture wearing with the rate of reduction of mandibular residual ridge using digital panoramic radiography. *International Journal of Dental Research*. 2014; 2:20-25.
- [4] Kovacic I, Zlataric D.K, Celebic A. Residual ridge atrophy in complete denture wearers and relationship with densitometric values of a cervical spine: a hierarchical regression analysis. *Gerodontology*. 2012; 29:935–947.
- [5] Atwood D.A. Some clinical factors related to rate of resorption of residual ridges. *The Journal of Prosthetic Dentistry*. 1962; 12:441-450.
- [6] KeurJ.J. Radiographic findings in edentulous person. *Journal of Oral.Rehabilitation*. 1985; 12:187-191.
- [7] Jagadeesh M.S, Patil R.A, Kattimani P.T. Clinical evaluation of mandibular ridge height in relation to aging and length of edentulism. *Journal of Dental and Medical Sciences*. 2013; 3:44-47.
- [8] Wical K.E, Swoope C.C. Studies of residual ridge resorption. Part I. Use of panoramic radiographs for evaluation and classification of mandibular resorption. *The Journal of Prosthetic Dentistry*. 1974; 32:7-12.
- [9] Matsumoto M. Morphological Changes in the Human Mandible Following the Loss of Molars and Premolars. *International Journal of Dental Morphology*. 1961; 8:344-348.
- [10] Stramotas S, Geenty J.P, Darendeliler M.A. Accuracy of linear and angular measurements on panoramic radiographs taken at various positions in vitro. *European Journal of Orthodontics*. 2002; 24:43-52.
- [11] Arifin A.Z, Asano A, Taguchi A, Nakamoto T, Ohtsuka M, Tanimoto K. Computer-aided system for measuring the mandibular cortical width on panoramic radiographs in osteoporosis diagnosis. *Journal of Medical Imaging*. 2005; 57:813-821.
- [12] Lopez-Roldan A, Santolaya-Abad D, Gregori-Bertomeu I, Gomez-Castillo E, Selva-Otaolaurruchi E. Bone resorption processes in patients wearing overdentures. A 6-years retrospective study. *Journal of Clinical and Experimental Dentistry*. 2009; 1:24-30.
- [13] Kordatzis K, Wright P.S, Meijer H.J. Posterior mandibular residual ridge resorption in patients with conventional dentures and implant overdentures. *International Journal of Oral and Maxillofacial Implants*. 2003; 18:447-452.
- [14] Wilding R.J, Levin I, Pepper R. The use of panoramic radiographs to measure alveolar bone areas. *Journal of oral rehabilitation*. 1987; 14:557-567.
- [15] Narhi T.O, Ettinger R.L, Lam E.M. Radiographic findings, ridge resorption, and subjective complaints of complete denture patients. *International Journal of Prosthodontics*. 1997; 10:183-189.
- [16] Bairam L.R, Miller W.A. Mandibular bone resorption as determined from panoramic radiographs in edentulous male individuals aged 25–80 years. *Gerodontology*. 1994; 11:80-85.
- [17] Pakota G, Hoover J, Neufeld B. A study of the height of intact alveolar bone on panoramic radiographs of adult patients. *Journal of Prosthetic Dentistry*. 1988; 80:504-509.
- [18] Naeem A. Evaluation of the amount of intact alveolar bone in dentulous mandibular ridges in institution of rural area: A radiographic study. *The International Journal of Dental Sciences*. 2009; 7:1-3.
- [19] Bianchi A, Sanfilippo F. Osteoporosis: The effect on mandibular bone resorption and therapeutic possibilities by means of implant prostheses. *International Journal of Periodontics and Restorative Dentistry*. 2002; 22:231–239.
- [20] Imirzalioglu P, Yuzugullu B, Gulsahi A. Correlation between residual ridge resorption and radiomorphometric indices. *Gerodontology*. 2012; 29:536-542.
- [21] Zmysłowska E, Ledzion S, Jędrzejewski K. Factors affecting mandibular residual ridge resorption in edentulous patients: a preliminary report. *Folia Morphology*. 2007; 66:346-352.

- [22] Lopez-Roldan A, Santolaya-Abad D, Gregori-Bertomeu I, Gomez-Castillo E, Selva-Otaolaurruchi E. Bone resorption processes in patients wearing overdentures: A 6-years retrospective study. *Journal of Clinical and Experimental Dentistry*. 2009; 1:24-30.
- [23] Hirai T, Ishijima T, Hashikawa Y, Yajima T. Osteoporosis and reduction of residual ridge in edentulous patients. *Journal of Prosthetic Dentistry*. 1996; 73:49-55.
- [24] Baat C, Kalk W, Hof M.V. Factors connected with alveolar bone resorption among institutionalized elderly people. *Community dentistry and oral epidemiology*. 1993; 21:317-320.
- [25] Solar P, Ulm C.W, Thornton B, Matejka M. Sex related differences in the bone mineral density of atrophic mandibles. *Journal of Prosthetic Dentistry*. 1994; 71:345-349.
- [26] Devlin H, Ferguson M.W. Alveolar ridge resorption and mandibular atrophy: a review of the role of local and systemic factors. *British Dental Journal*. 1991; 170:101-104.
- [27] Nishimura I, Hosokawa R, Kaplan M.L, Atwood D.A. Animal model for evaluating the effect of systemic estrogen deficiency on residual ridge resorption. *Journal of Prosthetic Dentistry*. 1995; 73:304-310.
- [28] Humphries S, Devlin H, Worthington H. A radiographic investigation into bone resorption of mandibular alveolar bone in elderly edentulous adults. *Journal of dentistry*. 1989; 17:94-96.
- [29] Engel M.B, Rosenberg H.M, Jordan S.L, Holm K. Radiological evaluation of bone status in the jaw and in the column in a group of women. *Gerodontology*. 1994; 11:892-896.
- [30] Schwartz-Dabney C.L, Dechow P.C. Edentulism alters material properties of cortical bone in the human mandible. *Journal of Dental Research*. 2002; 81:613-617.
- [31] Crum R, Rooney G.E. Alveolar bone loss in overdentures: a 5-year study. *Journal of Prosthetic Dentistry*. 1978; 40: 610-613.
- [32] Van Waas M.A, Jonkman R.G, Kalk W. Differences two years after tooth extraction in mandibular bone reduction in patients treated with immediate overdentures or with immediate complete dentures. *Journal of Dental Research*. 1993; 72:1001-1004.
- [33] Wright P.S, Glantz P.O, Randow K. The effect of fixed and removable implant-stabilised prostheses on posterior mandibular residual ridge resorption. *Clinical Oral Implants Research*. 2002; 13:169-174.

*Dr. Bhuma Jayaram " Analysis of Mandibular Ridge Resorption in Completely Edentulous Patients Using Digital Panoramic Radiography " *IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)* 16.8 (2017): 66-73