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Physical properties of root canal sealers

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Abstract:

Aim: The aim of this study was to evaluate the physicochemical properties(S.T, film thickness, dimension stability, PH and solubility) ofBoswellic Acid as a root canal sealer and compare it to four different commercial types of sealers(Endofill,AH plus, MTA fill-apex,Endosequense).

Methods: The endodontic sealers investigated in this study were Endofill, AH plus, MTA fillapex, Endosequence and Boswellic Acid sealer. The sealers were mixed according to the manufacturer's instructions.For experimental BA sealer preparation Tricalcium silicate has been prepared by solid state reaction. Setting time, film thickness, dimensional stability, PH and solubility after setting for tested sealers were measured according to ANSI/ADA standards for dental root canal sealing materials by one examiner blinded to the identification of the materials.Five specimens from each group were tested and the means were statistically compared.

Results: All results of tested sealers (Endofill, AH plus, MTA fill-apex, Endosequence and BA sealer) were matching physical characteristics according to ANSI/ADA specification no. 57.

Conclusion: The experimental sealer based on Boswellic Acid presented satisfactory results in the physicochemical tests required by the ANSI/ADA specification no. 57.

Introduction

The main goals of root canal sealers are sealing of patent accessory canal, forming a bond between the core filling material and the root canal wall, and act as a lubricant to facilitate the placement of the filling core material. In order to reach that goals, sealer should have ideal physical properties such as; good flow , proper film thickness, suitable PH and proper setting time. Also sealer has to be dimensionally stable in order to prevent marginal micro leakage. Various of root canal sealers with different formulas and components are available in the market. Both physical and chemical properties are one of the most important factors affecting the choice of the root canal sealer material[1,2]. Despite the great variety of root canal sealers, there is still no material which fulfills the ideal requirements of the American National Standards Institute/American Dental Association (ANSI/ADA). Thus, the development of new root canal sealers with adequate physico-chemical and biological properties is crucial[3].

The field of phytotherapy has shown a remarkable advance in recent years, which has stimulated the investigation into different herbal products with potential therapeutic properties for dental applications. Boswellia serrata is one of the ancient and most valued herbs. It is a moderate to large sized branching tree of the family Burseraceae (Genus Boswellia) that grows in dry mountain regions of India, North Africa and Middle East[4].

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Recently, modern medicine and pharmacology pointed out the use of Boswellia extracts as an anti-inflammatory, anti-bacterial, analgesic, anti-arthritic, anti-atherosclerotic and hepatoprotective. This valuable herb also can be used in skin and blood diseases, mouth sores, bronchitis, ashma and as antipyretic[5].

In (2018) Badria et al. evaluated the biocompatibility , anti- inflammatory and antimicrobial effects of boswellic acid (BA) in comparison to conventional and common root canal irrigants and intracanal medications; e.g. sodium hypochlorite, CHX, calcium hydroxide ,TAP, DAP and Ledermix. They concluded that BA showed to be biocompatible with strong anti-inflammatory and antimicrobial activities when compared to other commonly used irrigants and medications. Therefore this study proposed a new efficient and safe irrigant and medicament[6].

The properties of root canal sealers can be divided into the following categories: physicochemical, antimicrobial, and biological. When studying the ideal properties of a filling material, it is possible to establish research parameters for the development of new products and to evaluate those already existing on the market, thus achieving better clinical results in clinical practice[7].

In this context, it is important to study the properties of the filling materials in order to establish the appropriate parameters for the development of new products, as well as to evaluate those already available on the markets.

Review of literature

1. Importance of endodontic sealers:

The main functions of root canal sealers are (i) sealing off of voids, patent accessory canals, and multiple foramina, (ii) forming a bond between the core of the filling material and the root canal wall, and (iii) acting as a lubricant while facilitating the placement of the filling core and entombing any remaining bacteria[8]. Due to the relative biological and technical importance of sealers, their chemical and physical properties have been the subject of considerable attention since their initial development in the early twentieth century. Sealers are categorized according to their main chemical constituents: zinc oxide eugenol, calcium hydroxide, glass ionomer, silicone, resin, and bioceramic-based sealers[9].

2. Ideal Root Canal Sealer Properties:

Biocompatibility:

Biocompatibility is an essential requirement of any root canal sealer as the root filling material constitutes a true implant coming into direct contact with the vital tissue at the apical and lateral foramina of the root or indirectly via surface restoration[9].Biocompatibility is defined as the ability of a material to achieve a proper and advantageous host response in specific applications[10].In other words, a material is said to be biocompatible when the material coming into contact with the tissue fails to trigger an adverse reaction, such as toxicity, irritation, inflammation, allergy, or carcinogenicity[11]. Most studies assess biocompatibility through investigations of cytotoxicity, in reference to the effect of the material on cell survival.

.Setting Time

The ideal root canal sealer setting time should permit adequate working time. However, a slow setting time can result in tissue irritation, with most root canal sealers producing some degree of toxicity until being completely set. While the normal setting time is four hours, in patients with particularly dry canals, the setting time might be considerably longer [12].The amount of moisture present in the dentinal tubules of the canal walls can be affected by absorption with paper points [13].the presence of smear plugs, or tubular sclerosis[14].

Flow

Flow is an essential property that allows the sealer to fill difficult-to-access areas, such as the narrow irregularities of the dentin, isthmus, accessory canals, and voids between the master and accessory cones[15].According to ISO 6786/2001[16].a root canal sealer should have a flow rate of not less than 20 mm. Factors that influence the flow rate of the sealer include particle size, temperature, shear rate, and time from mixing. The internal diameter of the tubes and rate of insertion are considered when assessing flow rate via the Rheometer method[9].

Solubility

Solubility is the mass loss of a material during a period of immersion in water. According to ANSI/ADA Specification 57 [17].the solubility of a root canal sealer should not exceed 3% by mass. A highly soluble root canal sealer would invariably permit the formation of gaps within and between the material and the root dentin, thereby providing avenues for leakage from the oral cavity and periapical tissues[9].

Antimicrobial Properties

The antimicrobial activity of a root canal sealer increases the success rate of endodontic treatments by eliminating residual intraradicular infections that might have survived root canal treatment or have invaded the canal later through microleakage[20,21].According to the literature, the key antimicrobial properties of root canal sealers lie in their alkalinity and release of calcium ions which stimulates repair via the deposition of mineralised tissue [22].

Adhesion

Root canal sealer adhesion is defined as its capacity to adhere to the root canal dentin and promote GP cone adhesion to each other and the dentin [23].**Tagger et al** argued that the term adhesion should be replaced with bonding in the case of root canal sealers because the attachment between the substances involves mechanical interlocking forces rather than molecular attraction[24].. There is no standard method used to measure the adhesion of a sealer to the root dentin; therefore, the adhesionpotential of the root filling material is commonly tested using microleakage and bond strength tests [25]..The sealing ability of a sealer is related to its solubility and to its bonding to the dentin and root canal filling cones.

PH

the pH change of sealers may be related withantimicrobial effects and deposition of mineralized tissue, thus playing a role in the healing process [26].Alkaline pH of root canal sealers could neutralize the lacticacid from osteoclasts and prevent dissolution of mineralized components of teeth [22].

Film thickness

Sealer thickness is one of the A fundamental factor because of the tendency of sealers to shrinkand dissolve over time. Low sealer thickness is preferredover high thickness as low thickness enhances the long-term sealing ability of root filling materials[27].

Dimensional stability;

Dimensional change demonstrates the shrinkage or expansion of the material after setting in percentage. Dimensional changes of root canal sealers over time may introduce gaps and channels along the sealer/GP or sealer/dentin interface, channels which may be large enough to permit micro-organisms to pass along the spaces. Polymerization shrinkage of ZOE-based sealers can lead to stress development on root canal walls, resulting in marginal gaps, microleakage, and clinical failures. Forces of polymerization shrinkage can exceed its bond strength to root dentin, permitting debonding on one side of the root canal filling to relieve stress.

All the sealers which are used for obturation inherently shows shrinkage behavior during setting, this shrinkage associated with setting might jeopardize the seal of root canal, leading to root canal failure[28].

Physical properties of zinc oxide based sealers:

Kazemi et al 1993, compared the dimensional changes of endodonticsealers of diverse properties. AH26 and Endo-Fill had an initial expansion followed by a volumetric loss. The two zinc oxide eugenol-based sealers studied started to shrink within hours after mixing; the first volumetric loss for AH26 was recorded during the first 30 days and for Endo-Fill after 30 days. The least dimensional change at any time was observed for Endo-Fill. It was concluded that a significant dimensional change and continued volume loss can occur in some endodontic sealers[29].

Ørstavik et al 2001,evaluated a method proposed for measuring dimensionalchanges of endodontic sealers, and to assess the dimensional changes of 11 commercial sealers after prolonged storage in water. For most materials, thegreatest dimensional changes took place within the first 4 weeks. Zinc-oxide-eugenol based sealersgenerally showed shrinkage ranging from 0.3 to 1%, while the epoxy-based materials, AH 26 and AH 26 silverfree, exhibited a large, initial expansion of 4-5%. AH Plus expanded from 0.4% after 4 weeks up to 0.9%[30].

Physical properties of resin based sealers:

Allan et al 2001, determined the set of sealers under simulated clinical versus bench-top conditions. One hundred twenty extracted teeth were divided into four groups (Roth's, Tubuliseal, Sealapex, AH26).. In conclusion, underclinical conditions, sealers set slowly (particularly Roth's) and were more delayed than when tested in vitro[34].

Nielsen et al 2006,eleven sealers, including Resilon sealer, were mixed according to manufacturer's instructions. Setting times were determined in both aerobic and anaerobic environments. All samples were tested for setting times with a Gillmore needle at 15, 30, and 60 minutes, then hourly up to 8 hours, then at 24, 48 and 72 hours, and then weekly up to 3 weeks. Ketac Endo and Kerr Tubliseal, were the fastest sealers to set in aerobic environments. Ketac Endo and Resilon were the fastest sealers to set in anaerobic environments[35].

Razmiet al 2010, compared the setting time and post-setting solubility, flow, film thickness and dimensional changes of AH26 root canal sealer with AH26-Antibiotic combination. The physico-mechanical properties of AH26 antibiotic combinations were superior compared with AH26, with the exception of flow. Also, AH26/amoxicillin had a lower setting time than AH26. However, all values were within an acceptable range which conformed to ISO[36].

Faria-Júnior et al 2013, evaluatedantibiofilm activity against Enterococcus faecalis, pH and solubility of AH Plus, Sealer 26, Epiphany SE, Sealapex, Activ GP, MTA Fillapex (MTA-F) and an experimental MTA-based Sealer (MTA-S). Sealapex had the highest pH values 2 and 7 days post-manipulation. Regarding the solubility, at 2 days the highest values were observed for MTA-F, MTA-S, and Activ GP. At 7 days, MTA-S and MTA-F had greater solubility than the other materials. AH Plus had the lowest solubility for both post-manipulation periods.Sealapex and MTA-F were associated with a greater solubility[39].

Physical properties of MTA based sealers:

Silva EJ et al 2013,evaluated the pH, and flow of a calcium silicate-based and an epoxy resin-based endodontic sealer, MTA Fillapex and AH Plus, respectively. They concluded that MTA Fillapex presented alkaline pH in all experimental times, whereas AH Plus cement showed a slightly neutral pH and a flow significantly lower than that of MTA Fillapex.MTA Fillapexhave suitable physicochemical properties for an endodontic sealer[43].

Vitti RP et al 2013, evaluated the calcium release, pH, flow, solubility, water absorption, setting and working time of three experimental root canal sealers based on mineral trioxide aggregate (MTA Fillapex) and two forms of calcium phosphates (CaP). They concluded that MTA Fillapex showed the highest values of flow and working/setting times and the smallest values of solubility and water absorption.All experimental materials showed satisfactory physical-chemical properties to be used as endodontic sealers in clinical practice[44].

Kuga MC et al 2014, evaluated the flowability, pH level and calcium release of pure MTA Fillapex (MTAF) or containing 5% (MTAF5) or 10% (MTAF10) calcium hydroxide (CH), in weight, in comparison with AH Plus sealer.The flowability test was performed according to the ISO 6876:2001 requirements. The result was in relation to flowability: MTAF>AH Plus>MTAF5>MTAF10. In relation to the pH level, for 24 h: MTAF5=MTAF10=MTAF>AH Plus; for 7 and 14 days: MTAF5=MTAF10>MTAF>AH Plus. They concluded that the addition of 5% CH to the MTA Fillapex (in weight) is an alternative to reduce the high flowability presented by the sealer, without interfering in its alkalization potential[45].

Viapiana R et al 2014, evaluated the physicochemical and mechanical properties of Portland cement-based experimental sealers (ES) with different radiopacifying agents (zirconium oxide and niobium oxide micro- and nanoparticles) in comparison with the following conventional sealers: AH Plus, MTA Fillapex and Sealapex.The materials were tested for setting time, compressive strength, flow, film thickness, radiopacity, solubility, dimensional stability and formaldehyde release. The result was that MTA Fillapex had the shortest setting time and lowest compressive strength values compared with the other materials. None of the endodontic sealers evaluated released formaldehyde after mixing[46].

Lim ES et al 2015,investigated the physical properties and biological effects of an experimentally developed injectable premixed calcium-silicate root canal sealer (Endoseal) in comparison with mineral trioxide aggregate (MTA) and a resin-based sealer (AHplus).The pH, solubility, dimensional change, flow, and radiopacity of the materials were evaluated. The resultswas the solubility of the tested materials was similar. The dimensional change and flow of Endoseal was significantly higher than that of other materials[47].

Physical properties of Bioceramic based sealers:

Loushine BA et al 2011,investigated the setting time and micohardness of a premixedcalcium phosphate silicate-based sealer (EndoSequence BC Sealer) in the presence of different moisture contents (0-9 wt%). The moisture content that produced the most optimal setting properties was used to prepare set EndoSequence BC Sealer for cytotoxicity comparison with an epoxy resin-based sealer (AH Plus).They found that BC Sealer required at least 168 hours to reach the final setting using the Gilmore needle method, and its microhardness significantly declined when water was included in the sealer. All set sealers exhibited severe cytotoxicity at 24 hours. The cytotoxicity of AH Plus gradually decreased and became noncytotoxic, whereas BC Sealer remained moderately cytotoxic over the 6-week period[55].

Zhou HM et al 2013, evaluated the pH change, viscosity and other physical properties of 2 novel root canal sealers (MTA Fillapex and Endosequence BC) in comparison with 2 epoxy resin-based sealers (AH Plus and

ThermaSeal), a silicone-based sealer (GuttaFlow), and a zinc oxide-eugenol-based sealer (Pulp Canal Sealer).ISO 6876/2001 specifications were followed. They found that the MTA Fillapex and Endosequence BC sealers each possessed comparable flow and dimensional stability but higher film thickness and solubility than the other sealers tested[56].

Dudeja C et al 2015,compared the effect on fracture strength, pH and calcium ion diffusion from mineral trioxide aggregate (MTA) Fillapex, iRoot SP, and Ultracal when used for repair of simulated root resorption defects. The result was that theteeth filled with iRoot SP showed highest pH and calcium ion release followed by MTAFillapex and Ultracal group.Bioceramic sealers showed high pH, calcium ion release, and good root reinforcement potential[57].

Poggio C et al 2017, compared the solubility and the pH of different root canal sealers in vitro.BioRoot™RCS, TotalFill BC Sealer, MTA Fillapex, SealapexTM, AH Plus, EasySeal, Pulp Canal Sealer™ and N2 were tested. They found that BioRoot™RCS and TotalFill BC Sealer showed significantly higher solubility. All the remnant root canal sealers fulfilled the requirements of solubility of the International Standard Organization 6876 demonstrating a weight loss of less than 3%. BioRoot™RCS and Totalfill BC Sealer exhibited high alkaline pH over time; the alkalinity of the other tested cements was significantly lower.The prolonged alkalinity of bioceramic sealer matched the increase in solubility. This may encourage their biological and antimicrobial effects, but the ongoing solubility may impact their ability to prevent apical leakage[59].

Lee JK et al 2017,three bioceramic sealers (EndoSequence BC sealer, EndoSeal MTA, and MTA Fillapex) and three epoxy resin-based sealers (AH-Plus, AD Seal, and Radic-Sealer) were tested to evaluate the physicochemical properties: flow, final setting time, radiopacity, dimensional stability, and pH change. The MTA Fillapex sealer had a highest flow and the BC Sealer presented a flow significantly lower than the others. EndoSeal MTA had the longest setting time among the measurable materials and Radic-Sealer and AD Seal showed shorter setting time than the AH-Plus. BC Sealer showed the highest alkaline pH in all evaluation periods. Set samples of 3 epoxy resin-based sealers and EndoSeal MTA presented a significant increase of pH over experimental time for 4 weeks. In conclusion, the bioceramic sealer and epoxy resin-based sealersshowed clinical acceptable physicochemical properties, but BC Sealer and MTA Fillapex were not set completely[60].

Herbal Medicines in Endodontics:

Herbal medicines (Botanical medicine, Phytomedicine, or Phytotherapy) refer to herbs, herbal materials, herbal preparations, and finished herbal products that contain parts of plants or other materials as active ingredients. Today the Herbal or natural products have become more popular due to their high antimicrobial activity, biocompatibility, anti-inflammatory and anti-oxidant properties[62]As the incidence of increased resistance by pathogenic bacteria to currently used antibiotics and chemotherapeutics agents is more, the researchers are developing interest towards alternative treatment options and products for oral diseases. Hence, the natural phytochemicals isolated from plants used in traditional medicine are considered as good alternatives to synthetic chemicals.

According to the World Health Organization (WHO), as many as 80% of the world's people depend on traditional medicine (herbal) for their primary healthcare needs[63]. Herbal medicines have a long history of use for gum and tooth problems. In many traditional cultures, the use of herbal "chewing sticks" taken from plants, shrubs or trees with high anti-microbial activity are common. A herb may exhibit one or more following unique therapeutic properties like anti-bacterial, anti-inflammatory, astringents, anaesthetic, immune strengtheners, anticariogenic, anti plaque agents and tooth whitener[64].Herbs may be good alternatives to current treatments for oral health problems but there is lack of information about the effect of herbs in oral tissues, mechanism of effect, and side effects. So the more research is required to explore these traditional medicines.

Frankincense (Boswellia sacra) is a tree indigenous to Dhofar region and is one of the most famous plant of Sultanate of Oman. It is also known as Luban, Bakhor or Kendar in Arabic region[65]Its composed of about 5–9% essential oil, 65–85% alcohol-soluble resins, and the remaining water soluble gums 30–40%[66].

It's the most important multipurpose tree species in Central and Eastern Africa. possess multiple economic and ecological benefits in Africa. It is found in Ethiopia, Nigeria, Cameroon, Central African Republic, Chad, Sudan, Uganda and Eritrea[67]. It produced by several species of Boswellia. "Fran-kincense or Pure- incense" was known to the most of the ancient civilizations who used it in rituals and prayers to the gods. It is used in the traditional medicine in Oman, India and African countries for the treatment of variety of diseases. The oldest written evidence which mentions Frankincense as a drug is papyrus Ebres[68]. Essential oil was dominated by α-thujene 10% and pcymene 4-3%[69]. Boswellic acids have an anti-inflammatory action[70],active constituents for many of its medicinal uses[71]. Non-steroidal anti-inflammatory drugs (NSAIDS) used for inflammatory conditions, among the constituents of boswellic acid, β-boswellic acids (the major constituents of boswellic acids) was shown to have anti-inflammatory and anti-arthritic pain activity, which was found to be due to their ability to inhibit 5-lipoxygenase activity[72].

Frankincense consists of essential oils, gum, and terpenoids. The boswellic acids in the terpenoid portion are the active constituents in Boswellia[73]. The fresh gum obtained from the tree is hot dry with a pleasant flavor and slightly bitter in taste. When burned produces a brilliant flame and produces a pleasant aroma. It was widely used by ancient Egyptians, Greeks and Romans as prized incense, fumigant as well as a multipurpose aromatic. In the past it was used for trading across Asia and Europe. It was the most powerful fuel for the Arab economy as it was once more voluble than gold.

Boswellic acid and their derivatives were investigatedfor anti-inflammatory. Essential oil showed anti-bacterial, anti-fungal and immuno-stimulating activity[74]. Mono-terpenoids seem to be the dominant class of compounds found in the oils. The main compounds essential oil were α-pinene 45.7 %, α –terpinene 11.5% and trans-sabinenehydrate[75]. Resin oils showed similar chemical

profiles, with iso-incensole and iso-incensole acetate as the main di-terpenic components. Both n-octanol and n-octyl acetate, along with the diterpenic components incensole and incensole acetate, were the characteristic compounds of B. papyriferaoleogum resin oil. The anti-microbial activities of the essential oils were individually evaluated against fungi, Gram-positive and Gram-negative bacteria strains. Resins destroy microbial cell wall and stop protein synthesis in Strept. salivaris, Staph. aureus, and Bacillus megaterium(76).
Pharmacological activities of Frankincense, as crude extracts, the distilled essential oil and isolated compounds reported to exhibit in-vitro anti-bacterial, anti-fungal and immuno-modulatory activity. Volatile oils make sensitization of microbial cell contents and have anti-inflammatory effect on Staph. aureus, Staph. epidermidis, Staph. hominis, Bacillus cereus, E. coli, Proteus vulgaris and Candida albicans(77).

Frankincense application can lead to remarkable decrease in inflammatory indices in comparison to drug therapy. It's a safe and low cost herbal medicine, may be feasibly applied to improve inflammation based disease of gingival as an adjunct to the conventional mechanical therapy(78). The daily and ritual use of Boswellia is characteristic cultural of the horn of Africa which transcends the ethical and religious memberships(79). In general, most of the respondents were aware of beneficial therapeutic uses of luban, but 3/4 of the participants hardly had an idea that incense is considered as potential chemo preventive agent in modern medicine. Similarly, (38-46%) of the participants correctly believed that luban is having anti-inflammatory actions, a fact substantiated by scientific evidences and its commercial availability in the pharmaceutical market. More than 1/2 of the study population suggested that luban could be used in cosmetic industry because of its aroma and fragrance. Frankincense was once and still considered to be a national treasure(80).

KhosraviSamani et al 2011, evaluated anti-inflammatory effects of Frankincense in the treatment of gingivitis, which is a periodontal tissue inflammatory disease.The conclusion was the Frankincense is a safe and low-cost herbal medicine and may be feasibly applied to improve inflammation based disease of gingival as an adjunct to the conventional mechanical therapy(81).

Maraghehpour B et al 2016, evaluated the antibacterial effectof
Boswellia serrata (BS)and Nigella sativa (NS)on Aggregati bacter actinomycetemcomitans (A.a) known as main pathogen of aggressive periodontitis. Broth microdilution method was used to obtain minimum inhibitory concentration (MIC) of crude extract of BS and NS. They found that the MIC of BS and NS were 512 μg/mL and 128 μg/mL, respectively. No growth was observed in our negative control group. Both BS and NS are effective against A.a which should be taken into account as appropriate ingredient for oral hygiene products(82).

Governa P et al 2018, investigated the effects of two phytochemically characterized extracts of B. serrata and C. longa in an in vitro model of intestinal inflammation. Their impact on cytokine release and reactive oxygen species production, as well as the maintenance of the intestinal barrier function and on intestinal mucosa immune cells infiltration, has been evaluated. They found that the C. longa and B. serrataresulted to be promising agents for the management of inflammatory bowel diseases by modulating in vitro parameters which have been identified in the clinical conditions(83).

Saha S et al 2019, compared antimicrobial activity of endodontic sealers added
to herbal extracts.Three sealers mixed with three herbal extracts were evaluated against seven strains of bacteria at various time intervals using Agar Diffusion Test. Thethree herbal extracts used in this study were methanolic extracts of Licorice, Bakul, and GuduchiThe mean zones of inhibition were measured. They found that the Zinc Oxide Eugenol based sealer with herbal extracts produced largest inhibitory zones followed in descending order by Resin based sealer and Calcium hydroxide along with three herbal extracts respectively(84).

Recently **Badria et al 2018** evaluated the biocompatibility , anti-inflammatory and antimicrobial effects of boswellic acid (BA) in comparison to conventional and common root canal irrigants and intracanal medications; e.g. sodium hypochlorite, CHX, calcium hydroxide ,TAP, DAP and Ledermix. They found that the BA proved to be highly biocompatible (>95 % viability at 1μg/ml) which was further evaluated for inhibition of COX and LOX enzymes in comparison to Ledermix. The results showed that BA inhibits both COX and LOX by 83.44% and 79.26% Vs. 70.71 and 65.95 respectively for Ledermix. Upon pre-treatment the cells with BA, IL-6 expression was 65.230, 108.153, 92 pg/ml at 15, 30, and 60 minutes respectively. Moreover, Pre-treatment with BA reduced the level of TNF-α to 7.07037, 9.555, 2.1481 pg/ml at 15, 30, and 60 minutes respectively. The antibacterial effect (MIC, μg/ml) of BA against E. faecalis and C. albicans were 0.37mg/ml, 1.11mg/ml respectively.They concluded that the BA showed to be biocompatible with strong anti-inflammatory and antimicrobial activities when compared to other commonly used irrigants and medications. Therefore this study proposed a new efficient and safe irrigant and medicament(6).

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