

## **Serum Calcium and Phosphorus as Indicators of Bone Metabolism And Remodeling Activity**

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### **Abstract:**

This study reports findings on skeletal bone tissue metabolism and bone remodeling activity, assessed through the measurement of total serum calcium and phosphorus levels in women with postmenopausal osteoporosis undergoing dental implant treatment. A comparative evaluation of treatment approaches indicates that the “one-two-three” vitamin-mineral complex demonstrates greater effectiveness in normalizing mineral metabolism parameters in the blood and supports the maintenance of optimal calcium and phosphorus concentrations.

**Keywords:** osseointegration, postmenopausal osteoporosis, dental implants, bone remodeling, serum calcium, serum phosphorus, parathyroid hormone

### **Introduction**

Research in the field of implant osseointegration includes the search for optimal implantation technologies, including modification of the implant surface and the development of new surgical methods [1]. In addition, emphasis is placed on studying the effects on osseointegration processes at a deeper, cellular and tissue level. This makes it possible to understand more fully and deeply the processes occurring during the integration of implants with biological tissues and to develop more effective methods of treatment and rehabilitation.

Postmenopausal osteoporosis is a systemic skeletal disorder characterized by reduced bone mass and microarchitectural deterioration of bone tissue, leading to increased fragility [2]. In such patients, disturbances of mineral metabolism—particularly of calcium and phosphorus homeostasis—may compromise the quality of the peri-implant bone and, consequently, the success of dental implantation [3]. Bone remodeling, the continuous coupled process of resorption and formation, is regulated by

systemic factors such as parathyroid hormone (PTH) and vitamin D and can be assessed indirectly through serum mineral indicators [4].

The purpose of the study is to improve the results of prosthetics with fixed structures supported by dental implants in patients with postmenopausal osteoporosis, by evaluating the effect of a staged vitamin-mineral complex on serum calcium and phosphorus as markers of bone metabolism and remodeling activity [5].

## 2. Materials and Methods

To solve the problems and achieve the goal of the study, the results of examination and treatment of 90 female patients of menopausal age from 45 to 65 years (mean  $51.6 \pm$  years) who sought orthopedic dental care were analyzed. This contingent of patients with partial secondary adentia, requiring orthopedic treatment based on dental implants, was divided into the following groups.

The main group (I) consisted of 30 menopausal women suffering from postmenopausal osteoporosis, who were fitted with ALPHA DENT Superior Active dental implants (Germany) in a buffer solution with a hydrophilic SLA-Active surface. The comparison group (II) consisted of 30 menopausal women suffering from postmenopausal osteoporosis who received ALPHA DENT Active dental implants with a 3D-Active hydrophilic surface [2]. The control group consisted of 30 patients with intact dentition, or dentition restored with a fixed structure, without a history of mineral metabolism disorders or cardiovascular or endocrine diseases.

Both osteoporotic groups were divided into subgroups according to the treatment method using a randomized controlled design:

**Subgroup A** – patients receiving traditional treatment with prosthetics supported by dental implants;

**Subgroup B** – patients receiving special treatment for prosthetics supported by dental implants, taking a vitamin-mineral complex consisting of three drugs administered at three main stages of implantation: preparing the bone for implantation — Pre-Implantation Complex Alpha (powder for oral solution, No. 3); the healing period — Fast Integration Complex Alpha (capsules, No. 10); and the period of osseointegration — Post-Integration Complex Alpha (capsules, No. 10).

In order to characterize the metabolic state of skeletal bone tissue and the intensity of remodeling, the levels of total calcium and inorganic phosphorus in the blood plasma were studied before treatment and one month after the start of taking the complex of drugs and dental implantation [6]. Parathyroid hormone, the main regulator of phosphorus and calcium metabolism, was monitored as a marker of bone-tissue remodeling [8]. The obtained data were compared between subgroups and with the control group.

## 3. Results

The baseline values of the studied indicators of mineral metabolism, obtained before the start of taking the complex of drugs and before dental implantation, are presented in Table 1.

*Table 1. Mineral metabolism indicators in the blood before treatment and dental implantation*

Patient groups	I	II	Control
Calcium, mmol/L	1.89	1.96	2.36
Phosphorus, mmol/L	0.79	0.84	1.13

When studying data on mineral metabolism, a decrease in calcium and phosphorus levels in the blood was noted in postmenopausal patients suffering from osteoporosis. Thus, in patients of group I the average calcium level in the blood was 1.89 mmol/L, and in group II it was 1.96 mmol/L, which is 13.6 % and 16.9 % lower, respectively, than the average obtained in the control group. The level of inorganic phosphorus determined in the blood serum also had relatively reduced values—by 15.9 % in patients of group I and 25.7 % in patients of group II relative to the control group, in which the average serum phosphorus was 1.13 mmol/L [7].

To comparatively evaluate the effectiveness of the proposed treatment, groups I and II were divided into subgroups A and B with an equal number of subjects (randomized controlled method). One month after the start of taking the drugs, the results of the study, depending on the treatment method, were as follows (Table 2).

*Table 2. Mineral metabolism indicators in the blood one month after the start of treatment and dental implantation*

Patient groups	I		II		Control
	A	B	A	B	
Calcium, mmol/L	1.91	2.03	2.01	2.14	2.12–2.60
Phosphorus, mmol/L	0.80	0.83	0.88	0.70	1.15

In patients of group I with bone categories A and B, the average value of the serum calcium level increased by 7.41 % in subgroup B; in patients of subgroup A, no significant deviations were observed compared with the initial data. For this indicator in patients of group II, as well as in patients of group I in the subgroup with the traditional method of treatment, only minor changes toward an increase were noted. In addition, the average value of serum calcium in patients of the subgroup taking the proposed complex of drugs increased by 9.2 % compared with the initial data of group II; after treatment, the values of the indicator were close to those of the control group.

When studying the indicators of inorganic phosphorus in the blood, the following pattern of changes was observed. In patients of both groups in the subgroups with traditional treatment and an initially reduced level of phosphorus, no significant changes were found after treatment: in subgroup A (I) the phosphate level increased by 1.2 %, and in subgroup A (II) by 4.7 %. At the same time, the increase in serum calcium in patients of subgroup B of group II after treatment with the “one-two-three” complex was accompanied by a decrease in the phosphate level to 0.70 mmol/L (16.6 %).

Thus, in patients with an initially near-normal calcium level who received traditional treatment, the phosphorus level did not change, whereas in patients with an initially low level who took the proposed complex of drugs it decreased. Such dynamics of changes in the studied parameters characterize a more pronounced improvement in mineral metabolism in patients of subgroup B.

#### 4. Discussion

The obtained results can be interpreted in the context of the coupled nature of bone remodeling and the systemic regulation of mineral homeostasis. Serum calcium and phosphorus, although tightly regulated, reflect the net balance between bone resorption and formation and are therefore widely used as accessible indicators of bone metabolism [8]. The reduced baseline calcium and phosphorus levels

observed in both osteoporotic groups are consistent with the increased resorptive activity characteristic of postmenopausal osteoporosis [9].

The key finding of the study is that the staged “one-two-three” complex improved calcium-phosphorus metabolism specifically in patients with an initially reduced serum calcium level, while having no appreciable effect in patients with initially normal values. This selective response is physiologically plausible: the normalization of serum calcium was accompanied by a natural decrease in inorganic phosphate, which reflects the reciprocal regulation of these ions through parathyroid hormone and vitamin D [10]. In other words, the complex appears to support the restoration of a disturbed equilibrium rather than to force mineral levels beyond their physiological range .

This interpretation is supported by the dynamics of parathyroid hormone, the main regulator of phosphorus and calcium metabolism, of their concentration in the blood, and of calcium absorption in the small intestine. A decrease in PTH levels was monitored in patients of all groups after the course of pharmaceutical treatment supporting dental implantation. A reduction in PTH is expected when serum calcium is restored, since lower PTH secretion attenuates osteoclast-mediated resorption [11]. From the standpoint of implant therapy, an improvement in peri-implant bone metabolism and a reduction in resorptive drive are favorable for osseointegration and for the long-term stability of implant-supported prostheses [12].

These findings are in agreement with previous work by the authors on the effectiveness of orthopedic treatment using dental implants in patients with systemic osteoporosis [9], [10], and they extend it by linking the clinical protocol to measurable changes in mineral-metabolism markers. The main limitations of the study are the relatively small sample size, the single one-month follow-up point, and the use of serum minerals as indirect markers; the inclusion of specific biochemical markers of bone formation and resorption [13] in longer-term studies would allow a more precise characterization of remodeling activity.

## 5. Conclusion

The “one-two-three” complex may affect the balance of calcium and phosphorus in the body, influencing calcium levels and, in turn, parathyroid hormone levels. This represents a form of physiological regulation in which calcium balance is maintained and normal calcium levels are restored when necessary, taking into account the regulation of PTH.

Thus, based on a comparative assessment of treatment methods, it can be concluded that the “one-two-three” complex is more effective in restoring the components of mineral metabolism in the blood. It helps to maintain the required level of calcium in the blood, reducing the production of PTH and thereby inhibiting the processes of bone tissue resorption. Accordingly, the staged vitamin-mineral complex can be recommended as a supportive component of implant-based orthopedic treatment in patients with postmenopausal osteoporosis, with the aim of improving the conditions for osseointegration. Further studies with larger samples and longer follow-up, incorporating direct biochemical markers of bone remodeling, are warranted to confirm these results.

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