International Journal of Medical Science and Clinical Inventions 4(5): 2929-2940, 2017
DOI:10.18535/ijmsci/v4i5.12 **ICV 2015: 52.82**
e-ISSN:2348-991X, p-ISSN: 2454-9576

Research Article

Comparative Evaluation of the Efficacy of In-Office Bleaching (37.5% Hydrogen Peroxide) and At-Home Bleaching (15% Carbamide Peroxide) Using Different Activation Systems.

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ABSTRACT:

INTRODUCTION: The majority of contemporary tooth whitening involves the use of either hydrogen peroxide or Carbamide peroxide as the bleaching agent. A recent increase in the treatment options of discoloured teeth has led to the development of various new techniques and materials. With recent development in bleaching techniques, many auxiliary apparatuses have been introduced for efficient bleaching.

AIM: The purpose of the present study is to compare and evaluate the efficacy of In-office bleaching 37.5% hydrogen peroxide and At-home bleaching 15% Carbamide peroxide using different activation systems.

MATERIALS & METHODS: Total of 80 freshly extracted human incisor teeth were selected, sectioned below CEJ and further stained using extra strong black tea and kept for 24 hours. The samples were thoroughly washed and cleaned of external stains and evaluated for pre-shade using spectrophotometer. Samples were divided into groups and bleached using different concentrations, methods and activation systems. Post shades were evaluated and the samples were subjected to statistical analysis.

RESULT & CONCLUSION: Carbamide peroxide (15%) used in home bleaching is as effective as 37.5% hydrogen peroxide. On comparing in-office (37.5% hydrogen peroxide) with at-home (15% carbamide peroxide) it can be concluded that home bleaching with higher concentration of carbamide peroxide resulted in a better shade change. 37.5% hydrogen peroxide along with Laser activation resulted in superior immediate results but showed increased rebound of color after 1 week.

KEYWORDS- Spectrophotometer, 15% Carbamide Peroxide, 37.5% Hydrogen Peroxide, Epic Biolase, Rebound effect, In-office bleaching, At-home bleaching, Intrinsic stains, Extrinsic stains.

INTRODUCTION

"Smile is a curve that sets everything straight", **Phyllis Diller**

A recent increase in the treatment options of discoloured teeth has led to the development of various new techniques and materials. Thorough knowledge about the etiology of the discoloration has a profound effect on the treatment outcomes.

According to a study conducted by **Samorodnizky-Naveh,** among 37% of the patients are dis-satisfied with their dental appearance, out of which 90% have discoloration as the major reason of concern.

Any change in the structure of teeth is likely to cause an alteration in the appearance of the tooth. This may be caused due to changes in the light reflecting and transmitting properties of the tooth structure. The causes of tooth discolouration **(figure 1)** can be broadly classified on the basis of **location of the stains**, [A] Extrinsic or [B] Intrinsic.3 Discolorations which are located on the outer surface of the tooth are referred to as extrinsic stains. While discolorations caused by deeper internal stains or stains taken up by the enamel or dentin are referred to as intrinsic stains.

Tooth discoloration can be defined as, "**Any change in the hue, colour, or translucency of a tooth due to various causes such as food and beverages, tobacco, chromogenic microorganisms, restorative materials, aging, pulpal necrosis or haemorrhage, drugs systemic diseases such as porphyria, erythroblastosis fetalis etc".**

Tooth color can be improved by a number of methods and approaches including whitening tooth pastes, professional cleaning by scaling and polishing (to remove stain and tartar), internal bleaching of non-vital teeth, external bleaching of vital teeth, micro-abrasion of enamel with abrasives and acids, placement of crowns and veneers.8 among all, bleaching has been recognized as a simple, easy, most effective and well accepted method for treating discoloured teeth.

Bleaching is a de-colorization or whitening process that can occur either in solution or on a surface.8 According to **AMERICAN DENTAL ASSOCIATION "Dental Bleaching is a treatment modality involving oxidative chemical reactions that alter the light absorbing and or reflecting nature of a material structure, thereby increasing its perception of whiteness"**.

A number of methods and approaches have been described for the bleaching of vital teeth.

Various bleaching techniques can be broadly divided as:

A. Vital teeth:

a. In-office or Power bleaching

b. At-home or Dentist supervised night-guard bleaching

c. Over-the-counter (OTC) bleaching products

B. N**on-vital teeth:** There are numerous bleaching techniques available

a. Walking bleach & Modified walking bleach

b. Non-vital Power bleaching

c. Inside/Outside bleaching

The majority of contemporary tooth whitening involves the use of either hydrogen peroxide or Carbamide peroxide as the bleaching agent. In-office bleaching utilizes a higher concentrations of tooth- whitening agents (25-40% hydrogen peroxide), whereas at home bleaching basically involves the use of a lower concentrations of whitening agents (10-20% Carbamide peroxide, which releases 3.5-6.5% of hydrogen peroxide). Other potential vital tooth bleaching products include sodium perborate, per-oxy-mono-sulphate, peroxide plus metal catalyst, and oxy-reductase enzymes.

With recent development in bleaching techniques, many auxiliary apparatuses have been introduced for efficient bleaching. Light sources both coherent and incoherent have been used for tooth bleaching (arc/plasma lamps, halogen lamps, LED's, lasers).

Rebound effect after the tooth bleaching is a phenomenon associated with the regression of tooth whitening. Long term stability of bleaching is the most uncertain aspect. The first six months is marked for the initial colour regression resulting in a shade change which is mainly due to the demineralization and re-mineralization processes occurring during and post bleaching processes.

Shade matching is undoubtedly highly technical with an unpredictable outcome. It can be improved by a proper understanding of the variables that influences the colour perception, such as light source, environment and clinician. Various standardized shade guides like, Vitapan classical (CV), Vita Bleachedguide 3D-master, etc for the measurement of the tooth shade have been developed to assist the process of shade selection.

As a recent development in the field of shade selection, the Spectrophotometers are amongst the most accurate, useful and flexible instruments for overall colour matching. Easy shade spectrophotometer (Vita Bad Säckingen, Germany) is a self-contained, portable, digital shade matching device, simple in use and gives efficient accurate shade. They measure the amount of light energy reflected from an object at 1–25 nm intervals along the visible spectrum. A spectrophotometer contains a source of optical radiation, a means of dispersing light, an optical system for measuring, a detector and a means of converting light obtained to a signal that can be analysed.

The purpose of the present study is to compare and evaluate the efficacy of In-office bleaching 37.5% hydrogen peroxide and At-home bleaching 15% Carbamide peroxide using different activation systems.

The null hypothesis of the study is that, there would be no difference in the shade and the bleaching index among any of the groups at any given time interval and also there would be no difference between various activation systems used for the bleaching procedure.

MATERIAL AND METHODS

A total of eighty freshly extracted human incisor teeth were collected from the department of oral surgery, Manav Rachna Deantal College. Teeth were thoroughly cleaned using ultrasonic tips. All the teeth were decoronated 2-3mm below CEJ using straight handpiece and mandrel, so as to stabilize the teeth on a silicon putty base. All the teeth were stained using extra strong black tea and the samples were stored in the solution for 24 hours. Following staining, 3mm buccal window was prepared using nail varnish for standardization of the surface. Bleaching tray was fabricated for at home bleaching procedure. Two arches for ten samples each were prepared for the fabrication of trays using polyvinyl acetate sheets and vacuum moulding unit. For in-office bleaching samples were mounted on individual putty moulds for shade evaluation and bleaching procedure. All the samples were evaluated for pre shades. The samples were randomly divided into four groups based on the technique used and the different activation systems. Group I was at home bleaching group that used 15% carbamide peroxide as the bleaching agent. Bleaching procedure was carried out for 14 days with 4 hours sessions daily. Group II was in-office group that used 37.5% hydrogen peroxide as the bleaching agent. In-office group was further divided into three groups based on the activation systems. Group IIa which was Laser activated and the bleaching cycle was performed for 4 sessions of 15 minute each with 30 seconds of laser activation. Group IIb was LED activated and the bleaching cycle was performed for 4 sessions of 15minute each with 40 seconds of LED activation. Group IIc was chemically activated and the bleaching cycle was performed for 4 sessions of 15 minute each and without any activation system. Once the bleaching was done, the shades for each sample was evaluated using spectrophotometer at 1 day, 3 days and 1 week post bleaching

The spectrophotometer was used to measure only the central area on a tooth (**Basic shade measurement)** for each sample. This system was defined by the International Commission on Illumination in 1967, L* represents the value (lightness or darkness), a* is a measure of redness (positive a*) or greenness (negative a*); b* is a measure of yellowness (positive b*) or blueness (negative b*). CIE L*a*b* values based on Rectilinear Cartesian co-ordinate system were recorded before the bleaching procedure.

Readings were calculated using the **ΔE*** values for each individual sample.

$$\Delta E^* = [(\Delta L^*)2 + (\Delta a^*)2 + (\Delta b^*)2]1/2$$

STATISTICAL ANALYSIS

The results were subjected to statistical analysis to determine the shade change ΔE at different time intervals. Also, the efficacy of at home bleaching was compared with in office bleaching techniques

All the data was tabulated and statistical tests were performed using the statistical package for the social science SPSS version 18.0. Oneway ANOVA was applied to compare the mean values between the groups. Paired T-test was done to evaluate the relative change within the group.

RESULT

On comparing the effectiveness of shade change (ΔE - ΔE1) between group I (at home) and group II (in office), group II appeared to show a higher mean value (9.76) than group I (6.17), suggestive of an increased shade change of group II than group I, although the results were statistically non significant. (p=0.063) **(Table 1)**

Shade change		N	Mean	Std. Deviation	t-value	p-value
Delta E(pre shade) - E1 (Post 1 day shade)	Group I (at home)	20	6.17	6.87	1.884	0.063
	Group II (In Office)	60	9.76	7.54		

p-value <0.05 - significant

Table 1: Comparison of the bleaching effectiveness between the Group I (at home bleaching) and Group II (in-office bleaching) after 1 day post bleaching (ΔE-ΔE1)

On comparing the effectiveness of bleaching obtained between Group I (at home) and three different in office groups: Group IIa (laser activation), Group IIb (LED activation), Group IIc (chemically activated) after 3 days post bleaching (ΔE- ΔE2), the least mean value (-11.765) was of group I with group IIa and the highest mean value (5.83) was of group IIa with group IIc after 3 days post bleaching procedure. **(Table 2)**

Shade change	(I) Group	Mean values	(J) Group	Mean values	Mean Difference (I-J)	p-value
Delta E(pre shade) - E2 (Post 3 day shade)	Group I	3.56	Group IIa	15.33	-11.76500*	<0.001
			Group IIb	10.55	-6.98500*	0.009
			Group IIc	9.50	-5.93500*	0.036
	Group IIa	15.33	Group IIb	10.55	4.78	0.126
			Group IIc	9.50	5.83000*	0.04
	Group IIb	10.55	Group IIc	9.50	1.05	0.961

p-value <0.05 – significant

Table 2: Comparison of the bleaching efficacy between Group I (at home bleaching) and various in office groups Group IIa (LASER activated), Group IIb (LED activated), Group IIc (Chemically activated) post 3 day (E2) after the bleaching procedure.

DISCUSSION

The smile is considered to be indispensable for communication, and thus people's craving for white teeth have forced dentists to seek solutions that satisfy patient's expectations for an aesthetically pleasing smile. 72

Haywood & Heymann et al 1989, concluded that some stains are more responsive to bleaching process than others giving variable results.4 Yellowish and brown fluorescence stains are the most responsive to bleaching process, whereas blue grey stains are the slowest (*Haywood et al 2000,1991,1994* and *Leonard et al 2000)* 4 .

The international organization for standardization (ISO) defines tooth bleaching as "removal of intrinsic or acquired discolorations of natural teeth through the use different concentrations of bleaching agents, sometimes used in combination with the application of auxiliary lights. 10 Bleaching is an oxidative process that alters the light absorbing or light reflecting nature of the tooth increasing its perception of whiteness.

Carbamide peroxide and Hydrogen peroxide are the active ingredients used in tooth bleaching process regardless of the bleaching technique used. Chemically, a 10% concentration of carbamide peroxide is composed of approximately 3.5 parts of H2O2 and 6.5 parts of urea. Hence, H_2O_2 is considered as the true active ingredient used in case of tooth bleaching. 60 Various concentrations of tooth bleaching materials are being used, ranging from 25% to 40% for in-office bleaching while 3% to 20% for at-home formulation.10 A comparatively higher concentrations of Hydrogen peroxide and Carbamide Peroxide are used in case of in-office bleaching as compared to the concentrations used for home bleaching techniques. Higher concentration light sensitive bleaching agents used with in office bleaching aids in reducing the time required to achieve the expected results and also decreases the failure possibility.73 Lower concentrations of bleaching agents used with at home bleaching provides a slower release of active, oxidizing ions resulting in more effective and long lasting bleaching impact. 62

Various bleaching techniques have been reported since the introduction of whitening process in 1889. Two of the most applied approaches in the tooth bleaching treatment are in office bleaching and at-home (night guard) bleaching techniques. Latimer in 1868 used oxalic acid for bleaching of vital teeth as in-office bleaching procedure which was later replaced by hydrogen peroxide in 1911 by Fisher.1 The present in-office bleaching materials uses a light sensitive, higher concentration ranging from 15% to 40%, with or without the use of auxiliary light used in the presence of rubber dam isolation (*Haywood 2000, Ontivero 2011).4*

These are being performed in a single appointment thus reducing the time required to reach the expected results and also decreasing the failure possibilities.

The home bleaching technique, introduced in 1989 by Haywood & Heymann, involves self-application of 10-22% Carbamide peroxide, in a customized plastic tray, used nightly for approximately 6 to 8 hours, for a period ranging between 2 to 6 weeks. 59 *Mahony et al 2003*, stated that peroxide is released slowly for up to 4 hours after the application of the gel providing a significant tooth color improvement. 8

‘‘Over-the-counter’’ (OTC) bleaching agents were launched in the United States in 1990s, containing lower concentrations of hydrogen peroxide or carbamide peroxide and for home use by the consumers directly *Greenwall et al., 2001*. 4

The main oxidizing agents used are hydrogen peroxide of 30-35% and carbamide peroxide of 10-22%. 11 These chemical substances break down into oxygen molecules and the free radicals are generated which splits long-chained dark coloured molecules into lighter molecules. Consequently, the tooth appears to be whiter.49 Many efforts have been made for increasing the rate of reaction and accelerate the decomposition of hydrogen peroxide, including physical activation (heat or light), chemical activation and even the dual activation methods. 54

Many different light sources both coherent and incoherent have been used for tooth bleaching (arc/plasma lamps, halogen lamps, LED’s, laser’s). Light accelerates the whitening process in terms of photolysis and thermo-catalysis. Photolysis of HP occurs by high frequency light with wavelengths of 365nm or less. Most commercially available light sources (lamps) fall within the visible spectrum. Whereas thermocatalyst bleaching involves transmission of heat energy for the degradation of peroxide and therefore is considered the main action of light activated bleaching. 54

In order to optimize the benefits of light activation, pigments with beta carotene, urucum (B. orellana) and others are added to the bleaching products to absorb the specific wavelength emitted by the device, reducing the non-absorbed quantity of energy and thus augmenting the device efficiency. 31,53

According to a study conducted by Wetter et al 2004, the use of light source accelerates the chemical decomposition of hydrogen peroxide, hence achieving whiter smile in a short period of time.5

In an another study carried out by *Buchalla* & *Attin et al* concluded that, the use of light as an adjunct for the bleaching procedure limits the efficacy of bleaching agents, while accelerating the process, and thus producing heat.74 This raises the intra-pulpal temperature and increases the 62 penetration of the peroxide into the pulp chamber, leading to oxidative stress with negative effects on cell metabolism and finally resulting in pulpal necrosis. 72

Lasers have an added advantage of being quick and have minimal or no after treatment sensitivity or gingival irritations that is often encountered with the incoherent light sources. In case of pulsed mode operated lasers decreased gingival irritation and minimal tooth sensitivity are the most apparent features, as the laser beam being transmitted is in the form of packs of energies projected in very short time intervals, thus giving enough time for heat dissipation to the tissues. 11 This photo-thermal bleaching effect is used by the diode (810nm or 980nm) and Nd:YAG Laser (1064nm). As the recent advancements for effective bleaching results, photo-initiators or dyes are incorporated in the bleaching agents, which are adjusted to absorb the wavelength of the light source used.

In late 1990, a new commercially available instrument based colour measurement system was being introduced as Shade Scan System (Cortex Machina). The most commonly used are Vitapan Classical (Vita Zahnfabrik) shade guide system with the advancement of Vitapan 3D Master shade guides, tooth shade guides, bleach guides, increasing the predictability of shade matching.

As a most recent in this field, Vita EasyShade Compact Spectrophotometer is being developed by Vita Zahnfabrik, Germany in 2002. Spectrophotometer are amongst the most accurate, useful and flexible instruments for overall colour matching. They measure the amount of light energy reflected from the object at 1-25nm intervals along the visible spectrum. Spectrophotometer has various components that help in the evaluation of the shade. These include a source of optical radiation, a means of dispersing light, an optical system for measuring, a detector and a means of converting light obtained from a signal that can be analysed. The data obtained 63 from the spectrophotometers must be manipulated and translated into a form useful for dental professionals.14, 57

Epic 10 BIOLASE diode laser was used in the study which is a IV generation laser, having a wavelength of 940± 10nm and maximum power output of 10 watt. The Laser worked in a continuous pulsed mode with a pulse duration of 0.01ms – 20ms. This diode laser works under the InGaAaP Semi-conductor medium.

In a study conducted by *Dostalove et al 2004*, the use of laser is the most valuable energy source for power bleaching even with simple and short applications. The diode laser employs a solid state semiconductor that uses a combination of aluminium, gallium and arsenide to change electric energy into light energy. 62

Diode laser with the power setting of 10 watt and with activation time of 30 seconds was used as it provides the most effective bleaching without raising the intrapulpal temperature and can be used as a single visit bleaching process. 20

In the present study four cycles of 15 minute each was used for in office bleaching groups along with the different activation systems.

According to a study conducted by Aushill et al, it was concluded that 3.15 cycles of 15 minute each was necessary to

achieve the desired six Vita Shade Guide tab changes with in-office bleaching. 53

Use of spectrophotometer: Vita Easyshade Compact (Vita Zahnfabrik, Germany) used in the study, is a cordless, portable, cost efficient, battery operated, contact type spectrophotometer that provides enough information to 64 help aid in the colour analysis. In this different measurement modes are available:

i) tooth single mode

ii) tooth area mode (cervical, middle and incisal shades)

iii) restoration colour verification (includes lightness, chroma and hue comparison)

iv) shade tab mode (practice / training mode)

In a study performed by *Horn et al 1998*, it was concluded that spectrophotometers achieved 80% reproducibility of tooth shade than as compared to human eye which showed only 65% reproducibility.

The only disadvantage of using spectrophotometer is the convex surface of the tooth which complicates the correct placement of the probe tip hence making shade evaluation difficult.

In a study conducted by *Li et al 2010*, they concluded a positive correlation between the rebounding of mineral density of the tooth and degree of lightening. With at-home bleaching technique teeth receives a continual application of hydrogen peroxide during which the demineralization and re-mineralization processes interacts. While in power bleaching, the primary colour regression is a result of reversal of whitening which is due to just the re-mineralization process. 55

Hence the shade evaluation is delayed by at least 2 hours after the completion of the bleaching process rather than immediately thereafter. Even though the time is insufficient for the re-mineralization but any further delay in colour evaluation leads to regression of whitening and thus interferes with the true results. 55

Few studies have used third molars 31,35 premolars 73 lateral incisors 60 and canine 20 for the bleaching. Teeth were selected in the present 65 study because incisors provide a flat surface which helps in the preparation of a 3mm window on the buccal surface. 30 Teeth were stored in artificial saliva, i. For the re-mineralization of the bleached specimen (A*ttin et al 2000),* ii. Saliva is considered as an important factor in the formation of tooth staining. 18 The teeth in the present study were stained using extra strong black tea. 75,76 The tea was selected as extra strong black tea as it has a potential to cause deep and intense staining. This procedure of staining is explained by Sulieman et al, referred to as Sulieman's method.31,8 Many other staining agents used in studies are whole blood, coffee, red wine, coca-cola, hemolysate solution etc. 62

CONCLUSION

Within the limitations of the present experimental study it can be concluded that:

- Carbamide peroxide (15%) used in home bleaching is as effective as 37.5% hydrogen peroxide
- The in office bleaching treatment of vital teeth with 37.5% hydrogen peroxide showed comparatively better results immediately and post 1 day after the bleaching process.
- On comparing in-office (37.5% hydrogen peroxide) with at-home (15% carbamide peroxide) it can be concluded that home bleaching with higher concentration of carbamide peroxide resulted in a better shade change.
- Use of auxiliary light source fastens the bleaching process and also showed better immediate results.
- 37.5% hydrogen peroxide along with Laser activation resulted in superior immediate results but showed increased rebound of color after 1 week.
- Among all the activation groups chemically activated 37.5% hydrogen peroxide showed better results even after 1 week post bleaching and documented no significant rebound.
- The activation using LED source when used with in office treatment with 37.5% hydrogen peroxide showed better results at 1 week post bleaching evaluation than Laser activation group.

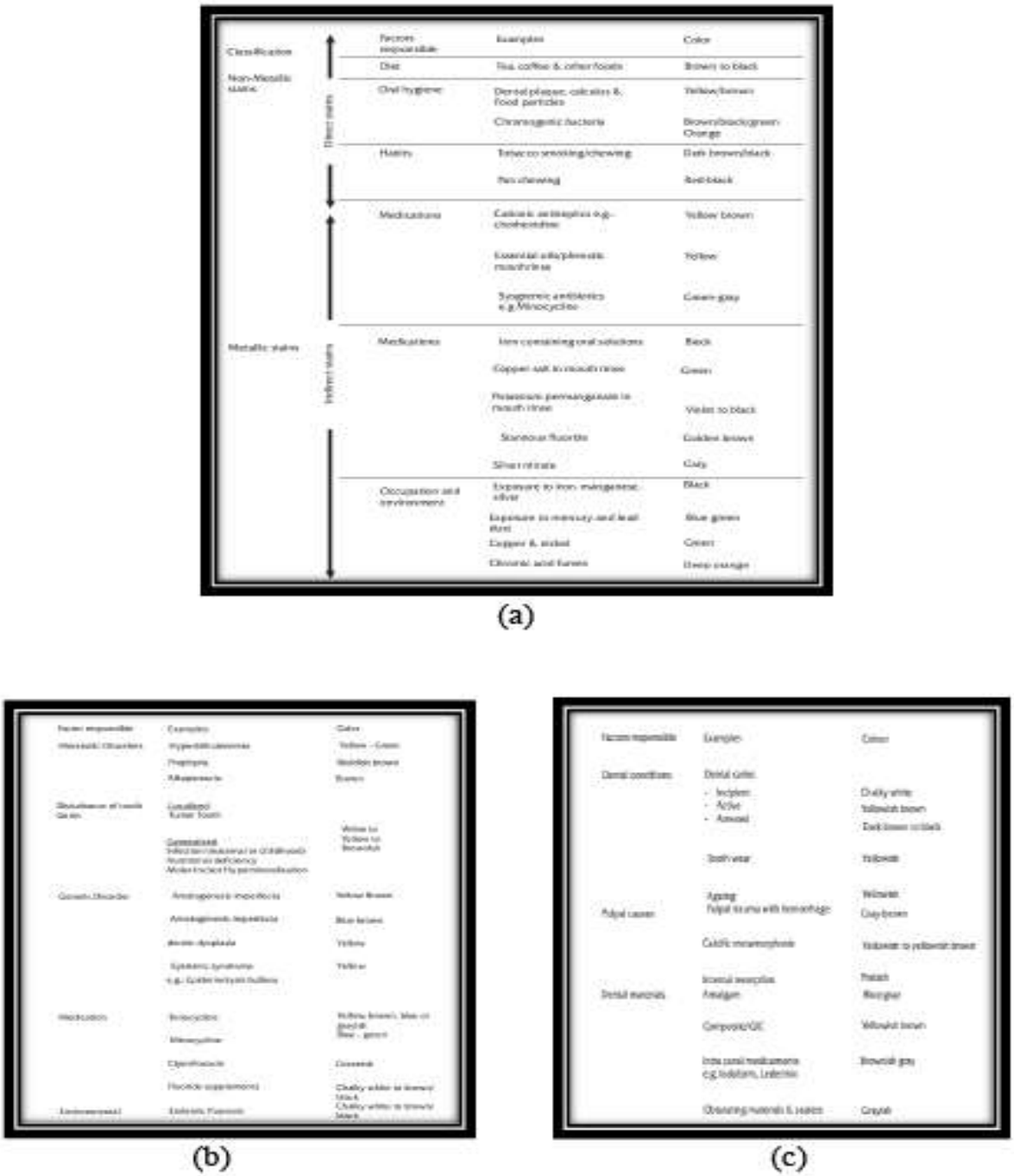

Figure 1: Causes of discolouration

(a) Extrinsic causes;

(b) Pre-eruptive intrinsic causes; (c) post-eruptive intrinsic causes

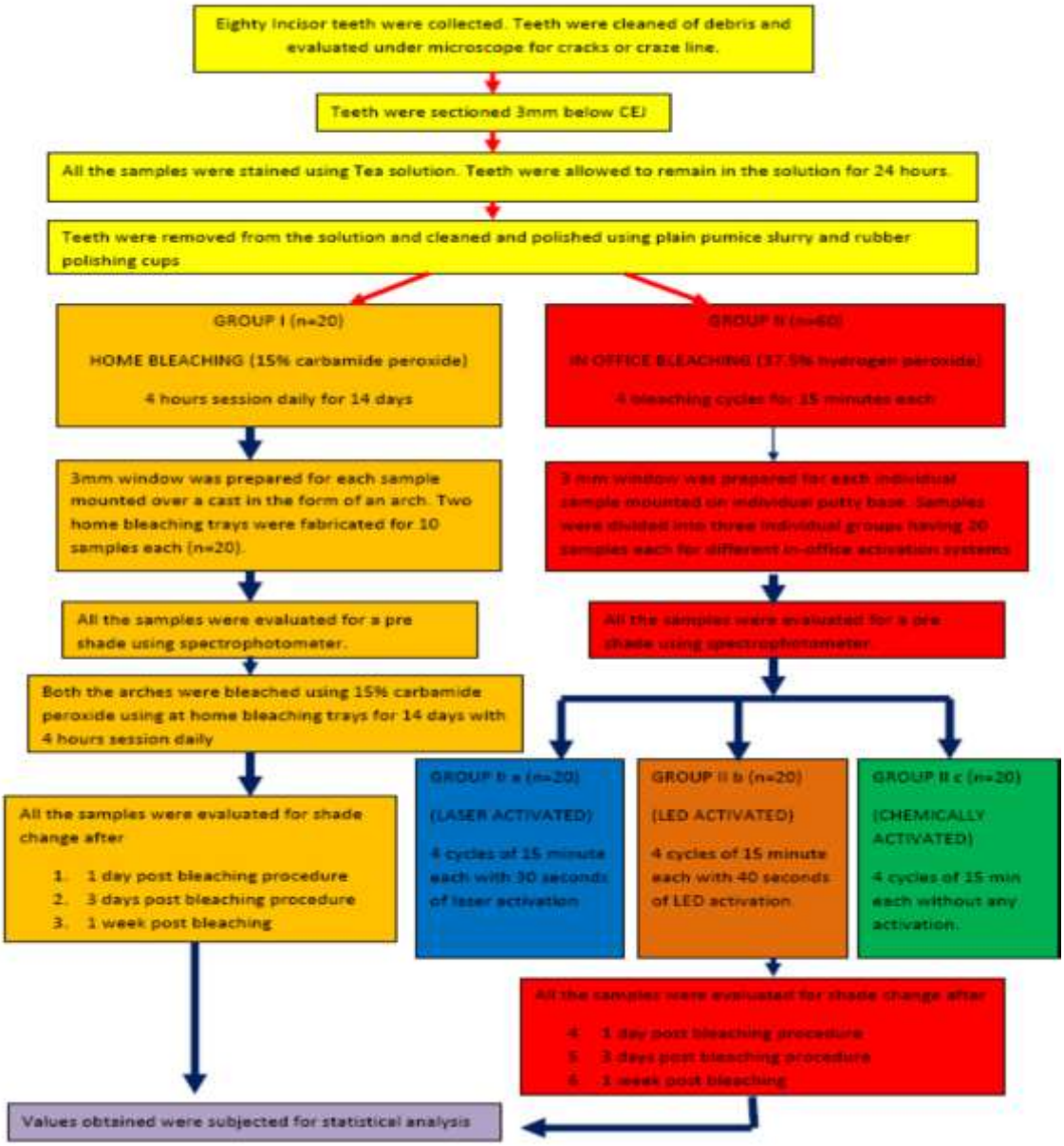

Figure 2: methodology

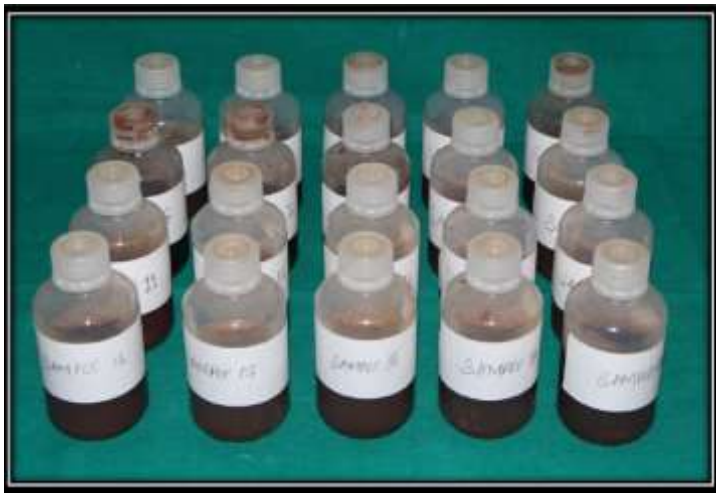

Figure 3: Bleached samples

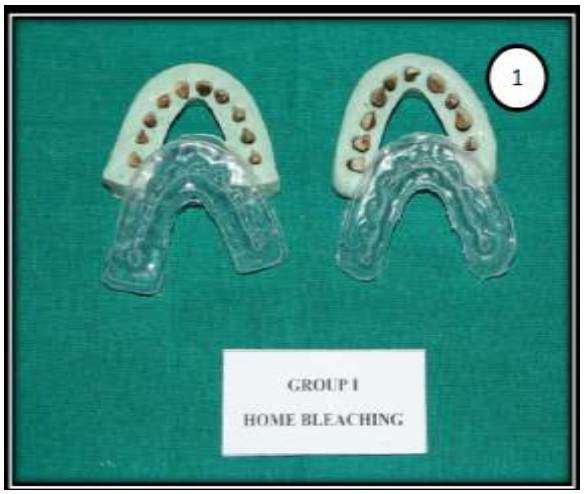

Figure 4: Home Bleaching group with bleaching tray

Figure 5: Bleaching materials (6)- opalescence 15%, (7)- 37.5% Pola office plus

Figure 6: armamentarium for in office bleaching using Laser activation

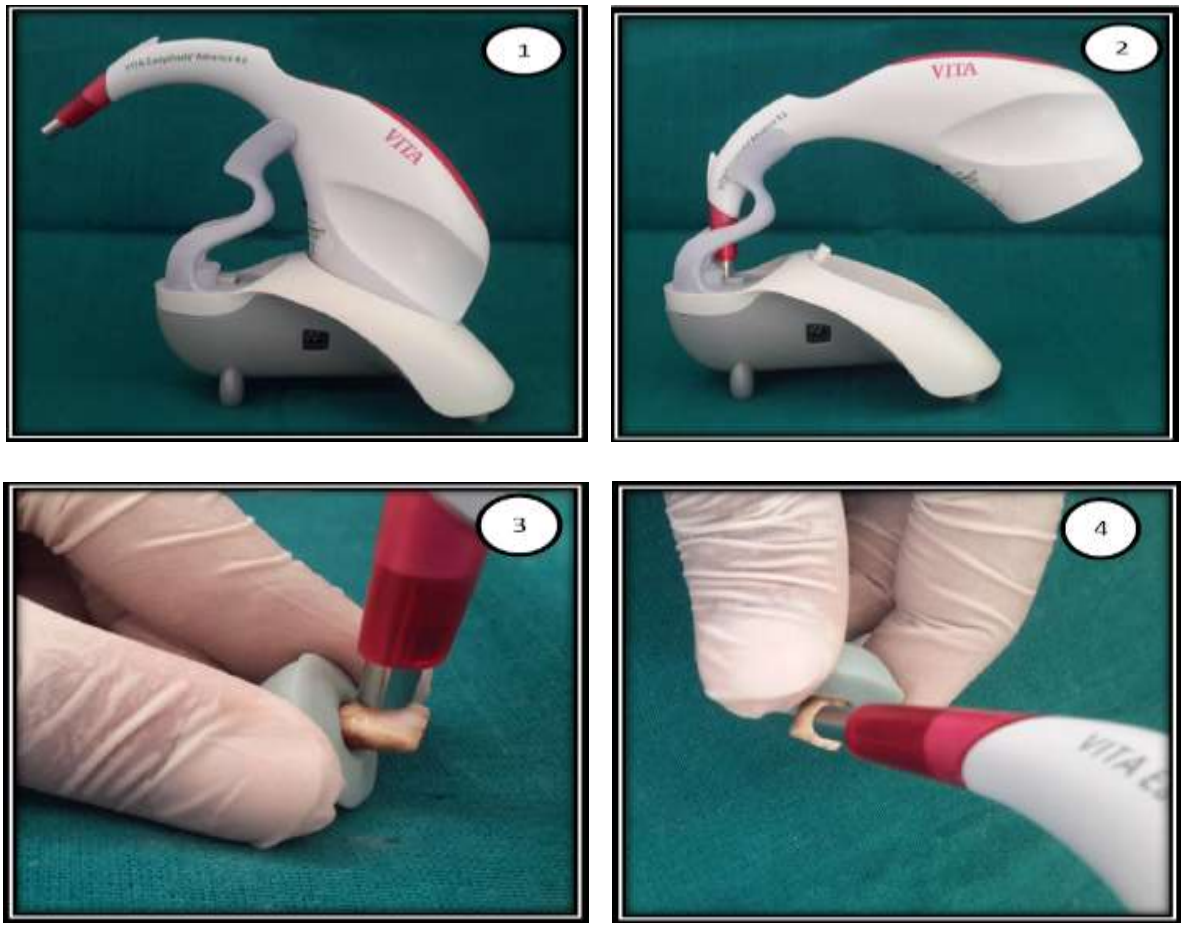

Figure 7: Spectrophotometer

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