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CONGRESS PROCEEDING

Evaluation of Styloid Process Length and Calcification Degrees of Renal Transplant Patients With Panoramic Radiographs

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Abstract

Purpose: The aim of this study was to evaluate the styloid process length and calcification degrees of renal-transplant patients and compare them with the healthy control group.
Materials and Methods: : Panoramic radiographs of 93 patients who had renal transplantation and 93 healthy patients were reviewed retrospectively. Length measurements were made from the apex to the base of the styloid process with a line following the profile. The elongation degrees were classified into five groups as normal (type 0), elongated (Type 1), pseudo-segmented (Type 2), segmented (Type 3) and non-continuous (Type 4). Calcification degrees were classified into four different groups as external (Type A), partial (Type B), nodular (Type C) and complete calcification (Type D).
Results: The study and control groups were matched for age and gender. Styloid process length was found to be significantly higher in male than in female ($p<0.001$). The extent of elongation and calcification did not differ in terms of gender. The mean styloid process length values were found to be significantly higher in the study group compared to the control group ($p<0.001$). There was a significant difference between the groups in terms of elongation degrees ($p<0.001$). For elongation types, while the majority of the study group was type 1, type 0 was observed more in the control group. No difference was observed between the groups in terms of the calcification degrees ($p=0.076$).
Conclusions: Changes in phosphate balance and parathyroid hormone levels, possibly due to hemodialysis treatment in renal transplant patients, may have led to styloid process elongation.

Key words: renal transplantation; styloid process; elongation; calcification

Introduction

Chronic renal failure (CRF) is a persistent medical condition that cannot be reversed and increasing in frequency globally and in our country, manifesting as deterioration in the stabilization of the fluid-solid balance and metabolic and endocrine functions of the kidneys. The incidence of CRF, which is more common among males, increases with age, and the most common causes include diabetes mellitus and hypertension. Therapeutic choices for individuals with end-stage renal failure (ESRF) encompass renal replacement approaches like hemodialysis, peritoneal dialysis, or kidney transplantation. The best replacement therapy option today is renal transplantation. Compared with dialysis, renal transplantation offers an increased chance of survival, a better quality of life due to the absence of long sessions, and lower treatment costs.[1]

With the progression of CRF, disturbances in the calcium-phosphorus balance occur. Decreased production of 1.25(OH)2 in the kidneys cause decreased excretion of phosphate in the urine, which results with hyperphosphatemia. Hyperphosphatemia is a common abnormality seen in most patients with ESRF. In ESRF, vitamin D synthesis decreases due to phosphorus elimination, and as a result, serum calcium levels decrease. Due to these changes in hyperphosphatemia, hypocalcemia, and vitamin D, long-term stimulation occurs in the parathyroid glands and the secretion of parathyroid hormone (PTH) increases, resulting in enlargement of the parathyroid gland. As a result, patients with CRF develop secondary hyperparathyroidism (SHP).[2]

Metastatic calcifications can be observed in patients with CRF as a result of SHP, elevated levels of PTH, imbalance in serum calcium and phosphorus levels, and drugs used due to renal failure. The

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phenomenon of metastatic calcification, characterized by the deposition of calcium salts in otherwise healthy tissues, is frequently observed in individuals with ESRF. These calcifications can be seen as atheromas, tonsilloliths, calcified lymph nodes, ossification of stylohyoid ligaments, and Mönckeberg arteriosclerosis.[3]

SHP, which occurs due to disturbances in Ca, P and vitamin D metabolism, is quite common in individuals with CRF. As a result of SHP, PTH secretion increases, and the condition results in hypercalcemia. In patients with SHP, a clinical picture called tertiary hyperparathyroidism often develops as a result of hypercalcemia after renal transplantation.[2] Tertiary hyperparathyroidism can cause metastatic calcifications, similar to SHP.

The styloid process (SP) is a bony prominence that originates from the temporal bone and progresses anteriorly and medially. SP, which is attached to the hyoid bone via the stylohyoid ligament; is surrounded by internal and external carotid arteries medially and laterally. The considered normal length values of the SP are between 15 and 30 mm, and a SP longer than 30 mm is considered elongated.[4]

There are few studies investigating the relationship between styloid process length and chronic renal failure. Costantinides et al. found that the length of SP was increased in patients who underwent kidney transplantation.[5] Şişman et al. observed bilateral prolonged CP in a patient treated with peritoneal dialysis. However, SP calcification grades were not evaluated in any of these studies.[6]

The aim of this study was to evaluate the SP in terms of the calcification and elongation degrees in patients with ESRF who were treated with renal transplantation.

Methods

This study was carried out retrospectively by examining the medical and radiological records of renal transplant patients who applied to Erciyes University Faculty of Dentistry, Department of Oral and Maxillofacial Radiology for dental examination. The research was approved by the Local Clinical Research Ethics Committee (Decision Number:2022/605). Medical records were scanned retrospectively and patients who had a renal transplant and had no other systemic disease affecting bone metabolism were included in the study group. In accordance with the age and gender distribution of the study group, a control group without any systemic disease and drug usage was formed. Patients under 18 years of age were not included, and patients whose radiological records were inadequate in terms of radiodiagnosis were excluded from the study.

The study was initiated by examining the panoramic radiographs of 117 patients with renal transplantation. However, 24 patients whose SP areas could not be observed in panoramic radiographs were excluded from the study. As a result, 93 patients (43 male and 50 female patients) were included in the study group. 93 patients (41 males and 52 females with adequate radiographic quality and clear image of SP were selected for the control group.

Panoramic radiographs of all patients were obtained between October 2015 and May 2022 with an OP200 D x-ray unit operating at 70 kVp, 10 mA, and 14.1 s exposure time. These panoramic radiographs were downloaded in Tagged Image File Format (TIFF) with a resolution of 5.5 Ip/mm and a size of 2976 × 1536 pixels and saved on a work computer (Dell Precision T5400 workstation (Dell, Round Rock, TX, USA)).

Two research assistants independently conducted all measurements and assessments. In case of disagreement, the evaluation was repeated by the two researchers and a consensus was reached. In addition, the measurements of 20% of the patients in the study and control group were repeated by both researchers 2 months after the 1st measurements to test the intraobserver reliability.

ImageJ v.1.52 software (NIH, Bethesda, MD, USA) was used for length measurement in the SP. A line was extended from the bottom of the SP to its peak, and the length of this structure was then quantified by following its contour. A horizontal line passing through the floor of the meatus acusticus externus was used to define the base of the SP (Figure 1). Pixel values obtained with Image J were obtained in mm in accordance with the manufacturer's recommendations. All panoramic radiographs were captured using the same imaging equipment. The panoramic device employed had a magnification factor of 0.25, which was taken into account during the transfer to the software program.

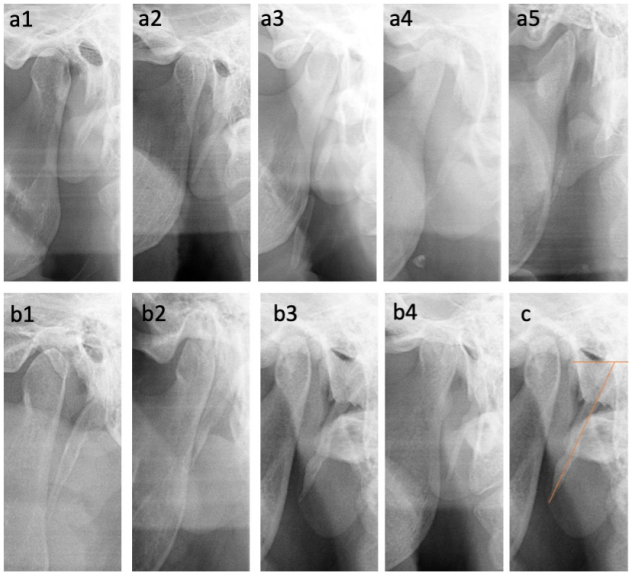

Figure 1. (a): SP Elongation Degrees; (a1): Type 0: Normal, (a2): Type 1: Elongate, (a3): Type 2: Pseudo-segmented, (a4): Type 3: Segmented, (a5): Type 4: Non-continuous (b): SP Calcification Degrees; (b1): Type A: External calcification, (b2): Type B: Partial calcification, (b3): Type C: Nodular calcification, (b4): Type D: Complete calcification (c): SP Length Measurement

For the evaluation of elongation types, the classification suggested by Sudhakara Reddy et al.[7] was used by adding the variant type 0, which defines the normal length. Thus, elongation degrees in the SP were evaluated in five different types: normal (Type 0), elongate (Type 1), pseudo-segmented (Type 2), segmented (Type 3), and non-continuous (Type 4). (Figure 1)

For the evaluation of calcification degrees, 4 different types were determined according to the classification of de Andrade et al.:[8] (Figure 1) Type A: Characterized by calcification occurring exclusively along the outer perimeter, external calcification. Type B: Featuring segments with radiopaque calcification, partial calcification. Type C: Displaying radiopaque nodular segments, nodular calcification. Type D: Total calcification that presents as entirely radiopaque with no radiolucent areas. All calcification grade assessments were made by two research assistants. In case of disagreement, the evaluation was repeated by the two researchers and a consensus was reached.

Statistical Analysis

Data analysis was carried out using SPSS 24.0 software (IBM Corp., New York, NY; formerly SPSS Inc., Chicago, IL). Shapiro-Wilk normality test was used for the normality analysis of the variables. Comparison of the study and control groups with normal distribution in terms of quantitative measurement parameters were made with independent t-tests; comparisons in terms of non-normally distributed quantitative measurement parameters were made using the Mann-Whitney U test. Examination of the relationship between the categorical variables of the study and control groups was carried out using the chi-square test. One-way ANOVA test was used to test whether there was a statistically significant difference between the means of independent groups. Tukey's test was used to com-

pare the means of the numerical variable among the independent groups in which a significant difference was observed according to the one-way ANOVA test. Intra-class correlation coefficient was used to evaluate the agreement inter-observer and intra-observer of the quantitative values. The Cohen κ test was used to evaluate the reliability of the assessment of SP elongation and calcification degrees. The statistical significance level was accepted as $p<0.05$.

Results

FThe inter-observer correlation coefficient was found to be very high and statistically significant for all values ranging from 0.971 to 0.993 ($p<0.001$). Intra-observer correlation coefficient was also found to be very high and statistically significant for all values ranging from 0.918 to 0.972 ($p<0.001$). The k-value of the elongation degrees was calculated as 0.976 (0.01). The k-value of the calcification degrees was calculated as 0.959 (0.01).

Distribution of Age and Gender by Groups

The mean age of the patients in the study group was 42.72 ±12.7 years, and the mean age of the patients in the control group was 42.7 ±12.6 years. The study and control groups did not differ significantly in terms of age and gender (for age $p=0.987$, for gender $p=0.677$). There was a statistically significant difference between gender and SP length. In the study group, the SP length of males was found to be significantly higher than that of females ($p<0.001$). Elongation and calcification degrees did not differ significantly in terms of gender (for elongation degrees $p=0.068$, for calcification degrees $p=0.07$) (Table 1).

The Relationship Between SP Length and Research Groups

A significant difference was found between the study and control groups in terms of mean SP length values ($p<0.001$). The mean SP length values in the study group (3.51 ±0.79) were significantly higher than the mean SP length values in the control group (3.22 ±0.73). (Table 1)

Relationship between SP Elongation Degrees and Research Groups

There was a significant difference between the study and control groups in terms of elongation degrees ($p<0.001$). While Type 1 elongation type was observed more in the study group, Type 0 elongation type was observed more in the control group. (Table 1)

Relationship Between SP Calcification Degrees and Research Groups

There was no difference between the study and control groups in terms of the calcification degrees ($p=0.076$). However, there was a significant difference between the calcification degrees and the mean SP length values ($p=0.038$). (Table 1) Mean SP length values were significantly lower in patients with type A calcifications than in patients with type B calcifications ($p=0.029$). There was no difference between other calcification degrees in terms of SP length measurements ($p>0.05$). (Table 2)

Discussion

Metastatic calcifications developing subsequently to SHP are quite common in individuals with CRF. Elongation of the SP resulting from the ossification of the stylohyoid ligament represents one form of metastatic calcification. Nevertheless, there is a scarcity of studies exploring the connection between the SP and CRF. In these studies investigating the relationship between SP length and CRF, no evaluation was made in terms of SP calcification types.[5,6,9] In presented study, besides the length measurements of the SP, length types and calcification degrees were also evaluated.

Investigating the role of ectopic calcification in SP elongation, Şişman et al.[6] observed a bilaterally elongated SP in a patient with ESRF treated with peritoneal dialysis. However, the SP is frequently encountered as an incidental finding observed on panoramic radiographs, and the number of patients examined in the above-mentioned study is not sufficient to confirm the hypothesis that SP may be elongated in renal patients. In a systematic review study by Nogueira-Reis et al.,[10] it was found that 30% of individuals without systemic disease had prolonged SP.

In patients with CRF, metastatic calcifications can be observed as a result of SHP, tertiary hyperparathyroidism developing due to SHP, elevated levels of PTH, imbalance in serum calcium and phosphorus levels, and drugs used in renal failure. Based on the findings of the study presented, it was determined that the average length of the SP in patients who have undergone renal transplantation was significantly greater compared to the healthy control group. In a similar vein, Costantinides et al.,[5] discovered that patients with elevated PTH levels exhibited an elongated styloid process in their research, which included renal transplant recipients who had undergone prior hemodialysis treatment. In a study by Okabe et al.,[9] they reported that as the SP length increases, serum calcium levels increase in direct proportion.

Costantinides et al.,[5] carried out the aforementioned study by examining serum calcium, alkaline phosphatase, phosphorus and PTH levels of renal transplant patients. In the presented study, the lack of information about the mineral and hormone levels of the patients seems to be a limitation of the study. While low levels of PTH concentration cause an increase in bone mass, increased concentration stimulates osteoclastic activity by mobilizing Ca from tissues and causes hypercalcemia.[5] In addition, the changes in PTH levels that occur in ESRF may decrease over time after transplantation. Rivelli et al.[11] observed that PTH levels decreased to normal levels 3 years after transplantation in their follow-up study after renal transplantation. Due to the retrospective nature of the presented study, the inability to evaluate the elapsed time after transplantation constitutes another limitation.

Due to the widespread use of panoramic radiography during routine dental examinations, it was the preferred imaging method in presented study. Thus, most patients who underwent renal transplantation were examined in our clinic and included in the study. However, changes may occur in the measurements made due to image distortion, magnification and incorrect patient position in panoramic radiographs. Cone-beam computed tomography (CBCT), on the other hand, provides a wider study area and structures in the region to be evaluated can be observed more clearly. CBCT also provides a chance to evaluate the volume of structures such as the SP. In the future, studies to evaluate the SP in patients with CRF can be performed with three-dimensional imaging methods.

Conclusion

According to the results of other studies and presented study, it can be said that the SP may be prolonged due to impaired mineral and hormone balance in patients with ESRF. Although it is not clinically significant on its own, Eagle's syndrome should be considered in a patient with a history of CRF and orofacial pain complaint, and radiographic and clinical examination should be performed for this purpose.

Table 1. Values of the relevant measurements in the study and control groups. SD: standard deviation *: statistically significant

		Research Groups								test	P value
		Study Group				Control Group					
Gender	Female	50				52				chi-square	0.677
	Male	43				41					
SP Elongation Degrees	Type 0	46				86				chi-square	0.00*
	Type 1	113				94					
	Type 2	20				5					
	Type 3	1				0					
	Type 4	6				1					
SP Calcification Degrees	Type A	73				88				chi-square	0.076
	Type B	60				63					
	Type C	0				0					
	Type D	53				35					
		Study Group				Control Group				test	P value
		Min	Max	Mean	SD	Min	Max	Mean	SD		
Age		20	68	42.72	12.17	19	69	42.7	12.6	t test	0.987
SP Length		2.24	6.31	3.51	0.79	1.6	5.54	3.32	0.73	t test	0.00*

Table 2. Evaluation of the relationship between calcification degrees and SP length. *: statistically significant

SP Calcification Degrees	Mean SP Length	test	p value
Type A	3,26	One-way ANOVA	0.038*
Type B	3,49		
Type D	3,37		
Calcification Degree	**Calcification Degree**	**test**	**p value**
Type A	Type B*	Tukey test	0.029*
	Type D		0.505
Type B	Type A*		0.029*
	Type D		0.490
Type D	Type A		0.505
	Type B		0.490

Author Contributions

Study Idea / Hypothesis: F.D. Study Design: F.D., A.C. Consultancy: A.C. Data Collection: F.D., B.Y., M.K.Y. Literature Review: F.D., B.Y., M.K.Y. Statistical Analysis and Interpretation of Results: F.D. Article Writing: F.D. Critical Review: F.D., A.C., B.Y., M.K.Y.

Conflict of Interest

The authors state that there was not any source of funding or financial interest.

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