Impact of using nano-hydroxyapatite on postoperative hypersensitivity of two bleaching techniques – randomized controlled clinical trial

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Abstract. To evaluate the impact of using Nano-hydroxyapatite on post-bleaching hypersensitivity after using two different bleaching techniques. Twenty-eight patients were enrolled in this study according to inclusion and exclusion criteria. The patients were randomly assigned into four groups (n=7). G1; bleaching was performed using photo-catalyzed bleaching technique (Philips, zoom), followed by application of Amorphous Calcium phosphate based desensitizing agent (ACP, Relief ACP). G2; bleaching was performed using chemo-catalyzed bleaching technique (Philips, Dash), followed by application of ACP. G3; bleaching was performed using zoom, followed by application of nano-hydroxyapatite based desensitizing agent (Nano p), G4; bleaching was performed using Dash, followed by application of Nano-hydroxyapatite. Post bleaching hypersensitivity was assessed using “Visual analogue scale”. Hypersensitivity was evaluated after: bleaching immediately, application of the desensitizing agent immediately, 24 hours, 48 hours and after one week. Cases with severe hypersensitivity were relieved immediately after Nano p application, meanwhile in case of ACP, cases with severe pain were relieved after 24 hours after its application. Statistically significant difference was evident with the photo catalyzed group immediately after Nano p application than before its application. Reduction in hypersensitivity by time was evident in both the chemo and photo catalyzed groups. In addition, it was found that after one week, all pain scores disappeared with all tested groups. Nano hydroxyapatite particles have an immediate (just post application) relief effect of severe pain with both used bleaching systems. However, the post bleaching hypersensitivity diminished completely after 1 week, irrespective of the desensitizing agent used. The application of Nano hydroxyapatite paste after bleaching is a valid method for diminishing severe post bleaching hypersensitivity when applied with either a photo or chemo catalyzed bleaching agents.

1. Introduction
The dream for a more esthetic smile has grown amazingly during the last few decades. Consequently, tooth color is currently believed to be one of the biggest today’s patient’s interest [1,2]. Tooth bleaching has been recognized as simple, effective and well-accepted method for solving the problem of teeth discoloration. There are three main ways to bleach vital teeth. In office bleaching, which is
done under clinician supervision, “night guard” bleaching which is administrated by the clinician for patient use at his home, and commercial bleaching products which are applied by the patient without clinician supervision [3]. In comparison between the three techniques, in-office bleaching has shown many advantages over the other techniques such as the professional control throughout the whole procedure, rapid initial results, reduced treatment time in addition to avoiding any accidental material ingestion and discomfort in wearing bleaching trays. This made the in-office bleaching a pioneer in bleaching treatment [4].

In-office whitening technique which was named power bleaching by many authors [5–8], is achieved via the use of high concentrations of hydrogen peroxides. This technique can be classified according to the mode of activation of the bleaching gel into photo catalyzed and chemo catalyzed in-office bleaching systems [2,9]. Post bleaching hypersensitivity is the most prevalent drawback of in-office bleaching technique. Although being the most prevalent drawback, the etiology of post bleaching hypersensitivity is not yet fully understood [10,11].

Currently, in the dental market, many desensitizing agents are available [12]. Recently, Nano technology has paved the way for introduction of materials at Nano scale having the same chemical composition of either organic or inorganic analogue of the hard tooth structure making them biomimetic [13–15]. Consequently appeared the revolutionary role of using the Nano hydroxyapatite. Gopinath et al [14] and Jena et al. [10], reported the desensitizing effect of Nano hydroxyapatite paste, however their studies were carried out on virgin dentin. They attributed this to its role to act as filler to fill and repair the small holes and pores in enamel. However, the impact of using Nano hydroxyapatite paste on post-bleaching hypersensitivity was not tackled enough in the literature.

The objectives of this study were to compare the post-bleaching hypersensitivity induced by two different bleaching techniques and to evaluate the impact of using Nano-hydroxyapatite on post-bleaching hypersensitivity using two different bleaching techniques.

2. Materials and Methods

2.1. Materials

Material’s composition, manufacturer and Lot numbers are presented in table 1. Two types of in-office bleaching agents were used in this study, Photo catalyzed bleaching agent (Philips ZOOM! Chairside tooth whitening system, Discus Dental, LLC Ontario, CA 91761 USA) containing 25% hydrogen peroxide gel and Chemo catalyzed bleaching agent (Philips Dash, Discus Dental, LLC Los Angeles, CA 90094 USA) containing 30% hydrogen peroxide gel. Two types of desensitizing agents were used in this study, amorphous calcium phosphate-based desensitizing agent. (Relief ACP, Discus Dental) and Nano-hydroxyapatite-based desensitizing agent (Desensitizable Nano P, FGM, Portugal, Brazil).

2.2. Methods

2.2.1. Study design. The study is a unicentered randomized controlled clinical trial. Twenty-eight participants with brown or yellow stains in their six anterior sound maxillary teeth were included in this study. Participants were divided into two equal groups (14 in each group) according to the type of bleaching agent used. A group received a photo catalytic bleaching agent and the other group received a chemo catalytic bleaching agent. Each group was divided into two equal sub-groups, (7 in each sub-group) according to the desensitizing agent used after bleaching. The first sub-group received amorphous calcium phosphate-based (ACP) desensitizing agent after bleaching (control group), while the second subgroup received Nano-hydroxyapatite-based (Nano p) desensitizing agent after bleaching (test group). The trial was approved by the institutional review board (IRB) of Misr International University (MIU- IRB-1516-0011). Reporting of this trial follows the Consolidated Standards of Reporting Trials (CONSORT) guidelines to ensure transparent and complete reporting.
Table 1. The material’s composition, manufacturer and Lot number.

| Character                     | Materials          | Composition                                                                                           | Manufacturer   | Lot no.  |
|-------------------------------|--------------------|-------------------------------------------------------------------------------------------------------|----------------|----------|
| In-office photo catalyzed bleaching agent. | Philips ZOOM       | 25% hydrogen peroxide, water, poloxomer, glycerin, Potassium nitrate, Potassium hydroxide, Mentha pipe Rita, Eugenol, and Ferrous gluconate. | Philips, Discus Dental | 2513     |
| In-office chemo catalyzed bleaching agent. | Philips Dash       | 30% hydrogen peroxide, water, glycerin, hydroxyethyl acrylate, sodium acryloyldimethyltaurate copolymer, etidronic acid, potassium stannate, ammonium hydroxide. | Philips, Discus Dental | 15267001 |
| Amorphous calcium phosphate-based Desensitizing agent. | Relief ACP         | Potassium Nitrate, Sodium Fluoride, water, Poloxamer, 338, Natural Mentha pipe Rita, Calcium Nitrate, Sodium Phosphate, Sodium saccharin. | Philips, Discus Dental | 113241   |
| Nanohydroxyapatite based Desensitizing agent. | Nano P paste       | Nanometer-sized (20 nm) calcium phosphates (in the form of hydroxyapatite), calcium fluoride, potassium nitrate, distilled water, surfactant, thickener, flavors, preservatives. | FGM            | 141015   |

2.2.2. Setting, participants and recruitment. The study took place at the outpatient clinic of Misr International University. Participants were recruited according to the inclusion and exclusion criteria summarised in table 2. All participants signed computerized informed consents after being completely aware of the aim, settings, procedures, benefits and potential side effects of the study. The study information and consent forms were written in Arabic language to be well understood by all the participants. Patients were enrolled into the study only after signing the informed consent.

2.2.3 Initial study visit. After screening for eligibility and prior to the study, eligible patients were identified by the primary investigator (DK). Teeth were re-assessed for confirmation. From 36 identified patients, 28 patients were included. Eligible patients were given a serial number (ID) at this initial study visit, from 1 to 28, according to the order for enrolment into the study. A preoperative
base line scoring of hypersensitivity was recorded. All participating patients then passed through scaling and polishing procedures. After scaling and polishing procedures, for ACP desensitizing agent application after bleaching (in the control group), preliminary impression of the maxillary arch was taken using alginate impression material. Impression was poured and soft vacuum trays were obtained. In the photo catalyzed bleaching system (Zoom), the kit was supplied with an “Iso prep retractor” for cheek and lip retraction. Meanwhile, in the chemo catalyzed bleaching agent (Dash), the kit was supplied with a “Cheek retractor” for cheek retraction.

Table 2. Inclusion and exclusion criteria.

| Inclusion criteria | Exclusion criteria |
|--------------------|--------------------|
| **Patient related criteria** | **Teeth related criteria** |
| Adult patients (age: 18 to 45 years) of both genders. | Presence of six anterior sound maxillary teeth. |
| Good oral and systemic health. | Teeth having brown or yellow stains. |
| Able to tolerate bleaching procedures. | Pre-operative shade of central incisor should be A2 or darker according to the value – oriented shade guide (Vita easy shade). |
| Willing to sign the informed consent. | Existing anterior crowns or large restorations. |
| Accepts the follow-up period. | Teeth with exposed roots. |
| Bruxer patients. | Severe internal tooth discoloration. |
| Smokers. | Patient with history of teeth hypersensitivity. |
| Alcoholism. | Teeth with congenital anomalies or surface defects. |
| Patient taking any anti-inflammatory or antioxidant drugs. | |
| Patient who had any previous whitening procedure. | |
| Pregnant or breast-feeding women. | |

2.2.4 Treatment visit. For both bleaching techniques, isolation was done following the concept of “No pink” according to the manufacturer instructions. The photo catalyzed bleaching agent (ZOOM) was dispensed out of its syringe and mixed with a brush to be activated. The whitening gel was applied on the upper and lower six anterior teeth. The photo catalyzed bleaching agent (ZOOM) whitening LED accelerator device, was used for 15 minutes (Each patient received three sessions, fifteen minutes each according to the manufacturer instructions). The gel was applied according to the manufacturer’s instructions. After the end of the 3 sessions, the Lamp was moved away and the whitening gel was carefully removed with a high volume suction tip and damp gauze. All means of isolation were removed. For the chemo catalytic bleaching system (Dash group), same isolation steps were done as the photo catalyzed bleaching system (Zoom). A whitening accelerator liquid (from the kit contents) was applied on the teeth using a cotton swab before the application of the whitening gel which accelerated the whitening chemical reaction according to the manufacturer recommended protocol. The whitening gel was then injected on the teeth surfaces using a flocked tip. The gel was applied for 3 sessions each is of 15 minutes according to the manufacturer instructions. After the 3 sessions were done, all isolation means were removed. For the control group, who received the amorphous calcium phosphate-based desensitizing agent (ACP), the ACP was placed into a vacuum tray and set on patient’s teeth for 30 minutes according to the manufacturer instructions immediately after bleaching. For the test group, who received the Nano-hydroxyapatite-based desensitizing agent (Nano p), it was placed also according to the manufacturer instructions immediately after bleaching. A pea-sized application was applied and rubbed on enamel for 10 seconds using a rubber cup mounted on a low speed hand piece. Afterwards, the material was left undisturbed for five minutes then it was removed by a slight dry cotton roll. (It’s worth mentioning that the lower arch was submitted to dental
bleaching but was not used for data assessment). Hypersensitivity was assessed immediately after bleaching procedure [3,16,17].

2.2.5 Data collection and follow-up examination. Patients were recalled for follow-up after bleaching sessions by 24 hours, 48 hours and 1 week to measure hypersensitivity using the visual analogue scale which was a qualitative verbal scale (no pain, mild, moderate, severe). The degree of sensitivity was evaluated using light air jet over the labial surface of the teeth near the root area for one second at distance from two to five mm [4,6]. Assessment was performed by one blinded, calibrated outcome assessor for each tooth who had not been involved in the treatment at all visits.

2.2.6 Sequence generation, allocation and blinding. In this clinical trial, quasi randomization was done by tossing a coin to choose the amorphous calcium phosphate-based desensitizing agent (ACP) and Nano-hydroxyapatite- based desensitizing agent (Nano p).

2.2.7. Statistical analysis. The obtained data of this clinical study was collected and tabulated for the statistical analysis. Qualitative data for hypersensitivity were presented as frequencies and percentages. Fisher's Exact test was used to compare between the techniques. Friedman's test was used to study the effect of time. Dunn's test was used for pair-wise comparisons when Friedman's test is significant. The significance level was set at \( P \leq 0.05 \). Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

3. Results
From table 3 and figure 1, the following data were analyzed, in the photo catalyzed bleaching group (Zoom) who received Nano p, before application of Nano p, cases with severe pain score presented 57.1%, while cases with moderate pain score presented 42.9%, with 0% for both scores of mild and no pain. Immediately after application, cases with severe pain score presented 0%, while cases with mild and moderate pain scores equally presented 42.9%. Meanwhile, cases with no pain score presented 14.3%. At day one, cases with moderate and severe pain scores presented 0%, while cases with mild pain score presented 14.3%, meanwhile cases with no pain score presented 85.7%. At day two and seven, all pain scores presented 0% except no pain score which presented 100% of cases indicating disappearance of pain. Before Nano p application, there was a statistically significant difference in the severity of pain, but immediately after Nano particles application there was no statistically significant difference till day seven indicating the gradual disappearance of pain. In the photo catalyzed bleaching group (Zoom) who received ACP, before application of ACP, cases with severe pain score presented 57%, while cases with moderate pain score presented 42%, with 0% for both scores of mild and no pain. Immediately after application, cases with severe pain score presented 57%, while cases with moderate pain score presented 42%, with 0% for both scores of mild and no pain. Immediately after application, cases with severe pain score presented 57%, while cases with moderate pain score presented 28.6%, with 0% for both scores of mild and no pain. Meanwhile, cases with no pain score presented 14.3%.

Meanwhile, cases with no pain score presented 0%. At day one, cases with severe pain score presented 0%, while cases with moderate and mild pain scores equally presented 28.6%, meanwhile cases with no pain score presented 42.9%. At day two, cases with severe and moderate pain scores equally presented 0%, while cases with mild pain score presented 14.3%, meanwhile, cases with no pain score presented 85.7%. At day seven, all pain scores presented 0% except no pain score which presented 100% indicating disappearance of pain. Before and immediately after ACP application, there was no statistically significant difference in degree of pain severity, no statistically significant difference between day two and day seven but they were statistically significant from before and immediately after application of ACP, considering day one as a midway in significance between immediately after application and day two. In the chemo catalyzed bleaching group (Dash) who received Nano p, before Nano p application, cases with moderate and severe pain scores equally presented 42%, while cases with mild pain scores presented 0%, meanwhile cases with no pain scores presented 14%. Immediately after Nano p application, cases with severe pain score presented 0%, while cases with mild and moderate pain scores equally presented 42.9%, meanwhile cases with no
pain score presented 14.3%. At day one, cases with severe and moderate pain scores equally presented 0%, while cases with mild pain score presented 14.3%, meanwhile, cases with no pain score presented 85.7%.

Table 3. The frequencies, percentages and results of Friedman's test for comparison between prevalence of hypersensitivity at different follow up periods.

| Group          | Hypersensitivity | Before NP | Immediately after | D1  | D2  | D7  | P-value |
|----------------|-----------------|-----------|-------------------|-----|-----|-----|---------|
| Zoom + NP      |                 | n %       | n %               | n % | n % | n % | <0.001* |
| No pain        |                 | 0.0       | 14.3              | 6   | 85.7| 7   | 100.0   |
| Mild           |                 | 0.0       | 42.9              | 1   | 14.3| 0   | 0.0     |
| Moderate       |                 | 3.0       | 42.9              | b   | 0.0 | b   | 0.0     |
| Severe         |                 | 4.0       | 57.1              | 0   | 0.0 | 0   | 0.0     |
| Zoom + ACP     |                 | 0.0       | 0.0               | a   | 42.9| ab  | 6   |
| No pain        |                 | 0.0       | 42.9              | 1   | 14.3| 7   | 100.0   |
| Mild           |                 | 0.0       | 14.3              | 2   | 28.6| 1   | 14.3   |
| Moderate       |                 | 3.0       | 28.6              | 2   | 28.6| 2   | 28.6   |
| Severe         |                 | 4.0       | 57.1              | 0   | 0.0 | 0   | 0.0     |
| Dash + NP      |                 | 0.0       | 14.3              | 6   | 85.7| 7   | 100.0   |
| No pain        |                 | 14.3      | 14.3              | 4   | 57.1| 6   | 14.3   |
| Mild           |                 | 0.0       | 28.6              | 2   | 28.6| 2   | 28.6   |
| Moderate       |                 | 14.3      | 14.3              | 1   | 14.3| 1   | 14.3   |
| Dash + ACP     |                 | 0.0       | 28.6              | 3   | 42.9| 0   | 0.0     |
| No pain        |                 | 0.0       | 42.9              | 0   | 0.0 | 0   | 0.0     |
| Mild           |                 | 0.0       | 28.6              | 2   | 28.6| 2   | 28.6   |
| Moderate       |                 | 42.9      | 42.9              | 1   | 14.3| 1   | 14.3   |
| Severe         |                 | 42.9      | 42.9              | 0   | 0.0 | 0   | 0.0     |

Superscripts with different letters are statistically significant. P≤0.05.

At day two and seven, all pain scores presented 0% except no pain score which presented 100% of cases indicating disappearance of pain. No statistically significant difference was found at all time intervals till day one, day two and seven showed a statistically significant difference from other time interval indicating gradual disappearance of pain. In the chemo catalyzed bleaching group (Dash) who received ACP, before application of ACP, cases with moderate and severe pain scores equally presented 42%, while cases with mild pain scores presented 0%, meanwhile cases with no pain scores presented 14%. Immediately after ACP application, cases with severe pain score presented 42.9%, while cases with mild and moderate pain scores equally presented 28.6%, meanwhile, cases with no pain score presented 0%. At day one, cases with severe pain score presented 0%, while cases with moderate pain score presented 14.3%, cases with mild pain presented 28.6%, meanwhile, cases with no pain score presented 57.1%. At day two, cases with moderate and severe pain scores equally presented 0%, while cases with mild pain score presented 14.3%, meanwhile, cases with no pain score presented 85.7%. At day seven, all pain scores presented 0% except no pain score which presented...
100% indicating the gradual disappearance of pain. No statistically significant change in pain severity between before ACP application and immediately after application, day one is considered a mid-way between the degree of significance which occurred in the time interval between immediately after application and at day two. Day two was statistically significant from all previous time intervals.

![Figure 1](image.png)

**Figure 1.** Bar chart representing prevalence of hypersensitivity at different follow up periods.

### 4. Discussion

Brighter smile became the latest trend in dental fashion. Thus, bleaching treatment is appealing as this type of treatment is in parallel with the physiology of conservative and minimal invasive dentistry [4]. Dental bleaching can be categorized into three approaches, in-office bleaching with high peroxide concentrations but for short time, at home bleaching with low peroxide concentration but for a long time and over the counter whitening. In the present study, two in-office bleaching products were evaluated in terms of post-bleaching hypersensitivity. A photo catalyzed system (Philips ZOOM), with blue LED light activated technology, is considered a cost effective alternative to laser and halogens as it requires less energy to generate light with less heat production [3]. The other was a chemo catalyzed alternative (Philips Dash), which is claimed by the manufacturer to be formulated for stability and efficacy, eliminating the need for syringe to syringe mixing or refrigeration. These two systems are the products of the same company. The selection of light or chemical activated products might help to reach a proper decision in different clinical situations. Yet remains the choice difficult, as it may be related to the patient’s choice, financial status and the cost effectiveness of both tested techniques.

Post bleaching hypersensitivity is a major drawback following the whitening process which is time dependent as it is an instant problem that disappears by time, however it might force the operator to terminate the whole whitening process. In an attempt to overcome this problem, most in-office bleaching kits now are supplied with desensitizing agents having dual effects of remineralization and desensitization. In the present study, both bleaching kits were supplied with Relief ACP desensitizing agent, which is based on the amorphous calcium phosphate technology. However, the Nano-p is gaining wide acceptance as being biomimetic with nano-sized particles similar to enamel building blocks and paved the way for manufacturers to use it as a remineralizing and desensitizing agent [15,18]. Some studies highlighted its desensitizing effect, but unfortunately, they were done on exposed virgin dentin [14,16] which is not the condition in case of dental bleaching. Additional numerous trials have proven its remineralizing effect [15,19]. Thus, this study was carried out to evaluate clinically post bleaching hypersensitivity of two different bleaching techniques with their corresponding desensitizing agent (ACP) and Nanohydroxyapatite paste.
The selection of patients in this study was done according to inclusion and exclusion criteria [20,21]. In addition, the selection was limited to those having obvious stains A2 or darker [22]. The chief complain of the selected patients was teeth discolorations which hinders their esthetic appearance, self-confidence and esteem [3,11,12]. In this study, “quasi randomization” was done for patient selection using the coin Tossing method (heads and tails) to decide which patients will be in the tested groups [22].

All patients went through primary steps of scaling and polishing before the actual bleaching treatment to ensure a clean, debris free surface that may interfere with pre-operative shade of the teeth. In both bleaching techniques, all patients received three whitening sessions each is of 15 minutes with a total time equals 45 minutes according to the manufacturer instructions. Hypersensitivity was assessed immediately after whitening procedure to monitor the post bleaching sensitivity of each system before applying the desensitizing agent then immediately after application of the desensitizing agent, after 24 hours, after 48 hours and after one week. It was assessed with a light air jet over the labial surface near the root area for one second at a distance from two to five mm to monitor the effect of different desensitizing agents [6]. Being an experience, pain is best assessed by subjective evaluation. This evaluation was done using the visual analogue scale by a qualitative verbal scale (absent, mild, moderate, severe) [3,16,23]. Results of the present study revealed that both bleaching techniques induced post bleaching hypersensitivity. No statistically significant difference was found between both groups. This observation is in line with Mondelli et al. [24], who found no difference in sensitivity between light activated and chemical activated systems after 24 hours. Kossatz et al. [25] also compared the post bleaching sensitivity of 15% hydrogen peroxide with halogen activated 25% hydrogen peroxide and found no difference in sensitivity.

Although the etiology of post bleaching hypersensitivity is not fully understood [3,6,21], hypersensitivity as a result of tooth whitening occur despite the lack of dentin exposure. Different theories are proposed, in accordance with De paula et al. [21], post bleaching hypersensitivity could be attributed to direct activation of the intra dental nerves via chemo sensitive channels which are sensitive to a variety of oxidizing products, including hydrogen peroxide. This assumption was further clarified by Thiensen et al. [26], who claimed that sensitivity after whitening occurs as a result of the functional properties of a chemo-sensitive ion channel called “TRPA1” (transient receptor potential ankyrin 1). This ion channel is associated with the pain caused by oxidants since the afferent fibers of the pulp contain this ion channel so it may be directly involved in the pain. Furthermore, this could explain why the pain after bleaching differs from the pain of normal tooth sensitivity as reported by patients who described the pain ( which is of very short duration and variable frequencies) as sensations that resembled “needles “ or “Shock like” and that were not triggered by thermal stimuli. Many studies reported the presence of acute inflammatory reaction in the dental pulp of human bleached teeth [27]. They suggested that some released mediators of inflammatory reactions such as bradykinin or substance P maybe involved in the etiology of post bleaching hypersensitivity. Basting et al. [28], assumed that the increase in enamel and dentin permeability have paved the way for easy passage of peroxide molecules, triggering the inflammatory reaction. According to Markwotiz et al. [27], hypersensitivity during bleaching is related to the hydrodynamic theory. Free radicals from hydrogen peroxide diffuse through the enamel and dentin, promoting the movement of fluid present in the dentinal tubules, stimulating nerves, and generating sensitivity. Huynh et al. [29] suggested that deep peroxide penetration into the pulp cells may cause pulp inflammation, which in turn leads to the release of cell derived factors such as adenosine triphosphate (ATP), neuropeptides and prostaglandins which excite pulpal nociceptors causing the post bleaching hypersensitivity.

The use of Nano p paste caused immediate significant reduction of post bleaching hypersensitivity with the photo catalyzed bleaching system and diminished the prevalence of severe pain with the chemo catalytic system. This finding is in line with Browning et al. [16] and Vano et al. [30], this could be assumed to three different approaches. First, this product contains potassium nitrate which is according to the neural theory, potassium nitrate is claimed to diminish the excitability of nerve fibers in the dental pulp, and in addition it’s assumed to be responsible for the sustained depolarization of
sensory nerves leading an “axonal accommodation” phenomenon [31-33]. Potassium nitrate is claimed to have a calming effect on the nerves by preventing it from repolarizing after it was depolarized in a pain cycle. It raises the extracellular potassium ion concentration to prevent any action potential by axonal accommodation. Meanwhile, potassium ion concentration above 8 mM to 16 mM (0.08-0.16% as KNO₃) around the axons is needed to sustain nerve depolarization [34,35]. Second, these products which contain Nano hydroxyapatite particles have a high surface area and strong affinity to enamel by strong adsorption [33,36,37]. In case of the photo catalyzed system with minimal surface alterations, the particle size of the Nano hydroxyapatite paste (20-40 nm) could be relatively larger than the surface micro and macro gaps, so it might have only covered the surface, resulting in instant fixation of enamel surface density and covering the surface gaps thus blocking any pathway for any stimuli that might induce post bleaching hypersensitivity according to the hydrodynamic theory. Third, this product contains calcium fluoride crystals which might have induced granular precipitates to block the dentinal tubules and fill the micro porosities induced as a result of enamel alternatives.

Although that the constitutional composition of ACP is in the same line with that of the Nano p, but it took the ACP 24 hours to act on relieving severe hypersensitivity pain cases. It contains potassium nitrate which acts on nerve depolarization. It also contains calcium, phosphate and fluoride compounds which enable them to be in active form once contacted saliva. [38,39] ACP might also induce enamel remineralization and block the dentinal tubules in an attempt to diminish the effect of any stimuli according to the hydrodynamic theory. However, it could be assumed that the form of supply and application might have played an important role as the Nano p is applied in a paste form which is to be scrubbed and left undisturbed on the tooth surface for five minutes according to the manufacturer instructions. This scrubbing action for the paste increased its “thixotropic phenomenon”, which might have enhanced deeper penetration of various items released among which is the potassium nitrate and calcium fluoride thus acting faster in relieving severe hypersensitive pain efficiently. It’s worth mentioning that post bleaching hypersensitivity diminished by time, irrespective of the desensitizing agent used. This might denote that pain alleviation is a time- dependent process.

5. Conclusion
Under the parameters of the given study, it was concluded that the used Nano hydroxyapatite particles showed immediate relief of severe pain in 100 % of the patients with both used bleaching systems, however, the post bleaching hypersensitivity diminished completely in 100 % of the patients after 1 week, irrespective of the desensitizing agent used.

Clinical relevance
The application of Nano hydroxyapatite paste after bleaching is a valid method for diminishing severe post bleaching hypersensitivity when applied with either a photo or chemo catalyzed bleaching agents.

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