THE EFFECT OF VITAMIN C ON ALVEOLAR HEALING FOLLOWING TOOTH EXTRACTION

Wpływ witaminy C na gojenie zębodołu po ekstrakcji zęba

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Abstract

Introduction: Over the past decades, significant advancements have been made in understanding oral wound healing mechanisms, which are increasingly being integrated into clinical practice. Tooth extraction remains one of the most common procedures in dental practice, underscoring the need for continued investigation into strategies that promote optimal regeneration of both soft and hard oral tissues. Ascorbic acid (vitamin C) is a water-soluble micronutrient essential for physiological functions, including collagen synthesis and immune modulation, both critical for efficient wound healing. Unlike most animals, humans are unable to endogenously synthesize vitamin C due to the absence of the enzyme L-gulonolactone oxidase, and therefore require its dietary intake. In post-extraction care, vitamin C supplementation may serve as a valuable adjunct to conventional dental management, offering a readily accessible means of enhancing tissue repair and improving clinical outcomes. **Aim:** This study aimed to assess the role of vitamin C in tissue regeneration, focusing on alveolar socket healing following tooth extraction. We performed a review of scientific literature addressing the impact of vitamin C on wound healing and bone regeneration processes to provide evidence-based recommendations for its application in dental practice. **Materials and methods:** The data presented in this study were derived from peer-reviewed scientific publications available in the PubMed database. The analysed studies spanned various countries and included populations diverse in age, geography, and socioeconomic status. **Conclusions:** Vitamin C promotes alveolus healing post-tooth extraction by accelerating tissue regeneration, reducing inflammation, and alleviating pain. Supplementation with doses of 600–2000 mg/day, as well as local application (including nanotechnology and submucosal injections), enhances healing and reduces the risk of alveolar osteitis. Vitamin C therapy can complement standard post-extraction care, especially in patients with impaired healing.

Streszczenie

Wprowadzenie: W ciągu ostatnich dziesięcioleci poczyniono znaczące postępy w zrozumieniu mechanizmów gojenia ran w jamie ustnej, które coraz częściej są wdrażane do praktyki klinicznej. Ekstrakcja zębów pozostaje jednym z najczęściej wykonywanych zabiegów w gabinetach dentystycznych, co podkreśla potrzebę dalszych badań nad strategiami wspomagającymi regenerację tkanek miękkich i twardych jamy ustnej. Kwas askorbinowy (witamina C) to rozpuszczalny w wodzie mikroskładnik odżywczy, niezbędny do wielu funkcji fizjologicznych, w tym syntezy kolagenu i modulacji układu odpornościowego, które są kluczowe dla efektywnego gojenia ran. W przeciwieństwie do większości zwierząt, ludzie nie mogą endogennie syntetyzować witaminy C z powodu braku enzymu oksydazy L-gulonolaktonowej, co wymaga jej dostarczania wraz z dietą. W opiece poekstrakcyjnej suplementacja witaminą C może stanowić cenny dodatek do tradycyjnego leczenia stomatologicznego, oferując łatwo dostępne narzędzie wspomagające naprawę tkanek i poprawiające wyniki kliniczne. **Cel pracy:** Celem niniejszego opracowania jest analiza roli witaminy C w procesach regeneracji tkanek, ze szczególnym uwzględnieniem gojenia zębodołu po ekstrakcji zęba. Badanie opiera się na przeglądzie literatury naukowej dotyczącej wpływu witaminy C na mechanizmy gojenia ran oraz procesy odbudowy kostnej i ma na celu opracowanie rekomendacji opartych na dowodach naukowych w zakresie jej zastosowania w praktyce stomatologicznej. **Materiały i metody:** Dane zaprezentowane w niniejszej pracy pochodzą z recenzowanych publikacji naukowych dostępnych w bazie PubMed. Analizowane badania zostały przeprowadzone w różnych krajach i obejmowały populacje zróżnicowane pod względem wieku, lokalizacji geograficznej oraz uwarunkowań społeczno-ekonomicznych. **Wnioski:** Witamina C wspomaga gojenie zębodołu po ekstrakcji, przyspieszając regenerację tkanek, redukując stan zapalny oraz łagodząc ból. Suplementacja w dawkach 600–2000 mg/dobę oraz miejscowa aplikacja (w tym z wykorzystaniem nanotechnologii i iniekcji) poprawiają gojenie i zmniejszają ryzyko zapalenia kości zębodołowej. Terapia witaminą C może stanowić uzupełnienie standardowego postępowania, zwłaszcza u pacjentów z trudnościami w gojeniu.

Keywords: tooth extraction; bone regeneration; vitamin C; alveolus

Słowa kluczowe: ekstrakcja zęba; regeneracja kości; witamina C; zębodół

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Introduction

The past few decades have witnessed a substantial expansion of knowledge of oral wound healing mechanisms, which are being increasingly introduced into modern clinical practice [1]. Tooth extraction remains one of the most common dental procedures, underscoring the need for ongoing research into regenerative potential of hard and soft oral tissues [2, 3].

Ascorbic acid (vitamin C) is essential for human life; it is water-soluble and obtained through the diet [4]. It can be synthesized from D-glucose by most animals, but not by humans, other primates, or some animal species such as guinea pigs, fruit bats, certain species of fish, insects, and birds. Vitamin C synthesis relies on the enzyme L-gulonolactone oxidase, which is absent in these animals [5], therefore it must be supplied exogenously. The recommended daily intake is 75 mg for women and 90 mg for men. Deficiency typically develops following long-term (several weeks) intake of less than 10 mg per day [6] (Tab. 1). Vitamin C deficiency can lead to scurvy, symptoms of which include gingival hyperplasia and bleeding, impaired wound healing, altered dentin structure, bone demineralisation, abnormal tooth mobility, and tooth loss [7].

In the context of tooth extraction, postoperative vitamin C supplementation may serve as an important adjunct to standard dental care. It is a readily available and potentially effective approach that supports tissue regeneration and enhances healing, which may translate into more favourable clinical outcomes [8].

The aim of this study was to assess the role of vitamin C in tissue regeneration, particularly in alveolar socket repair following tooth extraction, and to present evidence-based recommendations for its use in dental practice. The study was based on a review of scientific literature addressing the effects of vitamin C on wound healing and bone regeneration. It further evaluated the efficacy of vitamin C supplementation in improving clinical outcomes following tooth extraction, taking into account its potential role in accelerating tissue healing, reducing inflammation, and minimizing the risk of complications.

Materials and methods

The data presented were derived from peer-reviewed publications retrieved from the PubMed database. The studies analysed were conducted across multiple countries and encompassed populations diverse in terms of age, geographic location, and socioeconomic background. The literature search was conducted between January and May 2025. Only articles published in English or Polish and available full-text online were included. The following keywords were employed in the literature search: vitamin C, tooth socket, ascorbic acid, tooth extraction, and healing process. Only papers published in peer-reviewed journals directly related to the topic of the study were included in the analysis.

Physiological alveolar socket healing

The process of alveolar bone regeneration begins immediately after tooth extraction and can last up to six months [9]. Nevertheless, literature data indicate that alveolar modelling and remodelling are considerably longer, often extending beyond one year following the procedure [10, 11].

Following tooth extraction, the alveolar socket is immediately filled by a blood clot, initiating spontaneous healing. The clot subsequently undergoes progressive transformation into granulation tissue, typically within 2–7 days. Reepithelialisation is initiated within the first 24 hours following the procedure and is generally completed within 1–4 weeks [12]. Socket healing occurs in several stages, comprising four distinct yet temporally overlapping

Table 1. Daily vitamin C intake – RDA, deficiency, and excess (by sex)

Group	RDA (mg/day)	Deficiency (mg/day)	Symptoms of deficiency	Excess (mg/day)	Symptoms of excess
Female adults (≥18 years)	75	<10	Scurvy, gingival bleeding, impaired wound healing, fatigue	>2000	Diarrhoea, nausea, abdominal pain, risk of kidney stones
Male adults (≥18 years)	90	<10	As above	>2000	As above
RDA – recommended dietary allowance					

phases: haemostasis and coagulation, the inflammatory phase, the proliferative phase, and the remodelling phase. The development of lamellar bone and marrow facilitates the relatively rapid progression of the early stages of healing in humans; however, remodelling of the newly formed bone proceeds considerably more slowly and may continue for many years following tooth extraction [11, 13].

Haemostasis and coagulation

The socket healing process begins immediately after tooth extraction, with the first step being haemostasis, which aims to stop bleeding and stabilize the wound. Bleeding activates the coagulation cascade, leading to platelet aggregation on the exposed vascular surface. Platelets subsequently interact with the extracellular matrix and endothelial cells, giving rise to a fibrin clot [14].

In addition to its role in arresting bleeding, the clot serves as a biological scaffold, facilitating the attachment and migration of cells involved in the subsequent phases of tissue repair, including fibroblasts, mesenchymal cells, and leukocytes [15]. Platelets aggregate at the site of injury and release growth factors, including platelet-derived growth factor (PDGF) and vascular endothelial growth factor (VEGF), as well as proinflammatory cytokines, collectively initiating inflammatory and regenerative processes [14, 15]. A fibrin clot is formed, serving as a temporary scaffold and protective barrier that prevents further bleeding and facilitates the migration of cells involved in tissue repair [16].

During the first 7 days after the procedure, the clot gradually degrades and is replaced by well-vascularized granulation tissue, consisting mainly of young connective tissue containing multiple blood vessels, mesenchymal cells and leukocytes [11, 13]. In a histological study by Trombelli et al. (2008) [11], biopsies retrieved from alveolar sockets 2–4 weeks following extraction contained predominantly mesenchymal cells and a small number of red blood cells, suggesting that the primary clot undergoes complete transformation within the first week of the healing process. This early clot transformation lays the foundation for the initiation of subsequent repair phases, including the inflammatory and proliferative phases, during which further tissue maturation and structural alveolar socket remodelling occur [11, 14].

Inflammation

The inflammatory phase begins almost simultaneously with haemostasis and typically lasts 24 to 72 hours. Neutrophils, followed by monocytes and macrophages, infiltrate the extraction site, clearing dead cells, tissue debris, and microorganisms. Macrophages also play a regulatory role, by secreting cytokines and growth factors (including TGF-β, IL-1, IL-6), which initiate further repair processes. Although inflammation represents a physiological response, excessive inflammation may disrupt or delay healing [17, 18].

Proliferation

The proliferative phase begins within a few days following tooth extraction and may persist from several days to several weeks, depending on local and systemic conditions. A key role in this phase is played by the intensive proliferation of fibroblasts, which synthesize collagen and other components of the extracellular matrix, thereby facilitating tissue reconstruction [18]. Simultaneously, angiogenesis occurs, ensuring an adequate supply of oxygen and nutrients to the regenerating tissues.

According to research, the proliferative process occurs in two stages. The first, fibroplasia, involves the formation of granulation connective tissue, which gradually replaces the blood clot and remnants of the periodontal ligament. The resulting provisional matrix consists primarily of densely distributed mesenchymal cells embedded in a collagenous extracellular matrix, which is abundant in blood vessels and contains a small number of mononuclear leukocytes [10, 11].

The second stage involves the formation of woven bone, which represents the primary form of bone tissue deposited around the newly formed blood vessels by osteoblasts residing within the matrix [10, 14].

Woven bone becomes detectable approximately two weeks following extraction and progressively displaces the granulation connective tissue. It is believed that a substantial portion of granulation tissue is replaced by woven bone during the 6–8 week healing process [14, 19].

Bone modelling and remodelling

The final phase, comprising modelling and remodelling, may persist from several months to over a year following tooth extraction. During this period, granulation tissue is resorbed and replaced by mature bone. Osteoblasts synthesize new bone, while osteoclasts are responsible for modelling and removing structural excess. Woven bone is replaced by mature bone tissue, including bone marrow and lamellar bone [10, 20]. Remodelling leads to the final development of the alveolar process architecture, while also being associated with a physiological loss of bone volume, both vertically and horizontally [14, 21]. Alveolar healing following tooth extraction is a complex, multiphase biological process. Each phase follows precisely regulated cellular and molecular mechanisms that lead to the reconstruction of both soft tissue and osseous structures. Mesenchymal cells, inflammatory mediators, growth factors, as well as the processes of angio- and osteogenesis play a key role in this process. Nevertheless, the progressive modelling and remodelling of alveolar bone frequently result in a physiological loss of bone volume, which carries significant clinical implications for prosthetic and implant treatment planning [20, 22].

The role of vitamin C in the wound healing

Ascorbic acid, the biologically active form of vitamin C, plays a key role in tissue regeneration, particularly in wound healing and connective tissue repair [23]. As a potent antioxidant, it neutralizes free radicals and reactive oxygen species generated during oxidative stress induced by tissue injury or host immune responses. This helps reduce cell damage arising from excessive oxidative activity within the affected area [24].

Vitamin C is essential for the proper immune function, particularly in patients with open wounds. Its mechanism of action further involves supporting the regeneration of other antioxidants, such as vitamin E, and supporting enzymatic activity in collagen biosynthesis [25]. Ascorbic acid participates in the hydroxylation of proline and lysine during collagen biosynthesis, acting as a cofactor for the enzyme prolyl hydroxylase in procollagen [26].

Collagen represents a fundamental structural component of bone, cartilage, teeth, ligaments, gingival tissue, and blood vessels. Owing to its tensile strength conferred by ascorbic acid, newly synthesized collagen is capable of withstanding mechanical deformation without disruption. Ultimately, the initial protective layer of type III collagen is replaced within the extracellular matrix by a fully functional layer of type I collagen. Without ascorbic acid, the collagen structure becomes unstable, resulting in the formation of defective protein during synthesis [27].

Furthermore, vitamin C influences the functioning of immune cells, particularly macrophages, which play a pivotal role in clearing cellular debris from affected areas and regulating inflammatory processes. Furthermore, ascorbic acid supports angiogenesis, the process of creating new blood vessels, thereby ensuring the delivery of essential nutrients to regenerating tissues [28].

Discussion

Evidence from studies conducted across multiple countries demonstrates that vitamin C, administered systemically and topically, significantly enhances bone and soft tissue regeneration, which are critical determinants of clinical success. A study conducted by the International Institute of Nutrition and Stress in Florida demonstrated that oral vitamin C administered at a dose of 500 mg three or four times daily (1,500 mg/day and 2,000 mg/day) accelerates the healing of post-extraction wounds [29]. Nusgens et al. noted several significant changes following topical administration of vitamin C, including an increased number of fibroblasts, leading to the formation of more prominent collagen fibres. Furthermore, the formation of several newly developed small capillaries was also observed [27]. These changes consistently occur as new connective tissue forms in the healing wound.

Vitamin C is essential for neutrophil apoptosis and subsequent clearance during the inflammatory phase. As a cofactor in the hydroxylation of proline and lysine during collagen synthesis, vitamin C plays a role in the biosynthesis, maturation, secretion, and degradation of collagen during the proliferative phase. It is further associated with fibroblast proliferation, which in turn influences angiogenesis and capillary integrity [26].

In 2018–2019, researchers from the Department of Oral and Maxillofacial Surgery at the Faculty of Dentistry, Chulalongkorn University, conducted a study in which placebo or vitamin C (600 mg or 1,500 mg) was administered to patients for 10 days following extraction. The intervention was randomly assigned to each patient in a blinded manner. The most significant improvements in wound healing parameters, including a reduction in mesiodistal socket length and probing depth, reduction of pain and inflammation, as well as enhanced bone regeneration, were observed following administration of the 600 mg preparation [30].

In contrast, other *in vitro* studies have shown that rinsing with a low doses of vitamin C (20 µg/mL) improves gingival wound healing, fibroblast migration, and proliferation compared to higher doses (50 µg/mL). In oral fibroblast cultures, elevated doses of vitamin C have also been observed to compromise the viability of these cells [8, 31].

Another study, conducted at the Department of Oral and Maxillofacial Surgery, Saveetha University in Tamil Nadu,

Table 2. Therapeutic vitamin C dosage and healing outcomes following tooth extraction

Study/source	Route of administration	Dose	Study duration	Primary clinical outcomes
International Institute of Nutrition and Stress, Florida (1993) [29]	Oral	1500–2000 mg/day (500 mg 3–4 × day)	21 days	Accelerated healing of post-extraction wounds
Chulalongkorn University, Bangkok (2019) [30]	Oral	600 mg/day (3 × 200 mg)	10 days	Reduced postoperative pain and accelerated mesiodistal wound closure
Chulalongkorn University, Bangkok (2020) [31]	Local (rinsing)	20 µg/ml vs 50 µg/mL	3 and 7 days	20 µg/ml improves fibroblast migration and proliferation; 50 µg/ml reduces fibroblast survival
Saveetha University, Tamil Nadu (2021) [32]	Submucosal injection	200 mg	3 and 7 days	Improved healing outcomes on day 7; no significant effect on pain reduction
Complutense University, Madrid (2021) [33]	Local (nanoemulsion)	Intra-socket gel 3 × day	7 days	Reduced incidence of alveolar osteitis and postoperative discomfort
Chulalongkorn University, Bangkok (2021) [34]	Oral	600 mg	21 days	Reduced postoperative pain, enhanced bone regeneration, and increased radiographic bone density
Army Medical College, Rawalpindi (2023) [35]	Oral	500 mg (2 × day)	7 days	Decreased C-reactive protein, indicating limited systemic inflammation

India, evaluated the effect of submucosal injection of vitamin C (L-ascorbic acid) on wound healing following tooth extraction. Patients were divided into two groups: a vitamin C group and a control group. Signs of healing were assessed in the extraction sockets on days 3 and 7 following surgery. No significant differences were observed on day 3. On post-operative day 7, healing rates in the vitamin C group were significantly superior to those observed in controls. No significant reduction in pain was noted on days 3 or 7. The study authors concluded that L-ascorbic acid injection promotes favourable post-operative healing but does not significantly reduce post-operative discomfort [32].

Other researchers evaluated topical application of propolis extract, nanovitamin C, and nanovitamin E for the prevention of alveolar osteitis following the extraction of an impacted mandibular third molar. The study demonstrated the efficacy of nanovitamin C in reducing the incidence of alveolar osteitis and the associated discomfort [33].

Other studies have demonstrated that vitamin C significantly enhances soft tissue healing and increases radiographic bone density 21 days following extraction compared to controls [34]. Patients receiving vitamin C were also found to have decreased C-reactive protein levels compared to controls [35]. Table 2 summarizes the reviewed studies, stratified by vitamin C dose and route of administration.

Conclusions

Available evidence indicates that vitamin C plays an important role in alveolar socket healing following tooth extraction, supporting all critical stages of tissue regeneration. Vitamin C supplementation, both systemically and topically, may accelerate fibroblast proliferation, collagen biosynthesis, and angiogenesis, while also reducing inflammation and postoperative pain.

Oral administration of vitamin C at doses of 600–2,000 mg/day has been shown to exert a beneficial effect on healing dynamics, reduce postoperative pain, and improve regenerative parameters such as socket depth and radiographic bone density. Local application of vitamin C, including nanotechnology-based preparations and submucosal injections, has also been shown to yield beneficial clinical outcomes, including a reduced risk of alveolar osteitis. Based on the available evidence, adjunctive vitamin C therapy should be considered as a complement to standard post-extraction care, particularly in patients with impaired healing, nutritional deficiencies, or an elevated risk of postoperative complications. Nevertheless, further randomized controlled trials are required to establish the optimal dosage, duration of therapy, and most efficacious route of vitamin C administration across different patient populations.

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