Evaluation of Bone Radiodensity in Smokers

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Abstract

One of the most prevalent harmful habits that affect people daily is smoking. **The aim of our study** was to investigate changes in the bone density of the human paranasal sinuses under the influence of smoking using uncertainty calculation.

Material and Methods. The study involved 150 male and female individuals aged 20-40 years, which helps to exclude other factors that could influence the reduction in bone radiodensity (e.g., menopause in women, age-related changes, etc.). The participants were divided into three groups based on the duration of their smoking habits.

Results. Smoking has almost no effect on the maximum bone density. All groups show nearly identical values. In the first group, consisting of individuals who smoked for up to 5 years, the maximum density is 75.22 ± 37.61 Hu. In the second group, those who smoked for up to 10 years have a density of 84.22 ± 42.11 Hu, while in the third control group, the density is 74.29 ± 37.15 Hu. On the other hand, smoking has a greater impact on the minimum radiological bone density of the upper wall of the maxillary sinus. The lowest values are found in the group of individuals who smoked for 10 or more years, with a minimum density of 23.86 ± 11.93 Hu. For those who smoked for up to 5 years, the radiological bone density was 52.65 ± 26.32 Hu. In the control group, the density values were slightly higher than those of individuals who smoked for up to 5 years, with the highest values being 58.12 ± 29.06 Hu.

Conclusion. The study investigated changes in the bone density of the human paranasal sinuses under the influence of smoking, utilizing uncertainty calculation. It was found that the most sensitive indicator to nicotine exposure is the minimum radiological density, which can significantly increase the risk of developing complications. Specifically, the lowest radiological density was observed in the group of individuals who smoked for 10 years or more, with a value of 23.86 ± 11.93 Hu.

Keywords

Uncertainty, bone radiodensity, paranasal sinuses, computer tomography

1. Introduction

Harmful habits negatively affect all organs and systems of the human body. Today, there is a significant body of research dedicated to the impact of harmful habits on the cardiovascular and central nervous systems [1]. One of the most prevalent harmful habits that affect people daily is smoking [2]. According to statistical data, tobacco-related diseases are the leading cause of preventable and premature deaths in the United States and worldwide. Approximately one person dies every 6 seconds due to tobacco, accounting for one in five deaths. Furthermore, the average smoker dies at least 10 years earlier than a non-smoker. For instance, in 2000, mortality attributed to smoking surpassed the total deaths from HIV, illegal alcohol and drugs, suicides, homicides, and car accidents combined. If current trends continue globally, more than half of all long-term smokers will die from tobacco-related diseases, leading to eight million deaths annually by 2030 [3]. Previous studies have shown that smoking has a dose-dependent negative impact on bone mass loss and is associated with an increased risk of fractures, which decreases after quitting smoking. Smoking also

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poses a higher risk of certain complications [4] and is associated with an increased risk of fractures, which decreases after quitting smoking. Smoking also increases the risk of certain complications after a fracture. [5]. However, whether bone mineral density plays a causal mediating role in the pathway between smoking and fractures has not been proven. The mechanisms of reduced radiological bone density in long tubular bones are well-studied 6]. However, the harmful effects of smoking also significantly impact the density of trabecular bone tissue, particularly in the bones of the skull. The reduction in the radiological density of skull bones, which form the walls of the paranasal sinuses, is an equally dangerous process, although it is less studied [7]. The loss of bone mass in the walls of the paranasal sinuses can lead to complications in inflammatory processes in these sinuses, potentially spreading to adjacent organs and tissues [8]. For example, this can result in orbital and intracranial complications [9].

It can be assumed that the limited number of studies on the radiological density of trabecular bone is related to the difficulty in measuring this density due to the spongy structure of the bone tissue itself. Considering the challenges in selecting reference points to determine the radiological bone density of the paranasal sinus walls, we employed the method of uncertainty calculation.

Given all of the above, **the aim of our study** was to investigate changes in the bone density of the human paranasal sinuses under the influence of smoking using uncertainty calculation.

2. Material and Methods

Measurement uncertainty is a characteristic of the inaccuracy of measurements, adopted at the international level, which is associated with the measurement result and characterizes the range of values that can reasonably be attributed to the measured value. All components of the uncertainty of the input values are divided into two categories according to their estimation method: Type A includes components evaluated using statistical methods (by analyzing the results of multiple measurements), while Type B includes components estimated by other methods (based on characteristics from the specifications for measuring instruments, calibration certificates, measurement procedures from previous experiments, etc.). Measurement uncertainty is estimated according to the basic algorithm described in our previous works.

The study involved 150 male and female individuals aged 20-40 years, which helps to exclude other factors that could influence the reduction in bone radiodensity (e.g., menopause in women, age-related changes, etc.). The participants were divided into three groups based on the duration of their smoking habits. The first group included individuals who had smoked for at least 5 years, the second group consisted of those who had smoked for at least 5 but no more than 10 years. All participants in the study smoked between one and two packs of cigarettes per day. The control group consisted of individuals who had never smoked. All participants underwent multislice computed tomography (MSCT) for reasons unrelated to ENT pathology. In this regard, the patients underwent a CT examination of the paranasal sinuses on a spiral computed tomograph Toshiba Aquilion 64 [9-10]. One of the advantages of spiral tomography is the applicability of a densitometric scale, which let us determine the density indices.

RadiANT DICOM Viewer 4.6.9. (64bit) was used for determination of our measurements (thickness and density) as simple, fast DICOM viewer for medical images. The Hounsfield scale of this software showed the density (max, min) of the upper wall of the maxillary sinus [11-12].

Particular attention was given to the maxillary sinus, considering the fact that it is the most susceptible to inflammatory processes, such as bacterial rhinosinusitis. This vulnerability is due to the anatomical structure of the sinus, its size, the position of the sinus floor relative to its natural communication with the nasal cavity, and the proximity of the teeth. The focus on the upper wall of the maxillary sinus is due to its close proximity to the orbit, which implies that infection can easily spread into the orbital cavity through this wall.

3. Results

The results of measurements taking into account the expanded uncertainty U are given in the tables 1, 2. Assessing the data in the table, we can conclude that the probable spread of Y value is in the ±U range relative to the measured y value, and the degree of certainty for Y values in this interval is determined by the probability (confidence level) p = 0.95.

Table 1
The maximum radiological bone density of the upper wall of the maxillary sinus in the study and control groups

Indicator	Group 1	Group 2	Group 3
U_A (X)	37,608	42,111	37,146
U_B (X)	0,000568	0,00045776	0,00068489
Us (X)	37,6081	42,1106	37,1457
U(X)	75,2162	84,2212	74,2914

Assessing the data in the table, we can conclude that the probable spread of Y value is in the ±U range relative to the measured U value, and the degree of certainty for U values in this interval is determined by the probability (confidence level) p = 0.95.

As seen in Table 1, smoking has almost no effect on the maximum bone density. All groups show nearly identical values. In the first group, consisting of individuals who smoked for up to 5 years, the maximum density is 75.22 ± 37.61 Hu. In the second group, those who smoked for up to 10 years have a density of 84.22 ± 42.11 Hu, while in the third control group, the density is 74.29 ± 37.15 Hu. The difference of 10 Hu can be considered insignificant and may be attributed to the dataset used for each group as well as the inherent characteristics and heterogeneity of bone tissue structure.

Table 2
The minimum radiological bone density of the upper wall of the maxillary sinus in the study and control groups

Indicator	Group 1	Group 2	Group 3
U_A (X)	26,325	11,932	29,058
U_B (X)	0,00004517	0,00004531	0,00008627
Us (X)	26,3249	11,9320	29,0584
U(X)	52,6498	23,8640	58,1168

When evaluating the data on minimum density presented in Table 2, it can be inferred that smoking has a greater impact on the minimum radiological bone density of the upper wall of the maxillary sinus. The lowest values are found in the group of individuals who smoked for 10 or more years, with a minimum density of 23.86 ± 11.93 Hu. For those who smoked for up to 5 years, the radiological bone density was 52.65 ± 26.32 Hu. In the control group, the density values were slightly higher than those of individuals who smoked for up to 5 years, with the highest values being 58.12 ± 29.06 Hu.

4. Discussion

As evident from the study, the maximum radiological bone density is more stable and less susceptible to damaging factors such as smoking. It can be hypothesized that the minimum bone density is a more sensitive indicator that changes more significantly under the influence of smoking. This could be considered an unfavorable prognostic sign, potentially leading to the development of complications and the spread of infections to surrounding organs and tissues.

The study also suggests that changes in radiological density tend to correlate with the duration of smoking. In individuals who smoked for up to 5 years, the minimum density is only slightly different from the control group [13-14]. This may indicate that the body's internal compensatory reserves play a crucial role in maintaining bone density at a certain acceptable level during the initial years of smoking [15-16]. However, as nicotine exposure continues, these compensatory mechanisms may become depleted, leading to a significant decrease in bone density among smokers with a history of ten years or more [17-18].

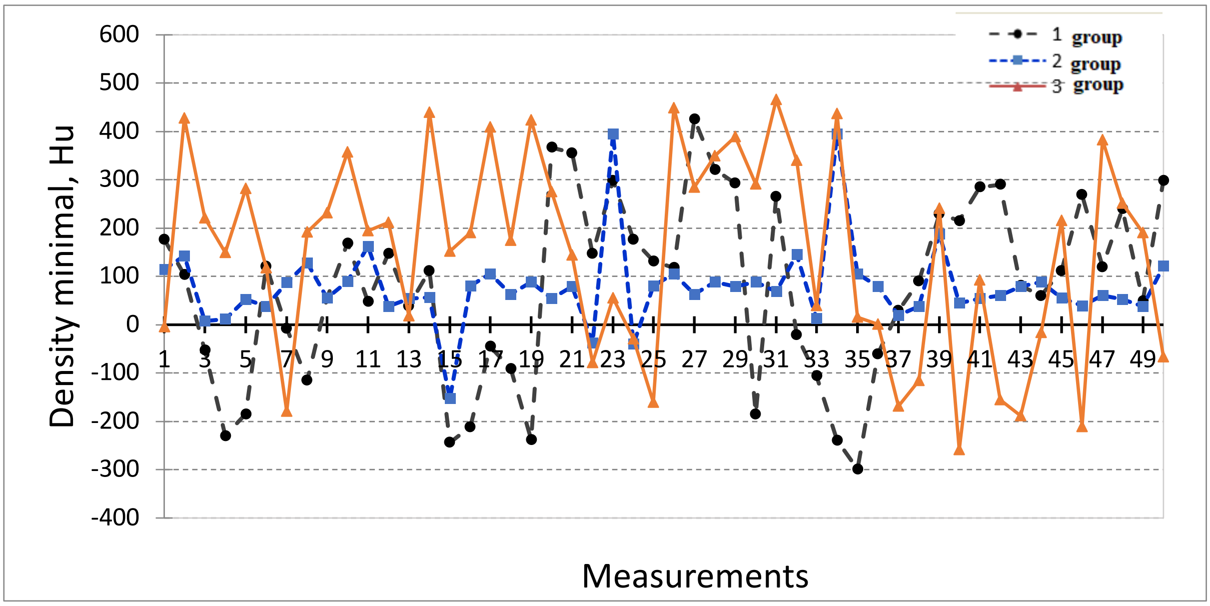

Figure 1: Minimal radiological bone density in 3 groups of patients

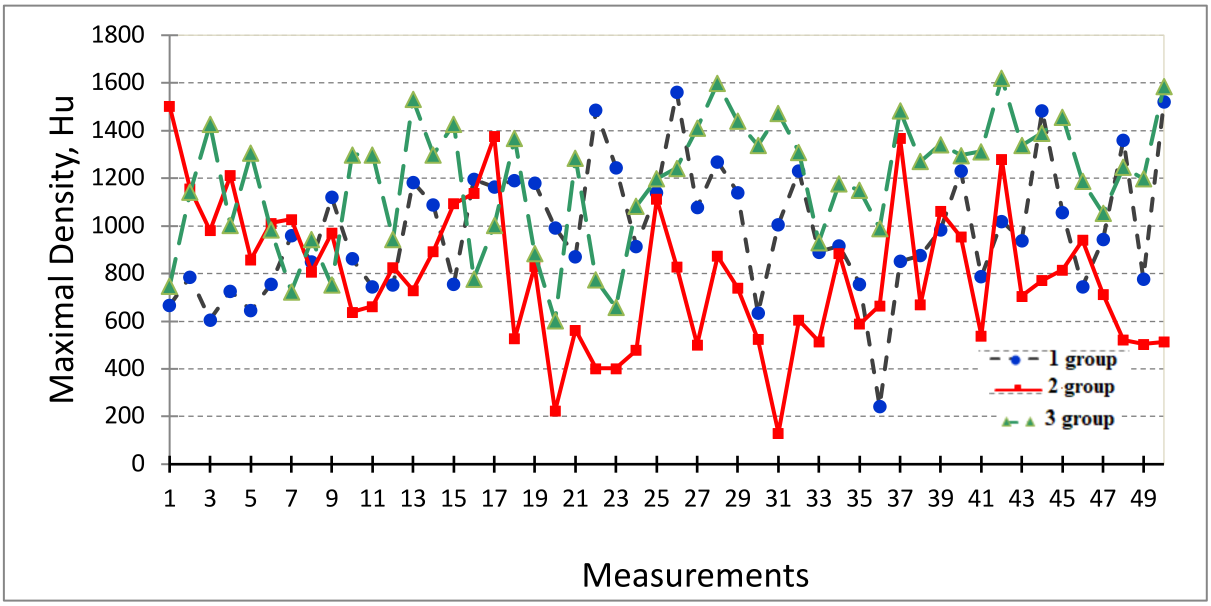

Figure 2: Maximal radiological bone density in 3 groups of patients

Thus, the study concludes that smoking has a negative impact on the bone tissue of the upper wall of the maxillary sinus. The reduction in radiological density due to nicotine exposure is likely driven primarily by factors such as impaired blood circulation [19-20]. Continuous nicotine use can cause long-term constriction of small capillaries, which may lead to inadequate blood supply to the bone tissue, resulting in oxygen and nutrient deficiencies necessary for bone repair. Additionally, free radicals produced as a result of cell damage from smoking may not only cause direct harm but also stimulate destructive processes by activating osteoclasts [21].

Another factor to consider when discussing the harmful effects of smoking on the human body is hormonal imbalance. Specifically, disruptions in the balance of hormones like estrogen and testosterone can negatively impact calcium absorption in bone tissue, further exacerbating bone density loss [22]. In the context of examining the impact of smoking on bone density, our findings align with the broader scope of research in healthcare-related intelligent systems. Studies on an intelligent expert system for knowledge examination of medical staff regarding infections associated with the provision of medical care [23], as well as works in the areas of smart systems, data-driven services in healthcare, and the application of smart technologies for medical services, may contribute to the growing body of knowledge in the field of the detection of bone density [24].

The integration of smart systems and data-driven services in healthcare, as explored by some authors [25-27] emphasizes the importance of leveraging technology for improved medical outcomes with future storage of a data in the clouds [28-29]. Our study, focusing on the influence of smoking on bone density, adds to this discourse by shedding light on a specific aspect of health that may be impacted by lifestyle choices such as smoking.

To date, numerous studies have focused on bone density in various locations [30-32]. Most of these are based on densitometry, which demands further research, additional time, and increased costs for medical staff [33]. Our study, however, utilizes data from previously performed CT scans, eliminating the need for extra expenses.

5. Conclusions

The study investigated changes in the bone density of the human paranasal sinuses under the influence of smoking, using uncertainty calculation. It was found that the most sensitive indicator to nicotine exposure is the minimum radiological density, which can significantly increase the risk of developing complications. Specifically, the lowest radiological density was observed in the group of individuals who smoked for 10 years or more, with a value of 23.86 ± 11.93 Hu. In contrast, the relatively stable radiological density in the group of individuals who smoked for a shorter duration can be attributed to the compensatory mechanisms of the body.

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