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Linear Vertical Jaw Resorption Potential in Elderly Complete Denture Wearers: A Five-Year Follow-Up Study

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A B S T R A C T

Human bones decrease in quality and increase in porosity beginning at about the third decade of life. The aim of this study was to establish an equation to predict the maxillary and mandibular linear vertical resorption potential for elderly edentulous patients on the basis of the analysis of the cervical vertebrae in a single cephalometric radiograph. The morphology of the bodies of the third and fourth cervical vertebrae and measurements of linear vertical resorption in the frontal region of the jaws were analyzed in two consecutive cephalometric observations of 26 elderly edentulous patients over the five-year period of wearing complete dentures. An equation was determined to obtain maxillary and mandibular linear vertical resorption on the basis of measurements in the third and fourth cervical vertebral bodies and the average errors between the predicted and the actual values were 0.14 mm. The cervical vertebrae exhibited significant decrease in the height and width, and residual alveolar ridges exhibited significant decrease in the height over the 5-year period of wearing dentures ($p<0.01$). These results suggest that using cervical vertebral measurements might allow predicting the maxillary and mandibular resorption for edentulous elderly patients wearing complete dentures.

Key words: *residual ridge resorption, complete denture, cervical vertebrae, cephalometric radiograph, osteoporosis*

Introduction

In the past three decades, the relationship between residual ridge resorption and different types of prosthodontic appliances has received increasing attention in the prosthodontic field. Various qualitative and quantitative indices and techniques, such as mandibular cortical index[1], bone quality index[2], panoramic mandibular index[3] and mandibular cortical thickness measured at different regions of the lower border of the mandible[3,4], as well as densitometry and morphometry[5–8] techniques have described the resorptive changes in mandible. However, the quantitative relation between maxillary and mandibular linear vertical resorption (LVR_{max}, LVR_{mand}) and decrease in cervical vertebral size over a period of denture wearing is still not fully explored in the literature.

It has been previously proved that some systemic factors, such as nutrition (Ca and vitamin D), hormonal imbalance, osteoporosis, renal diseases, and local factors like denture retention and stability, incorrect vertical or horizontal relation of the dentures, non-balanced occlusion or duration of denture wearing contribute to the degree of residual ridge resorption[9–19].

The purposes of this study were to establish an easy way to use cervical vertebral bone measurement to predict LVR_{max} and LVR_{mand} and to calculate the average errors between the predicted and the actual maxillary and mandibular resorptive changes.

Materials and Methods

Sample

The subjects of this study were 26 patients selected from the files of Department of Prosthodontics, School of Dental Medicine. There were 12 women (mean age 66;

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range 56 to 74 years) and 14 men (mean age 70; range 56 to 79 years).

All subjects fulfilled the following criteria: edentulous for at least five years, complete denture wearers for more than five years, no systemic disease that could affect general bone status (osteopenia, osteoporosis, renal diseases, thyroid hormone misbalance, etc.). Ethics Committee of School of Dental Medicine had approved this study, as the patients were exposed to X-rays for the need of diagnosis and future prosthodontic treatment planning. Voluntary written informed consent was obtained from each patient.

Radiographs

Two cephalometric radiographs were obtained for each patient: first radiograph taken at the time of delivery of the complete dentures (initial stage) and second radiograph was taken five years later (final stage). Lateral cephalograms were obtained with the dentures in the mouth, in the position of maximal intercuspation during the exposure. All the dentures were made according to the same criteria (semiadjustable articulator, no attempt of occlusal balance).

All the radiographs were made using the same equipment (Siemens Roentgen Kugel 2E:220 V, 15 mA, 70 kV) and the exposition varied from 1.2 to 1.6 ms, dependent on the constitution of the patient. During the exposure, the head position was standardized using cephalostat in the way that the Frankfort horizontal plane (tragion – orbitale) was parallel to the horizontal plane, and the mediosagital plane was perpendicular to the horizontal plane.

Cephalometric analysis

Cervical vertebral bodies on the lateral cephalometric radiographs, the body of the third cervical vertebra (C3) and the body of the fourth cervical vertebra (C4) were selected because C3 and C4 could be observed even when a thyroid-protective collar was worn during radiation exposure. The following points described by Baccetti et al.[20] and the following lines for the description of the morphologic characteristics of the cervical vertebral bodies were traced by pencil and measured with micrometer calipers (Figure 1):

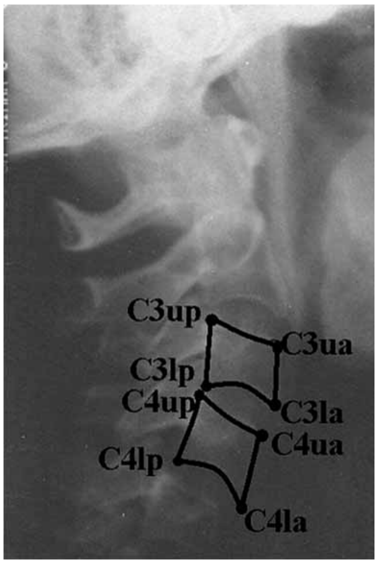

Fig. 1. Cephalometric landmarks for the quantitative analysis of C3 and C4 in this study.

C3up, C3ua – the most superior points of the posterior and anterior borders of the body of C3;

C3lp, C3la – the most posterior and anterior points on the lower border of the body of C3;

C4 up, C4 ua – the most superior points of the posterior and anterior borders of the body of C4;

C4lp, C4la – the most posterior and anterior points on the lower border of the body of C4;

AH3, AH4 (anterior vertebral body height of the C3 and C4) – the distance between C3ua and C3la and the distance between C4ua and C4la;

PH3, PH4 (posterior vertebral body length of the C3 and C4) – the distance between C3up and C3lp and the distance between C4up and C4lp;

AP3, AP4 (anteroposterior vertebral body length of the C3 and C4) – the distance between C3la and C3lp and the distance between C4la and C4lp.

Maxillary and mandibular linear vertical resorption measurement

In the jaws, the height of the residual alveolar ridges was used to stand for the decrease in linear vertical resorption ($LVR_{max,\ mand}$).

$LVR_{max,\ mand}$ were determined as the differences in height of the residual alveolar ridges during the two stages of observation, by means of two horizontal and ten vertical planes on a calibrated grid. The horizontal line of the calibrated grid for measurement of the height of the maxillary edentulous alveolar ridge was orientated over the palatal plane (Sna-Snp). The referent point was the intersection point of the first perpendicular line and maxillary alveolar crest ridge where the alveolar height was measured (Figure 2). The perpendicular line of the grid had graduations of 0.2 mm.

In order to measure the resorption of the mandible, horizontal line of the grid was orientated parallel to the mandibular line (Gn – Go) and the referent point was the intersection of the first perpendicular line and the crest of the mandibular alveolar ridge where the alveolar height was measured (Figure 3).

Both LVR_{max} and LVR_{mand} were determined by the differences between measurements in initial and final stage.

Statistical analysis

The data were analyzed by statistical software SPSS Version 10.0 for Windows (SPSS Inc., Chicago, Ill). In the multiple regression analysis, the values of the LVR_{max} and LVR_{mand} were used as dependent variables, and the values of the cervical vertebrae at the initial stage were

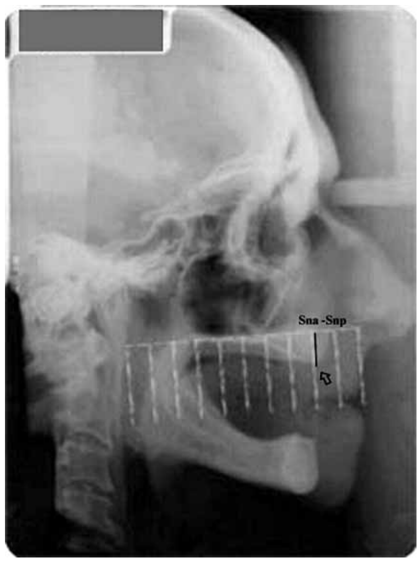

Fig. 2. Maxillary linear vertical resorption measurement.

Fig. 3. Mandibular linear vertical resorption measurement.

used as independent variables. The selection of the independent variables was complete according to the stepwise method.

Results

Measurements

Means and standard deviations and the results of Student's t-test for dependent samples between initial and final stages are shown in Table 1. All the measurements in the first stage were significantly higher than those in final stage ($p<0.01$). The cervical vertebrae exhibited significant decrease in the height and width, and the maxillary and mandibular residual alveolar ridges exhibited significant decrease in the height over the 5-year period of wearing dentures ($p<0.01$).

Measurement error

No significant differences were found between the measurements repeated after a week interval ($p>0.05$). The standard deviations ranged from 0.18 to 0.28 mm.

Multiple regression analysis

We selected six factors as independent variables and LVR_{max} and LVR_{mand} as the dependent factors.

The equation for LVR_{max} is:

$$LVR_{max}\ (mm) = 1.45 - 0.58 \times AH3 + 1.11 \times PH3 + 0.28 \times AP3 - 0.71 \times AH4.$$

In the present study R^2 for LVR_{max} was 67.3%. R^2 indicated the portion of the variability of the dependent variables. The combination of the AH3, PH3, AP3 and AH4 explained the variability of LVR_{max} by 67.3%.

The equation for LVR_{mand} is:

$$LVR_{mand}\ (mm) = 1.36 - 0.82 \times AH3 + 2.28 \times PH3 + 0.74 \times AP3 - 1.89 \times PH4.$$

In the present study R^2 for LVR_{mand} was 62.8%. R^2 indicated the portion of the variability of the dependent variables. The combination of the AH3, PH3, AP3 and PH4 explained the variability of LVR_{mand} by 62.8%.

TABLE 1
THE MEASUREMENTS OF C3, C4, MAXILLARY AND MANDIBULAR ALVEOLAR RIDGE HEIGHT

	Initial stage		Final stage		t	df	p
	X	SD	X	SD			
AH3	17.08	2.70	16.25	1.87	2.78	25	0.01
PH3	16.87	2.14	15.73	1.51	5.22	25	0.00
AP3	19.17	2.78	18.01	2.61	4.56	25	0.00
AH4	15.20	1.39	14.72	0.97	3.35	25	0.00
PH4	15.62	1.75	15.62	1.75	6.05	25	0.00
AP4	19.18	1.89	18.05	2.38	5.96	25	0.00
Alveolar ridge $height_{max}$	17.50	4.22	16.46	4.24	9.10	25	0.00
Alveolar ridge $height_{mand}$	25.85	6.17	23.96	5.96	19.37	25	0.00

$p<0.01$

Predictive accuracy

Average errors for LVR_{max} ranged from 0.08 to 0.21 mm (mean – 0.14 mm), and average errors for LVR_{mand} from 0.06 to 0.22 mm (mean – 0.14 mm).

Discussion

The purpose of this study was to provide the prosthodontist with an easy tool to help determine the decrease in both maxillary and mandibular residual ridge height. This was to be accomplished by analyzing the size of the cervical vertebrae on the lateral cephalometric radiograph of the patient's head.

The anatomical features of C3 and C4 were evaluated here as visualized on lateral cephalograms in a time interval of five years of wearing complete dentures. The model of measuring only C3 and C4 was chosen because they were the most visible on lateral head films.

The modifications in size and shape of the cervical vertebrae in growing subjects have gained increasing interest in the last decades as a biological indicator of individual skeletal maturity.

The shape of third and fourth cervical vertebrae through the stages of development change from trapezoid to rectangular horizontal and finally to squared in shape[20,216], and the lower borders of C2, C3 and C4 change from flat to concavities that increase through the stages of growth and of development[20,21].

In the present study, we have proved that the size of the cervical vertebre (C3, C4) and the maxillary and mandibular residual ridges height change in elderly patients, probably due to the bone mineral density decrease of the skeleton (Table 1)($p<0.01$).

Some previous studies had already suggested that mandibular bone loss and osteopenia of the remaining skeleton might be related[22]. Significant relationships have been documented among total body calcium, bone mineral content of the radius, and mandibular bone density in a small group of women with osteoporosis[10].

Many edentulous subjects with severe alveolar resorption also have low bone density of the radius[23,24]. Edentulous men needing vestibuloplasty have significantly lower bone density of the radius than an age-matched control group of men with intact dentition[25].

Few studies have compared mandibular bone mass and bone mass in both iliac crest (where no significant correlation was found) and the metacarpals (where a significant correlation was reported)[26,27].

Some studies compared bone mineral changes in mandible with bone density of forearm[28,29], lumbal spine[30–32] or femoral neck[32].

In Von Wowern's study the osteoporotic women had significantly lower bone mineral content values than controls in the mandible and forearm proving that the degree of osteopenia in the mandible corresponds to that in other cortical bones of the skeleton[28]. She had also found that the mean bone mineral content loss at the standard sites of the mandible and the forearm bones was 5.6% year[29].

Comparing mandibular measurements with the measurements of bone mass in the lumbal spine (L1-L4) and the wrist, Kribbs et al.[30,31] found that the mandibular bone mass was not significantly affected with age but significantly correlated with skeletal bone mass.

Low bone density in the skeleton is accepted as a predisposing factor for rapid residual ridge resorption in the mandible but, because skeletal bone mineral density is correlated with mandibular bone mineral density, high local bone mineral density values have been seen as an indication that bony tissues are protected against residual ridge resorption.

Klemetti and Vanio[33] reported that the remaining height of the edentulous mandibles was more dependent on the BMD values of the femoral neck than on the BMD of the lumbar spine. The height of the maxillary ridge, on the other hand, seemed to be more closely related to the lumbar values. This may be because the amount of cortical bone in the femoral neck, approximately 75% is similar to that in the mandible and the bone in both the lumbar spine and the maxilla is primarily trabecular.

In the previous study, we found that the most significant factor influencing the residual alveolar ridge resorpiton in complete denture wearers was the time of edentulousness with higher rates of resorption in patients being edentulous less than 1 year, than in patients being edentulous 1 – 10 years, or over 10 years ($p<0.05$)[34]. The rate of residual ridge resorption was significantly higher in anterior regions than in lateral regions of the jaws, due to the fact that front teeth are frequently the last preserved teeth before extraction and they are still remodeling[34]. This was the reason why we chousen the anterior region of the edentulous alveolar ridges for the prediction of linear vertical resorption. At the same time, body mass index had no significant influence on the rate of residual ridge resorption[34].

In order to eliminate the influence of the time of edentulousness, as well as the influence of remodeling of the bone immediately after the extraction of the teeth, and the delivery of the first pair of complete dentures to the residual ridges, only the patients edentulous for more than five years and complete denture wearers at the delivery (the second pair of the complete dentures) were considered in this study. It was also important to exclude all the patients with any signs or symptoms of systemic diseases that could affect general bone status, such as postmenopausal hormonal disbalance in women, metabolic bone diseases (generalized skeletal osteoporosis), renal diseases, etc.

In this research we used a stepwise regression analysis to define prediction models that could be used to forecast individual future LVR of residual ridges in complete denture wearers. The stepwise method was used to select the explanatory variables. The variability of the dependent variable that could be the regression equation is characterized by R^2, which is considered high for biological data when it ranges from 30 to 67%[35]. In the present study, R^2 for LVR_{max} was 67.3% and for LVR_{mand} was 62.8%. According to the statistical rule, the number of samples must be at least twice as many as the number of independent variables[36]. The present sample consisted of 26 cases. This was a satisfactory number to make the regression coefficients and the R^2 values truly representative of the actual population.

In this study, the values of the LVR_{max} and LVR_{mand} were used as dependent variables, and the values of the cervical vertebrae at the initial stage were used as independent variables. As the result of the statistical analysis on the present sample, a set of four independent variables (AH3, PH3, AP3 and AH4) was significantly selected among the parameters studied to explain the LVR_{max} and a set of four independent variables (AH3, PH3, AP3 and PH4) was significantly selected among the parameters studies to explain the LVR_{mand}.

In order to establish an equation to predict the mandible growth potential for Class III malocclusion, Chen used the same independent variables (C3, C4) as we did, and the increment of the mandibular length as the dependent variable[37]. In their study, the same variables as in this study (AH3, PH3, AP3 and AH4) showed the highest correlation with the dependent variable.

To be clinically useful, it may be necessary to improve the predictive accuracy by increasing the number of subjects in our future studies.

Conclusions

We established a special equation for complete denture wearers to predict LVR in both jaws. The equation might be one possible method for predicting the LVR based only on a single cephalometric radiograph.

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LINEARNA VERTIKALNA RESORPCIJA ČELJUSTI U STARIJIH NOSITELJA POTPUNIH PROTEZA – PETOGODIŠNJE ISTRAŽIVANJE

S A Ž E T A K

U tridesetim godinama života ljudska kost počinje gubiti na svojoj kvaliteti uz stvaranje poroznosti. Srha ovog istraživanja bila je oblikovati jednadžbu kojom je moguće predvidjeti pojavu linearne vertikalne resorpcije gornje i donje čeljusti u starijih bezubih pacijenata, temeljem analize vratnih kralješaka na telerengenu. Morfologija tijela trećeg i četvrtog vratnog kralješka te iznos linearne vertikalne resorpcije prednjeg dijela čeljusti analizirani su na dvama telerengenima, izrađenima unutar 5 godina nošenja potpunih proteza, svakog od 26 starijih bezubih pacijenata. Temeljem mjerenja tijela trećeg i četvrtog vratnog kralješka oblikovana je jednadžba kojom se izračunava iznos linearne vertikalne resorpcije gornje i donje čeljusti. Prosječna pogreška između predviđenih i stvarnih vrijednosti iznosila je 0,14 mm. Vratna kralješnica pokazala je značajan gubitak visine i širine, a rezidualni alveolarni grebeni značajan gubitak visine tijekom petogodišnjeg nošenja proteza ($p<0,01$). Rezultati dokazuju kako se mjere vratnih kralješaka mogu koristiti u svrhu predikcije resorpcije gornje i donje čeljusti potpuno bezubih, starijih nositelja potpunih proteza.