

THE IMPACT OF NATURAL PRODUCTS EXTRACTS ON ORTHODONTIC TEETH MOVEMENT: AN EXPERIMENTAL IN VIVO STUDY

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1. ABSTRACT

Background: The use of natural products in the field of dental health and improving oral hygiene is well established in multiple previous studies. However, their use in orthodontics and especially their impacts on teeth movements have not been previously described. Among the wide range of natural products spread in many parts of the world and the increased interest in them in recent years are green tea, pomegranate extracts and virgin coconut oil.

Aims: This experimental study aimed to estimate the impact of green tea extract, pomegranate extract and virgin coconut oil on orthodontic teeth movement.

Methods: An experimental in vivo study design was adopted to conduct this study. Forty rabbits were selected for the experiments. Inclusion criteria were rabbits to be of good health, without dental abnormalities, weight of 1.7-2 kilogram (average adult rabbit weight), aged 7-10 months. Exclusion criteria were rabbits outside the aforementioned parameters, and those who have dental abnormalities. Four groups were assigned with 10 rabbits in each. One group was control, and other three groups were green tea, virgin coconut oil, and pomegranate. Selected rabbits underwent orthodontic experiment, and the study groups started feeding on these three natural products. After three weeks study period, distance obtained from tooth movement and serum calcium and phosphorus were measured.

Results: Statistical analysis comparing the means of these studied groups revealed a statistically significant differences in the orthodontic teeth distance obtained by the coconut oil group versus the other studied groups ($p = 0.03$). Additionally, A student t-test analysis to compare means of serum calcium and phosphorus levels showed no statistically significant differences between the mean differences in serum calcium levels ($p = 0.84$) and mean serum phosphorus levels ($p = 0.56$).

Conclusion: Rabbits received virgin coconut oil feeding protocol obtained higher mean orthodontic teeth movement distance compared to control, green tea, and pomegranate groups.

KEYWORDS: Orthodontic teeth movements, Virgin coconut oil, Green tea, Pomegranate.

2. INTRODUCTION

The use of natural products for general health is as old as human civilization [1]. Their extract, juice, peel, seeds, leaves, oil, or whole plant have been used traditionally for improving health. Because of the many limitations of available methods of accelerating tooth movements and the trend of recent health support to use biologic alternatives extracted from natural plants, there is a lot of interest from orthodontists to introduce these products to the field [2]. In addition to their availability as a daily food source, the major advantages of using herbal alternatives are: daily natural food sources, cost-effectiveness, increased shelf life,

low toxicity, and lack of reported microbial resistance [3] [4] [5].

Of the wide spectrum of such natural products, a special interest has been emphasized in the use and effectiveness of virgin coconut oil, green tea extract, and pomegranate extract in enhancing orthodontic treatment [6][7]. Such an interest stemmed from their theorized antioxidant, anti-inflammatory, anti-osteoporosis, and positive bone metabolic effects [8].

Based on the principle of orthodontic tooth movement, which relies on coordinated tissue resorption and formation in the surrounding bone and periodontal ligament, many preclinical and clinical approaches have been performed and tested in order to achieve faster orthodontic

results [9] [10]. However, there are still many limitations and unanswered questions regarding most of these techniques due to some of the estimated direct and indirect bone and health effects of these products [11][12][13].

It is important to note that few studies have been conducted in general to assess the effects of natural products in the dental field and the available information about their impact on tooth movement [14]. Thus, the purpose of this study is to estimate the effect of green tea extract, pomegranate extract, and virgin coconut oil on orthodontic tooth movement.

3. MATERIALS AND METHODS

The experimental prospective in vivo study design is used in this study. The study was done at the Duhok University Orthodontic Department Experimental Lab. The primary outcome of this study was to measure the effect of daily consumption of green tea extract, pomegranate extract, and virgin coconut oil for three weeks on orthodontic tooth movement. Secondary outcome measures include measuring the resultant distance between teeth after displacement, assessing metabolic bone markers after the index procedure by measuring serum calcium and phosphorus levels, and comparing effects and differences between study groups. The study was done on rabbits.

The included rabbits were 7–10 months old and weighed 1.7–2 kilograms. To ensure good health prior to the trial, the rabbits were chosen one month before the trial and examined for any health anomalies or illnesses. The exclusion criteria were any unhealthy rabbits, rabbits outside the selected age and weight criteria aforementioned, and rabbits with apparent dental anomalies. The selected rabbits were then transferred to special hutches during the experiment. The collected data were analyzed

using SPSS (Statistical Package for Social Service), version 18 for Windows (SPSS, Chicago, Illinois, USA). A comprehensive descriptive analysis was done, including calculating the means, standard deviation, standard errors, and variances.

A proper ethical approval was obtained, and the animal selection and surgical protocol were also reviewed prior to the conduct of this experimental study by the Animal Care Center in the Basic Science Department of Duhok University.

4. EXPERIMENTAL RESULTS

On the day the rabbits were obtained, their weight was measured before the surgery and at the conclusion of the experiment in order to detect any changes in their body weight. The rabbits were randomly divided into four groups, each consisting of ten rabbits, and placed in individual hutches: the first group served as the control, which was subjected to banding but was not given any type of natural product; the remaining three groups were experimentally subjected to tooth movement, and each group was given certain natural products, of the following three types:

1-green tea extract (1.5% w/v) as the only source of drinking water

2- pomegranate group 2 g/kg of PGE

3-Virgin Coconut oil 0.5 ml/kg

All of the above-mentioned doses were chosen based on previous research indicating the proper range of oral intake daily, which was started on the day of bracketing and continued throughout teeth movement [15][16][17]. The animal body weight and activity of the animals in each group were checked weekly for the 3-week experimental period. A summary of the experimental design is illustrated in figure 1 .

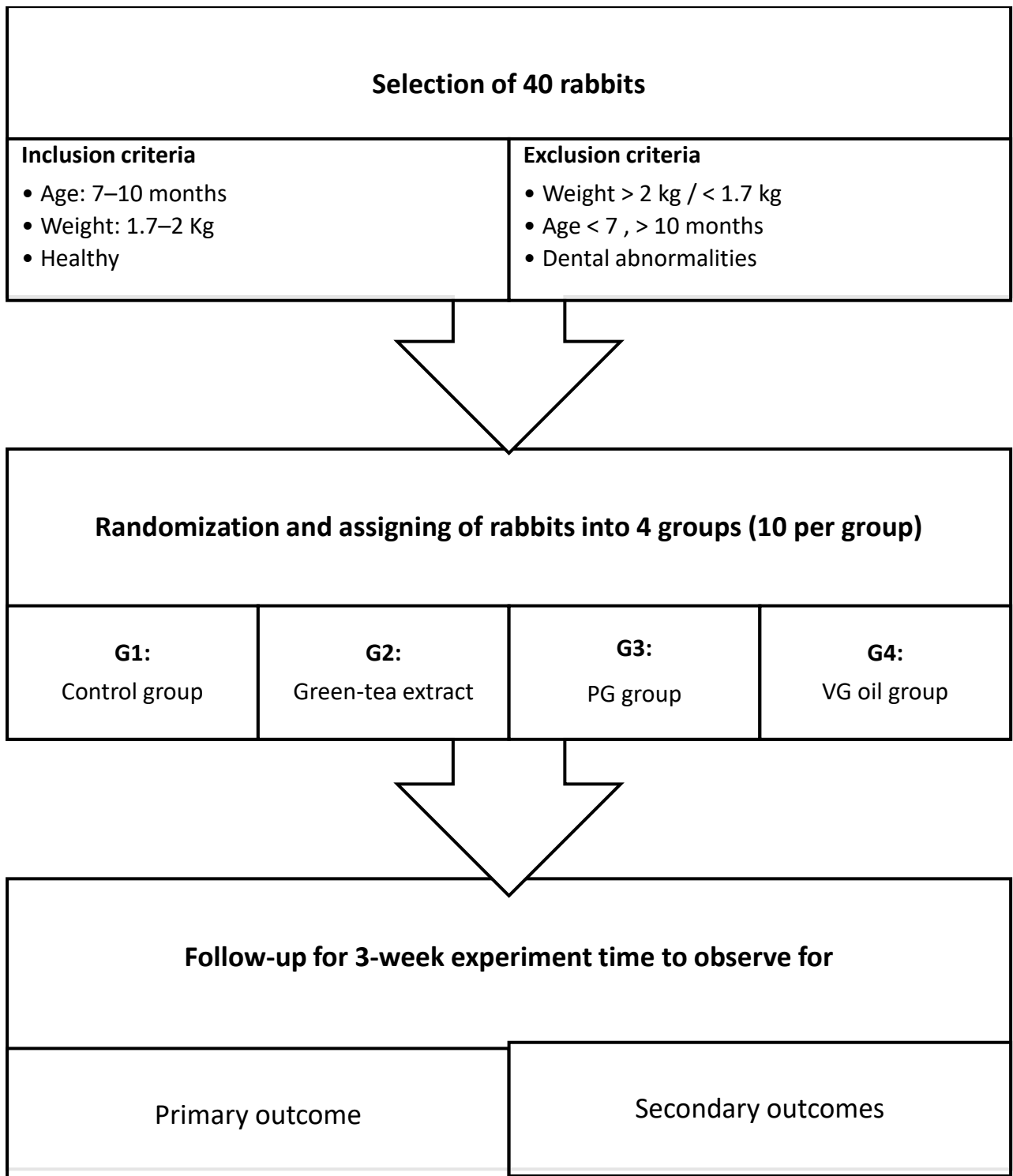


Fig. (1): Summary of the experimental design.

Appliance fixing procedure

Before the index procedure, each rabbit was pre-medicated with an intramuscular injection of 0.2 ml/kg Ketamine (10%) and 0.025 ml/kg Xylazine (2%). Complete anesthesia was obtained within 10 minutes, and this dose kept the animal anesthetized for about 1 hour. The

experiment site was the upper central incisors. After the teeth have been cleaned, brackets are applied with dental adhesive cement. (Biodinamica BIOFIX Adhesive Brackets, 4 g) This process usually takes a few seconds per tooth [18].

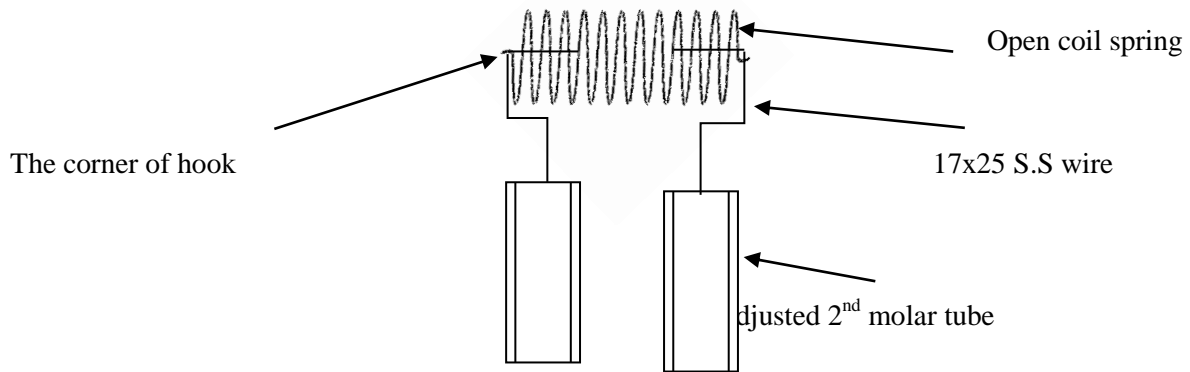


Fig. (2): Appliance design

Orthodontic appliances were fixed for all 40 rabbits. The device was made up of two mini buccal tubes measuring 2.4 mm in length and 2 mm in diameter, with a slot measuring 0.018 by 0.028 inches. The tubes were attached to the labial surface of the rabbit's upper central incisors, near the cervical third of the clinical crown.

An L-shaped stainless-steel wire of 0.017*0.025 inches with a long arm of 5 mm was inserted in the mini tube, while the short arm of 3.5 mm faces the other short arm arch wire of the other mini buccal tube on the other upper central incisor. The force (approximately 35 g) was applied by a light strength nickel-titanium open coil spring fitted over the two horizontal wire sections with a 0.079-inch

Teeth Movement initiation and Span measurement

The movement was initiated distally by the force application (about 35 mg will be measured by a force gauge) of compressing the open coil between the two angles of the l shaped wire . Before applying force to any animal in any group, the distance Span was measured in millimeters from the mesioincisal angle of one tube to the mesioincisal angle of the other. After finishing the span measurement, the rabbit entered postoperative recovery. Once they are fully recovered, the rabbits are transferred to their respective holding areas. During all the periods of this study, the animals received a balanced diet.



Fig. (3): initial span measurements

Rabbit feeding

All of these natural products were given to the rabbits through the oral route according to the predetermined dose as a loading dose for 3

weeks, starting from the day of tooth movement initiation. A diet adjustment of the total sample was made to exclude the possible effects of food type on the rate of tooth movements.

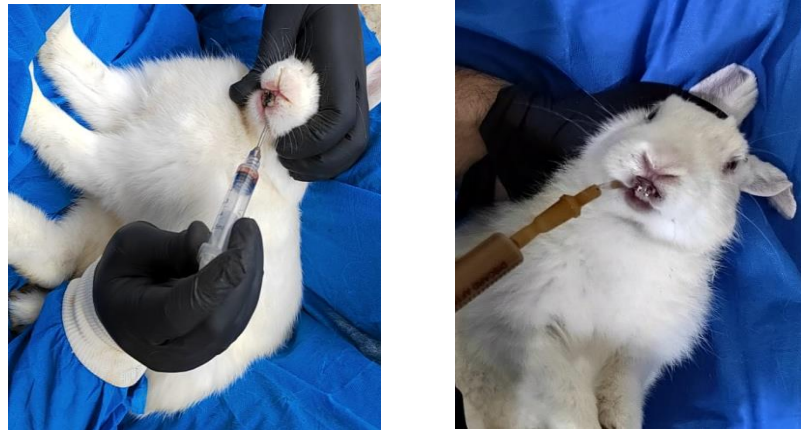


Fig. (4): Rabbits feeding with products.

Post-feeding rabbits handling and experimental protocol completion

After three weeks, all of the rabbits were sacrificed under the same conditions, in the same specially prepared location. The second

measurement of space created after tooth displacement was then recorded. A biochemical and metabolic evaluation were conducted, involving measuring calcium and phosphorus levels in serum.



Fig. (5): the second measurements after the end of the experiment

5. RESULTS

The Illustrated tables summarizing these findings were generated as well. Additional analysis was done, including a student t test to test for association.

The data was analyzed statistically by the Sigma Plot software program for statistical analysis. The data were presented as mean values \pm standard error (SE) and analyzed by one-way ANOVA, while the Duncan Multiple Range Test was used to find out the significance of the difference between the means comparison at $P \leq 0.05$. The scores are descriptive expressions of the granulation tissue, angiogenesis, re-epithelialization, and inflammation of the

gingiva for 3 rabbits in each group, done by a pathologist, and then the scores are analyzed statistically by the Sigma Plot software program by Kruskal–Wallis for ranks (ANOVA on Ranks) in the comparison of groups and periods with a Tukey test comparison at $P \leq 0.05$.

The distance between teeth was calculated for each of the four study groups. The mean obtained distance for the control group was (3.57 ± 1.53) millimeters, and for the Coconut oil groups was (5.21 ± 1.15) millimeters, for the Green tea group (4.64 ± 0.90) millimeter, and for the Pomegranate group was (3.85 ± 0.55) millimeters. A student t-test comparing the means of these studied groups revealed statistically significant differences in the

distance obtained by the coconut oil group versus the other studied groups ($p = 0.03$). A summary of these findings is illustrated in **table**

1 which the data expressed as Mean \pm stander deviation

Table (1): The mean of the obtained distance between the teeth of the groups

Groups	obtained distance mean
Control group	3.57 \pm 1.53 B [*]
Coconut oil group	5.21 \pm 1.15 A ^{**}
Green tea Group	4.64 \pm 0.90 AB ^{***}
Pomegranate Group	3.85 \pm 0.55 B [*]
P-Value	0.039

Where:

B^{*}:

A^{**}:

And AB^{***}:

The similar letters mean there is no significant differences between groups in the column at $p \leq 0.05$

After three-weeks of experiment, metabolic bone markers were assessed by measuring serum calcium and phosphorus levels to compare effects and differences between study groups.

For the control group, the mean serum calcium level was 14.2 mg/dl, and the mean serum phosphorus level was 5.4 mg/dl; for the Coconut oil group, the mean serum calcium

level was 14.1 mg/dl and the mean serum phosphorus level was 4.9; for the Green tea group, the mean calcium serum level was 13.6 mg/dl, and the mean serum phosphorus level was 4.8 mg/dl; and for the Pomegranate group, the mean calcium serum level was 14.2 mg/dl and the mean serum phosphorus level was 5.5 mg/dl. A student t-test analysis to compare these obtained means showed no statistically significant differences between the mean differences in serum calcium levels ($p = 0.84$) and mean serum phosphorus levels ($p = 0.56$). A summary of these findings is illustrated in **table 2** which the data expressed as Mean \pm stander deviation:

Table (2): The mean levels of the calcium and phosphorus (mg/dl) in the serum

Groups	calcium (serum) mg/dl	phosphorus (serum) mg/dl
Control group	14.22 \pm 1.439 A [*]	5.42 \pm 0.487 A [*]
Coconut oil group	14.144 \pm 0.754 A [*]	4.911 \pm 0.617 A [*]
Green tea Group	13.64 \pm 1.679 A [*]	4.82 \pm 2.163 A
Pomegranate Group	14.286 \pm 1.529 A [*]	5.529 \pm 0.658 A [*]
P-Value	0.848	0.561

Where:

A^{*}:

The similar letters mean there is no significant differences between groups in the column at $p \leq 0.05$

6. DISCUSSION

Teeth, throughout their natural history, move and migrate. Prior to their eruption into the oral cavity, due to the growth of dental structures and the concomitant remodeling of neighboring tissues, the teeth continue with their eruption movements until the tooth moves to its functional position in the arch from its

intraosseous position [19][20][21]. This process is continuous process does not stop at reaching the tooth to occlusal plane, but continues throughout life [22].

As soon as the tooth appears in the oral cavity, it is subject to multiple environmental factors and forces. These forces also continue to act until the tooth reaches its final functional position in the oral cavity [23]. At the same time, it adapts to the growth of the jaw and its contact with the teeth of the opposite jaw and compensatory movements of wear (occlusally or proximally) [24].

Pathologic tooth movement or migration (PTM) is defined as tooth displacement that occurs when the balance among the factors that maintain the physiologic tooth position is disturbed by periodontal disease [25][26]. On the other hand, orthodontic teeth movement is defined as a permanent and stable method of resorption and apposition of bone in areas of applied mechanical force [9].

Recently, there have been a great interest in the use of natural products in enhancing teeth movement [27]. Natural products from plant sources continue to play an essential role in health care, and the World Health Organization has estimated that nearly 80% of the world's population relies primarily on traditional medicines for primary health care [28]. The plant acts as an important reservoir for molecules of potential therapeutic interest. Plant products consist of toxins, hormones, or molecules that have biological agents that can be beneficial to humans [8].

Three natural products came to our interest in this research project, the green tea, the pomegranate, and the virgin Coconut oil.

There are different previous studies reported the use of green tea in the field of orthodontics. Elvina et al. studied the effect of green tea provided as a gargling solution in decreasing pain after orthodontic appliances, and green tea showed a significant pain reduction compared to Acetaminophen and chewing gum [29]. Sitasari et al. investigated the effects of methanolic extract of green tea in alveolar bone remodeling in orthodontal tooth movement in rats, and reported increased expression of inflammatory mediators (RUNX2 and OSX) at tension side of the implant [30]. Liao et al., studied the application of green tea extracts epigallocatechin-3-gallate in dental materials, the article revealed their excellent potential, for

use in oral materials such as oral repair materials, bone tissue engineering materials and antibacterial and anti-caries materials [31]. No previous reports, however, reported the effects of green tea extracts in orthodontic teeth movement.

Pomegranate, a commonly found fruit found to be beneficial in maintaining oral health. Its antibacterial effects have been reported by Kote et. al. Kote reported that there was a significant reduction in the number of colony forming units of streptococci and lactobacilli in the oral mucosa in a clinical trial done of thirty healthy volunteers. The ruby red seeds may be a possible alternative for the treatment of dental plaque bacteria [32]. Beside these antibacterial effects, an anti-demineralizing and anti-inflammatory effects have been proved by Fernandes et. al.[33]. In our study, a positive effect has been reported to pomegranate on orthodontic teeth movement.

Use of virgin coconut oil have been also reported in the field of orthodontics. Ripari et. al. reported that use of coconut oil in the form of mouthwash lead to significant and promising improvements in reducing plaque formation and gingivitis [34]. Another study done by Mohammed et. al. reported its usefulness in orthodontic patients as preventive therapy at home to maintain oral hygiene[35]. same dental hygiene positive enhancement was proved by the systematic review done by Woolley et. al [36]. By this study, an additional benefit of coconut oil has established which is improved orthodontic tooth movement compared to control, green tea, and pomegranate.

The action of coconut oil could be due to its role in increasing the TNF- α expression [37]. The significant increase in TNF- α expression was likely attributable to the lauric acid content of the virgin coconut oil, which functions in the inflammatory process and also possesses antibacterial properties, thereby accelerating tissue regeneration and healing. An increase in TNF- α also upregulate the receptor activators, which will result in the uptake of the TNF-Receptor Associated Factor-6 (TRAF-6) adapter protein, which will initiate a signal transduction cascade that increases the activation of Nuclear Factor of Activated T Cells c1 (NFATC1), a transcription factor for osteoclast formation that increases the number of mature osteoclasts. These osteoclasts then become active, stimulating periapical alveolar bone resorption and remodeling [38-40].

7. CONCLUSION

In this novel study which investigated the effects of three natural products (green tea, virgin coconut oil, and pomegranate extracts) on orthodontic teeth movements. This in vivo experimental animal (rabbits) trial showed a positive effect of feeding with virgin coconut oil on orthodontic movement distance obtained by tubes compared to control, green tea, and pomegranate.

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