

DENTAL BITES

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RESTORATIVE AND RECONSTRUCTIVE DENTISTRY



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KMCT
DENTAL COLLEGE



KMCT Medical College Campus, Mukkom, Kozhikode - 673 602

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Editorial

Dear Readers,

The field of facial reconstructive surgery stands at the confluence of art, science, and technology. In recent years, this specialty has witnessed remarkable progress, transforming the way we approach complex maxillofacial deformities and trauma. At KMCT Dental College, we take immense pride in embracing these advancements—offering our patients world-class care while simultaneously enriching the learning experience for our students.

This edition of our institutional journal is dedicated to the exciting and evolving domain of Facial Reconstructive Surgery. Through collaborative efforts and a commitment to innovation, our Department of Oral and Maxillofacial Surgery has integrated cutting-edge technologies such as Virtual Surgical Planning (VSP) and 3D Printing into clinical practice. These technologies allow for precise preoperative planning, customization of surgical procedures, and enhanced patient outcomes—all at a fraction of the cost compared to conventional methods.

The shift toward technology-driven reconstruction has made surgeries more predictable, less invasive, and quicker in recovery, while significantly reducing operative errors and postoperative complications. Moreover, the adoption of such innovations would be incomplete without the support of robust research initiatives. At KMCT, we strongly believe that the future of surgical excellence lies in evidence-based practice. Our faculty and students are encouraged to engage in research that not only deepens their understanding but also contributes to global scientific discourse.

In a country where access to high-quality healthcare is still a challenge for many, our focus remains on delivering state-of-the-art surgical solutions that are both affordable and accessible. The journey ahead is exciting, and through sustained efforts in innovation, training, and research, we aim to continue leading by example.

Let this issue inspire clinicians, students, and researchers alike to explore, innovate, and make meaningful contributions to the noble art of healing and reconstruction.

With warm regards,

Dr Manoj Kumar K.P
Principal

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Herbodontics: Application of Herbal irrigants in Endodontics

*Dr Rose Maria Jaimon **Dr Ravi S V

Abstract

The use of chemical substances such as sodium hypochlorite and ethylene diamine tetra acetic acid along with mechanical instrumentation has been a constitutive part of endodontic therapy. However, these agents have shown negative side effects such as tissue reactions if extruded. This led to the search for more biocompatible herbal alternatives. Various herbal extracts have been researched and its effect on areas such as pulp tissue dissolving capacity, smear layer removal and antimicrobial capacity were studied. This article aims to review the various herbal endodontic irrigants studied, their advantages and disadvantages.

Keywords: *Herbal irrigants*

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Introduction

Oral microbes, which are typically opportunistic pathogens that might enter a root canal with necrotic tissue and start an infectious process, are the primary cause of primary endodontic infections. The main aim of an endodontic treatment is to remove diseased tissue and to prevent its recontamination.¹ Irrigating solutions are very important during root canal preparation because they aid in the cleaning of root canal, lubricate the files, flush out debris, have antimicrobial effect,

provide tissue dissolution without damage to the periapical tissues.² This process mainly revolves around “chemo-mechanical preparation”, where in chemically active solutions are used along with mechanical instrumentation of the root canal space. Sodium hypochlorite [NaOCl] is the chemical that is most frequently utilised in this procedure, and its concentrations can range from 1 to 6%.³ Due to its exceptional antibacterial activity and distinct capacity to disintegrate pulp tissue, this chemical is

preferred above other irrigants. NaOCl has several drawbacks, such as a nauseating smell, toxicity and the inability to dissolve only organic material, which prevents it from dissolving the smear layer on its own. For this reason, Ethylene diamine tetra acetic acid (EDTA) was used, which effectively demineralises the smear layer but has to be used along with NaOCl to remove the organic part and does not have disinfective ability.⁴ Chlorhexidine is another commonly used antimicrobial agent which is being used to irrigate the canals due to its wide spectrum antimicrobial activity, biocompatibility and ability to disinfect the infected root canals. However, it does not have tissue dissolving capabilities and also has some undesirable effects as it may discolour the teeth, may result in oral dryness and possibly a mouth burns by making the mouth more sensitive to moisture.⁵ To overcome the side effects of the above agents and to meet the requirements of an ideal irrigant, wide variety herbal products have been used in the past in medicine. This method of using herbs to treat a variety of disorders is referred to as "Phytotherapy" or "Phytomedicine" or "Ethnopharmacology". The World Health Organization defines herbal medicine as a plant derived preparation or substance that contains raw or processed components from one or

more plants that have therapeutic characteristics. Traditional Indian medical writings mention Neem (*Azadirachta indica*) trees for their benefits. Herbal medicines are now being incorporated into toothpaste to prevent dental caries. The primary cause of polyphenol's anti-cariogenic effects is their direct interaction with *S.mutans* and it interacts with microbial membrane proteins to prevent bacterial cells from adhering to the tooth surface. Because of the potential benefits of employing non-ionizing radiation diagnostic tests in dentistry and the difficulties that occur with their use, scientific study in this field has led to some fascinating discoveries that will be beneficial in the future. The most interesting advancements in this sector are magnetic resonance imaging (MRI) and ultrasonic imaging. The purpose of this review is to identify and discuss many herbal substitutes that are now on the market and can be used as efficient endodontic irrigants.⁶

History

Taft suggested sodium chloride as a deodorizer for irrigation. Potassium and sodium metals were employed by Schreir et al. in 1893 to remove necrotic pulp. The root canal was sealed in 1894 by Callahan et al using 5% sulfuric acid.

(“cascade”platinum concentrating still for sulphuric acid, 1894) Grossman and Meimann used a combination of double strength sodium hypochlorite and hydrogen peroxide for the removal of pulp tissue remnants. Percy marketed this product under the name "Eau de Javel."Bleaching solution made of hypochlorite was employed. Moreover, it was used to stop childbed fever. Koch and Pasteur demonstrated that it has disinfectant properties during the late 19th century. For the irrigation of infected wounds during World War I, sodium hypochlorite buffered solution was employed. A formulation of sodium hypochlorite has tissue-dissolving effects on necrotic tissues and is effective against a variety of bacteria. It's usage as the primary irrigant in endodontics is due to these characteristics. Solutions of sodium hypochlorite are also inexpensive, accessible and have a long shelf life. In comparison to hypochlorite, other chlorine -releasing substances including sodium di chloro iso cyanurate and chloramine-T were shown to be less efficient. Hence, they were not widely accepted in endodontics.

Ideal requirements of root canal irrigants

- Wide antibacterial spectrum.

- Capacity to degrade remains of necrotic pulp tissue.
- Systemically safe, not corrosive to periodontal tissues and unlikely to result in allergic responses when they come into touch with vital tissues.
- Non-irritating to the periapical tissues, effective as a fungicide and germicide and active in the presence of blood, serum and tissue protein derivatives.
- Minimal surface tension, no tooth staining and no negative impacts on the physical characteristics of exposed dentin.
- Has no negative effects on the filler components.
- Capacity to seal.
- Simple to use or apply.
- Inexpensive

Classification of endodontic irrigants

Based on the Composition (Kandaswamy and Venkateshbabu, 2010) □ Chemical - Tissue dissolving, Antibacterial, Chelating □ Natural -Antibacterial agents
 [Commonly used irrigants: The Irrigants currently used are (Gomes et al., 2001) □ Sodium hypochlorite, Chlorhexidine,



Ethylenediaminetetraacetic acid (EDTA)

Kale and raut classification (2021)

□Herbal root canal irrigants with antimicrobial property E.g., Neem leaf extract (*Azadirachta indica*), Triphala, Propolis, *Morinda citrifolia*, Aloe vera, Garlic (*Allium sativum*), Ginger (*Zingiber officinale*), Green tea, etc.

Herbal root canal irrigants with chelating ability E.g., Neem extract (*Azadirachta indica*), Triphala extract, *Morinda citrifolia*, Garlic (*Allium sativum*), Green tea, Tea tree oil (*Melaleuca alternifolia*), Tulsi (*Ocimum sanctum*), etc.

Root canal irrigants made from herbs that have chelating and antibacterial properties E.g., Neem leaf extract (*Azadirachta indica*), Triphala, *Morinda citrifolia*, Garlic(*Allium sativum*), Green tea, Tea tree oil (*Melaleuca alternifolia*), etc.

Herbal root canal irrigants with the capacity to dissolve pulp tissue E.g, *Sapindus mukorossi*, Garlic (*Allium sativum*), *Nepenthes khasiana* digestive fluid *epenthes khasiana* digestive fluid.

Herbal endodontic irrigants

1) *Curcuma longa* (turmeric):

Curcumin, is an Indian spice and traditional medicine a member of a *Zingiberaceae* family which is a perennial plant with small stem, large oblong leaves and bears ovate brownish

yellow rhizomes ,possesses anti-inflammatory ,antioxidant, antimicrobial, anticancer activity, antimalarial and hepatocellular. A recent report suggested that curcumin in aqueous preparations exhibits phototoxic effect against gram positive and gram-negative Bacteria. Diferuloylmethane, the primary easily soluble in organic solvents but insoluble in water. The possible mechanism of action of curcumin suggests the inhibition of assembly of a protein filamenting temperature-sensitive mutant Z (FtsZ) and it also increases the guanosine triphosphatase activity of FtsZ which is lethal for the bacteria. In a study conducted by Prasanna Neelakantan, it has been shown that curcumin has significant antibacterial activity against *E.faecalis* and can be used as an alternative to sodium hypochlorite for irrigation. As a result, this herb can be utilised specifically in situations of root canal failure in endodontics.

2) *Acacianilotica* (babool):

Acacia nilotica also known as the *Acacia arabica*, is an imperative multipurpose plant. It is a medium sized tree and is broadly scattered in tropical and subtropical countries. It

consists of tannins, phenolic compounds, essential oils & flavonoids, condensed tannin, gallic acid, protocatechuic acid, pyrocatechol, catechin, epigallocatechin-3-gallate and epigallocatechin-5,7-digallate. Epicatechin, dicatechin, quercetin, gallic acid, leucocyanidin gallate, sucrose and catechin-3-gallate are compounds usually present in barks of babool which possesses good antimicrobial, antioxidant, antifungal, antiviral and antibiotic activity. Extracts of *Acacia Nilotica* damage electrolytic and essential cellular constituents (proteins and nucleic acids) of pathogens, altering the cell integrity and cell wall permeability indicating that acacia extracts damaged the cellular membrane of the pathogens. Extracts of liquorice, clove, cinnamon and babool were examined for their antimicrobial activities in a study by Dhanya Kumar et al. It was shown that babool at a concentration of 50% had the highest activity against *E. faecalis*.

3) *Azadirachta indica*

(neem):

Neem, also known as *Azadirachta Indica*, is a species of tree in the mahogany family. Indian neem, Margosa tree and Indian lilac are other names for it. This ubiquitous medicinal tree in India is

valued. US National Academy of Sciences entitled neem as “a tree for solving global problems” as it produces numerous biological activities. It is widely used in Ayurvedic medicines and neem cream is prescribed for skin disease. The tetranortriterpenes, nimbidinin, nimbolide, and nimbidinic acid are derived from neem. Their leaves, bark, flowers, roots and seeds have a variety of pharmacologic effects. Neem’s antiviral, antifungal, antibacterial and anticarcinogenic activity makes it a potential agent for root canal irrigation. Neem leaf extract is also used to treat dental plaque and gingivitis. Being a biocompatible antioxidant, use of neem is advantageous as it is not likely to cause severe harms to patients that might occur through sodium hypochlorite accidents.

Neem’s ethanolic extract shown antibacterial efficacy against *E. faecalis*, according to research by Naiyak Arathi et al.

4) Propolis:

Propolis is a substance that has been used for generations in traditional medicine. Honeybees [*Apis mellifera* L.] gather propolis, a resinous substance, from a variety of plant species and combine it with wax. It is composed of resin (55%), essential oils and waxes (30%) mixed with bee glue (bee salivary

secretions), pollen (5%), amino acids, minerals, ethanol, vitamins, and highly active bioflavonoids (10%) and other substances. Scientific research has revealed its antioxidant, antibacterial, antifungal, antiviral, anti-inflammatory, antitumor and immunomodulating properties. It possesses anti-bacterial activities against streptococcus sobrinus and streptococcus mutans. Viscidone is another ingredient that makes it suitable for use as an irrigating solution. It can also be used to transport teeth that have been avulsed since it keeps the periodontal ligament cells healthy. It has been used as a pulp capping agent, cariostatic agent, as a mouth rinse and in the treatment of periodontitis. Propolis exhibits antibacterial activity that is comparable to sodium hypochlorite, according to research by Al- Qathami and Al-Madi that examined the antimicrobial effectiveness of propolis, sodium hypochlorite and saline as intracanal irrigants.

5) Morinda citrifolia(noni): Morinda Citrifolia also known as Indian mulberry, Cheese plant One of the most important sources of traditional remedies is noni, which is a plant that grows abundantly over the Pacific. Major components includes 6 α hydroxyadoxoside, 6 β , 7 β -epoxy-8scopoletin, octoanoic acid,

terpenoids, alkaloids, anthraquinones, bisterol, carotene, flavone glycosides, linoleic acid, alizarin, acubin, Lasperuloside, caproic acid, caprylic acid, ursolic acid, rutin and proxeronine. Although pectinases and hemicellulases in Morinda citrifolia juice cause differential disintegration of bacterial cell wall polymers, Morinda Citrifolia juice functions by depolymerizing hydro soluble pectins. It has a wide range of uses due to its biocompatibility, antibacterial, anti-inflammatory, antiviral, antioxidant and analgesic effects. It is among the earliest herbal substitutes offered for an intra canal irrigant. In an in vitro experiment, the ability of MC juice to clean the smear layer from instrumented teeth root canal walls was compared to that of NaOCl and chlorhexidine. The effectiveness of Morinda Citrifolia as an intracanal irrigant was determined to be comparable to that of NaOCl combined with EDTA.⁷

6) Aloe vera (Aloe barbadensis miller):

The green portion of the leaf that surrounds the clear gel in aloe vera. Aloin and aloeemodin are the two substances that make aloe vera active. Due to protein synthesis in bacterial cells, aloe vera has strong antibacterial effect. It is also high in vitamins, minerals, enzymes,

carbohydrates, lignin, saponins, salicyclic acids, amino acids and has antifungal activity. In a study conducted by Suresh Chandra, antimicrobial effect of water, alcohol, chloroform extracts of aloe vera gel were investigated and it was found that chloroform extract of aloe vera had significant antimicrobial effect against *E.faecalis*.

7)Triphala and green tea polyphenols:

The dried and powdered fruits of the three medicinal plants *Terminalia bellerica*, *Terminalia chebula* and *Emblica officinalis* make up the Indian ayurvedic herbal mixture known as triphala. Citric acid, which is abundant in triphala's fruit, aids in the removal of the smear layer. Triphala may also disrupt microbial membranes. For root canal irrigation, its chelating ability makes it a useful substitute for sodium hypochlorite. Green tea prepared only from *Camellia sinensis* leaves. Green tea polyphenols have significant antioxidant, anticariogenic, anti-inflammatory, thermogenic, probiotic and antimicrobial properties. The bacterial enzyme gyrase is inhibited by binding to the ATP B subunit, which results in the antimicrobial action. In a study by Madhu Pujar et al, antimicrobial efficiency of triphala, green tea polyphenols and 3% sodium hypochlorite were compared against *E.faecalis* and it was observed that triphala and green tea

polyphenols showed significantly better antibacterial activity against 2 week biofilm.⁸

8)Salvadora persica

solution(miswaksiwak):

Miswak is a word which is traditionally known for the wooden stick used for cleaning teeth and it is derived from a plant called "Arak". Miswak or Siwak is the name of this stick. Miswak translates to "stick to clean your teeth" in Arabic. The Babylonians have been brushing their teeth with miswak since over 7,000 years ago. *Salvadora persica*'s antibacterial properties are assumed to be a result of its rich chemical composition, which includes tannins, chlorides, trimethylamine, salvadorine, nitrate, thiocyanate and sulphur. It has been demonstrated that these anionic chemicals exhibit antibacterial activity against different microorganisms. These substances interact with the sulfhydryl groups in the bacterial enzymes, ultimately causing the death of the bacterium. Alcoholic *Salvadora persica* extract was compared to 5.25% sodium hypochlorite, 0.2% chlorhexidine and normal saline in a research by Nawal A.K. AlSabawi et al. It was shown that *Salvadora Persica* extract had a significant antimicrobial effect against both aerobic and anaerobic bacteria with its efficacy being maximum at 15%.⁹

9) *Alliumsativum* (garlic)

Throughout Asia and Europe, garlic was utilised for other health benefits, including as strengthening the immune system against cold and cough. The major component is Diallyl sulphide (allicin) which is like Penicillin. The active constituents are several complex sulphur containing compounds such as Allin, Ajoene and Flavonoids that are rapidly absorbed, transformed and metabolized. Plants bulbis mostly commonly used. It is an antidiabetic agent. Garlic contains allicin which destroys the cell membrane of root canal bacteria which is used as an alternative irrigant for NaOCl.

It inhibits the growth of oral pathogens like streptococcus mutants and porphyromons gingivalis used for management of dental infections like periodontitis

10) *Teatree oil* (*melaleucaalternifolia*)

Australia's lowland wet regions are native to this tree. Its height is usually 10-25 feet and has a papery white bark, dark green needle-like leaves and colorful blossoms with many properties like antiseptic, antifungal and mild solvent has an active component of terpinen-4-ol have efficacy of removing smear layer superior to NaOCl but less than EDTA.

11) *Marticaria Recutitia* linn (german chamomile)

German Chamomile also known as *Matricaria Chamomilla* L. belongs to Asteraceae family is one of the very important medicinal plants native of Europe of south and east Europe. A range of chemically active substances may be found in the chamomile plant's flowers (chamazulene, capric acid and caprylic acid). Moreover, it contains terpenoids, flavonoids and other chemical components. German chamomile oil concentrates on the bacterial cell membrane. It has an anti-inflammatory, analgesic, antimicrobial, antispasmodic and sedative properties. It disinfects root canal system with less toxicity when used as irrigants. An endodontic irrigant is good for irrigation at a field capacity of 70%, according to a study done on various content and compositions of chamomile using various irrigation regimes, however if water supply is adequate, 85% field capacity of German chamomile may be employed.¹⁰

12) *Syzigium aromaticum* - clove

Eugenol, iso eugenol and vanillin, which are included in clove essential oils, have antioxidant, antibacterial and anodyne properties. The calming effects of clove oil reduce pulpal inflammation. Three distinct plant extracts, *Syzygies aromaticum* (clove), *Ocimum sanctum* (tulsi), and *Cinnamum zeylanicum* (cinnamon), were the subject of a SEM

investigation conducted by Gupta et al. to assess their efficacy as endodontic irrigants. According to the study findings, *Syzigium aromaticum* and EDTA were the most successful experimental groups at removing smear layer.

13) *Agaricus bisporus*- mushroom

It contains active substances with both low and high molecular weights (LMW, HMW). It has therapeutic qualities including immune modulating, anti-inflammatory, antiviral, antioxidant and antibacterial capabilities because of these components. Plectasin, confuentin, grifolin, and neogrifolin are low molecular weight components found in mushrooms that have the ability to deeply enter dentinal tubules. Mushroom gel is used as an intracanal medication.¹¹

14) *Citrus limonum* - lemon solution

Lower acidity and a pH of 2.21 describe lemon solution. It functions as a chelating agent by removing the smear layer effectively. Due to its antimicrobial properties, fresh lemon solution is a perfect, risk-free root canal treatment. Fresh lemon solution has been proven in research by Abuziad & Eissa et al. to have broad antibacterial effectiveness against *E. faecalis* and may thus be utilized as an intracanal medication.¹²

15) Papaine

Papaine, a proteolytic cysteine enzyme, is derived from the latex of the green mature

papaya's leaves and fruits. Significant bacteriostatic and bactericidal effects are present. The antibacterial activity of natural extracts of *M. citrifolia*, papine, *A. vera* gel, 2% CHX and calcium hydroxide against *E. faecalis* was compared in the study by Anug Bhardwaj et al. Papaine provided findings

16) *Ricinus communis* - Castor

Castor contains ricinoleic acid which is abundant in it. It can be used both as an irrigant and an intracanal medicament can be utilised with it. Castor was reported to be able to eradicate *Candida albicans* in an in vitro investigation by Marcio Carneiro Valera et al. It was also discovered that castor considerably decreased the number of *E. faecalis*. It was discovered in another study by Lucas da Fonseca Roberti Garcia et al. that calcium hydroxide and Castor oil paste showed superior action than calcium hydroxide and propylene glycol paste against bacteria usually seen in endodontic infections.¹³

Conclusion

Herbal medicines are becoming popular and employed in endodontics because they are mostly harmless when used correctly and can be dangerous if overused. Considering that they have been shown to be beneficial and have few adverse effects, herbs can also be used in endodontic treatment techniques. Safety,

ease of accessibility, longer shelf life, economic efficiency and the absence of microbiological resistance thus far are the main benefits of herbal irrigants. Combining irrigants and using them sequentially will assist to meet all of the requirements for irrigation of the root canal, which will result in successful root canal therapy

References

1. Raj, James & Priyadharshn B. Herbal Irrigants -Future trends. *Int J Pharm Technol* 2015;6:3061-6.
2. Mohammed Torabinajad, Shahrokh Shabahang, Ray Dalfo, James D. Anti microbial effect of MTAD an in vitro investigation. *J Endod* 2003;29(6):400-3.
3. Siqueira JF Jr, Rôças IN, Favieri A, Lima KC. Chemomechanical reduction of the bacterial population in the root canal after instrumentation and irrigation with 1%, 2.5%, and 5.25% sodium hypochlorite. *J Endod*. 2000;26(6):331-334.
4. Sahni A, Chandak M Get al. Herbal usage in root canal irrigation: A review. *Int J Dent Health Sci* 2015;2(1):76-82
5. Kanisavaran ZM. Chlorhexidine gluconate in endodontics: an update review. *Int Dent J* 2008;58(5):247-57.
6. Yamashita JC, Tanomaru Filho M, Leonardo MR, Rossi MA, Silva LA. Scanning electron microscopic study of the cleaning ability of chlorhexidine as a root canal irrigant. *Int Endod J* 2003;36(6):391-4.
7. Murray PE, Farber RM, Namerow KN, Kuttler S, Garcia-Godoy F. Evaluation of morinda citrifolia as an endodontic irrigant. *J Endod* 2008;34:66–70.
8. Ferrazzano GF, Amato I, Ingenito A, Zarrelli A, Pinto G, Pollio A. Plant polyphenols and their anti-cariogenic properties: A review. *Molecules* 2011;16:1486–1507
9. Reda R, Zanza A, Cicconetti A, Bhandi S, Miccoli G, Gambarini G et al. Ultrasound imaging in dentistry: A literature overview. *J Imaging* 2021;7:238.
10. Aishuwariya T, Ramesh SI. Review of literature on herbal irrigants. *Ann RSCB*. 2021;25:15839-46.
11. Zehnder M. Root Canal Irrigants. *J Endod* 2006;32:389-98.
12. Basrani B, Haapasalo M. Update on endodontic irrigating solutions. *Endodontic topics* 2012;27(1):74–
13. Kandaswamy D, Venkateshbabu N. Root canal irrigants. *J Conserv Dent*. 2010;13(4):256-264.

Review Article

Induced Pleuripotent Stem Cells: Current trend in Regenerative Prosthodontics

*Monisha VS, ** Niveditha S Prasad, **Nivea T Francis

Abstract

Tooth loss is a significant health issue that affects the physiological and social aspects of everyday life. Induced pluripotent stem cells (iPSCs) have emerged as a significant focus in regenerative dentistry and prosthodontics due to their ability to differentiate into various cell types essential for dental tissue regeneration. These cells are generated by reprogramming adult somatic cells into a pluripotent state, enabling them to develop into cells of all three germ layers. Current approaches use a combination of dental progenitor cells, scaffolds and growth factors to create biologically based replacement teeth to serve as improved alternatives to currently used artificial dental prosthetics.

Keywords: *stem cells, tissue regeneration, pluripotency, induced pluripotent stem cells*

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Introduction

Human adult mesenchymal stem cells (MSCs) are non-hematopoietic, adherent fibroblast-like cells with intrinsic ability of self-renewal and potential for multilineage differentiation. Stem cells have the remarkable potential to develop into many different cell types in the body during early life and growth. In addition, in many tissues they serve as a sort of internal repair system, dividing essentially without limit to replenish other cells as long as the

person or animal is still alive. Stem cells are unspecialized cells that develop into the specialized cells that make up the different types of tissue in the human body.

Sources of stem cells

There are two primary sources of stem cells: adult stem cells and embryonic stem (ES) cells. In addition to these stem cells, which are naturally present in the human body, induced pluripotent stem (iPS) cells have been recently generated artificially

via genetic manipulation of somatic cells.^{6,7,8}

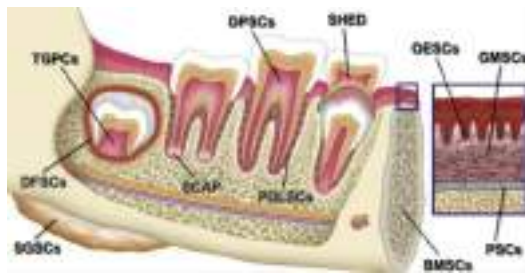


Fig-1: Sources of adult stem cells in the oral and maxillofacial region-

Embryonic Stem Cells: Embryonic stem cells (ESCs) are imitative from embryos that are 2-11 days old known as blastocysts. They are best developed from supernumerary embryos obtained from in vitro fertilization centers. They are totipotent - cells practically capable of differentiating into any type of cell as well as the germ cell. There is a restriction in the use of ESCs as they are gained from human embryos, so they are ethically and morally controversial and it is hard to generate disease and/or patient-specific ES cells.

Adult Stem Cells: These are undifferentiated cells that occur in a differentiated tissue. Sources of Adult Stem Cells (ASCs) consists of bone marrow, brain, blood, eye, skeletal muscle, lining of the gastrointestinal tract, pancreas, dental pulp, and skin. Adult stem cells are somatic in nature and show the

differentiation of the cells of their particular origin unless they are induced.

Induced pluripotent stem cells:

The ability of cells to differentiate into any kind of cell is referred to as the pluripotency of that cell and these cells are called induced pluripotent stem cells (IPSCs). These cells are derived from any source such as skin or alveolar bone or blood cells. They can divide indefinitely and are capable of generating all three derivatives of germ layers.

IPSCs functions in the same manner as ESCs. These IPSCs are the source of unlimited undifferentiated stem cells that can be differentiated into any kind of human cell as per the therapeutic requirement.

By direct reprogramming, pluripotency can be induced in somatic cells, which can be an alternative to ESCs.⁴

With the discovery of IPSCs, there is increased substantial demand for this technology as it does not require a human embryo for its pluripotency property and this property can be induced into any human stem cell.⁵

Source of induced pluripotent stem cells in dentistry

IPSCs are often generated without cutting the living tissues. Dental stem cells can be easily obtained from the oral mucosa or gingival tissues and can be attained by wiping the oral mucosa with a cotton swab or could also be extracted from deciduous teeth or third molar which is considered biomedical waste. There are abundant stem cells in dental tissues such as PDL, dental pulp, and apical papilla and they can be differentiated into IPSCs. In the oral cavity, stem cells are extracted from different areas of the teeth. They are as follows:

- 1 DPSC
- 2 Human exfoliated deciduous tooth
- 3 Stem cells from the apical papilla (SCAP)
- 4 Stem cells from the dental follicle
- 5 PDL stem cells (PDLSC)
- 6 Bone marrow-derived MSCs.

Prosthodontic Applications:

Regeneration of tooth/root

Stem cell technology has also gained popularity by replacing missing teeth with bioengineered teeth. In the field of prosthodontics, regeneration of the root is

a more practical and clinically acceptable proposition, especially for fixed-prosthodontic treatments, like crown and bridge as the root generated can be used as a good abutment.

Salivary gland regeneration

For the treatment of salivary gland diseases, therapeutic and regenerative potentials of IPSCs were extrapolated. *In vivo* studies have been done in mice using IPSCs for the treatment of salivary gland carcinoma. With the use of IPSC technology, the activity (expression of a gene) of α -amylase has increased significantly, indicating improved salivary gland function. Even with increased activity, the gland showed malignant degenerative changes in its minor ductal, acinar, and vascular structures.¹⁸

To restore damaged salivary glands functionally, two main regenerative approaches were formerly used. The first approach was by using tissue engineering technology, the artificial salivary gland could be developed, and the second approach was to use stem cells for the treatment of the mutilated salivary gland tissue.

Successful reparation of the function of irradiated salivary glands by intraglandular transplantation of salivary gland stem cells

isolated from the mice has been performed recently²⁰ suggesting that the damaged salivary glands can be functionally repaired through transplantation of induced stem cells .

Alveolar bone/regeneration

The use of bone grafts has been the gold standard for the reconstruction of bone defects, but it also has side effects such as donor site morbidity, and bone resorption, and also the grafts may not be available in sufficient amounts.

Using iPSC technology one can substitute autogenous grafting with bone tissue engineering. In this method, somatic cells of patients were induced to differentiate into bone-forming cells which were then loaded on a suitable scaffold in conjunction with proper bioactive molecules.²¹ A variety of mediums such as ascorbic acid, osteogenic media, bone morphogenetic proteins, β -glycerophosphate, dexamethasone, and Vitamin D3 were proposed in isolation or in combination, to induce osteogenic differentiation of iPSCs.

Temporomandibular joint regeneration

iPSC technology may be useful to study the complex etiology, onset, and progression of temporomandibular

disorder disease on a cellular level.^[24] The current research has shown that reprogramming, synoviocytes and chondrocyte cells from osteoarthritis patients to iPSCs can lead to the formation of chondrocyte cells that deposit cartilaginous matrix.²⁵ Cartilage can be regenerated from lineage-restricted MSCs and chondroprogenitors cells obtained from Human ESCs and iPSCs which holds a more promising approach that does not lead to teratoma formation. MSCs and chondroprogenitors cells obtained from human pluripotent stem cells, constitute a promising future to obtain “off-the-shelf” available cell sources in large numbers thereby overcoming the issues of donor variability and cellular senescence of adult MSCs.²⁶

Pluripotent stem cell and periodontal tissue regeneration.

Regeneration of the periodontal tissues using iPSCs was first done on mice by implanting the iPSCs into surgically created periodontal fenestration defects. This investigation comprises regeneration of periodontal tissues using iPSCs along with enamel matrix derivatives (EMD)/Emdogain gel.²⁷ Emdogain gel exhibits greater regeneration of periodontal tissues by stimulation of multiple MSCs with enhanced expression

of reprogramming tissue-specific factors. Periodontal defects treated with combined implantation of Emdogain gel with MiceIPSC (mIPSC) have shown greater bone regeneration than the defects treated with EMD_{TM} alone. Moreover, defects treated with EMD_{TM} and mIPSC showed almost an intact layer of regenerated cementum with a newly formed PDL between the regenerated cementum and alveolar bone, as was not shown on the control defects. This study, therefore, shows the capacity of mIPSC to regenerate PDL tissues.²⁸

Induced pluripotent stem cell and oral cancer

One of the most challenging fields is the treatment of oral cancer, which requires an average treatment outcome with minimal morbidity and death rate. Autologous immune cells such as anti-tumor monoclonal antibodies, natural killer (NK) cells, and adoptive transfer for the regression of solid tumors are used for the treatment of cancer.²⁹ For cancer immunotherapy, NK cells play a major role as they are innate immune cells or lymphocytes which show an anticancer potential. Using IPSC for cancer immunotherapy is greatly achievable by the generation of large-scale NK cells.³⁰ The research in the field of

oncology, especially for oral cancer using IPSC will be perpetual to achieve better treatment modality and has a big advantage of its patient-specific nature.

The Future of implantology-induced pluripotent stem cell dental implants

Advancements in dental implants have come up rapidly in recent years to provide a proper dimension to functions, esthetics, and health issues due to missing teeth. The use of conventional dental implants takes a prolonged healing period with a rejection rate of 5%, which is not a perfect solution for replacing missing teeth. The use of IPSC in implant dentistry with its undifferentiated specificity could rather be the future of implant dentistry.

Stem cells for these implants are derived from the cells of the root apex contributing to better tissue regeneration and the ability to form bonds with the bone. These innate implants formed are called bio-roots. The bio-roots have an advantage over conventional implants in that they do not pose the risk of gum disease or loosening, which is generally a complication seen with conventional implants.³²

Research is going on to modify the technique of acquiring and using stem cells and make them cost-effective. Stem cell dental implant technology has just come

up and is currently not a treatment option for replacing missing teeth. Yet the future lies in stem cell dental implants to provide a greater success rate and substantial longevity.

Advantages of induced pluripotent stem cell

1. Genetic and epigenetic memories can be retained using patient-specific iPSCs and this too reduces the probability of immune rejection along with host versus graft reaction
2. The use of iPSC avoids ethical issues, as they are obtained from the patient's tissues
3. IPS cells are the same as ES cells in many ways, such as cell morphology, long telomeres, expression of pluripotency, and the ability to make embryoid bodies, viable chimeras (person with two genetically distinct types of cells derived from one zygote), and teratoma
4. Besides the use in cell-based therapy, IPS cells when derived from diseased patients become an efficient tool in understanding the mechanism of disease including cancer.

Disadvantages of induced pluripotent stem cell

1 The drawbacks in the use of iPSCs are mostly related to their current reprogramming methods. The integration of multiple viruses into IPS cell genomes by viral vectors has been employed for cell delivery, leading to tumorigenesis because of genetic abnormalities of the cells.³³

2 Second, iPSCs, like ESCs, can lead to the formation of teratoma if they do not fully differentiate into somatic cells. Even though efficient differentiation protocols or techniques are developed, the separation of the differentiated cells from undifferentiated iPSCs is still a task with currently available cell purification technologies. This may increase the chance of transplanting undifferentiated or partially differentiated iPSCs into the patient.³⁴

3 Genomic instability and aberrations

4 Increased risk of development of cancer.

Conclusion

iPS cells provide an alternative option to ES cells without any ethical concerns and with universal usage. Their use and application in dentistry is relatively recent and currently under research. These cells can be derived from a variety of dental

tissue stem cells like, stem cells from apical papillae, dental pulp, deciduous teeth, third molars, buccal mucosa, gingiva and periodontal ligament.

iPS cells derived from dental cells lines can have clinical applications and future prospects, both in the field of medicine and dentistry. However viable and practical solution to issues like, epigenetic memory, tumorigenesis, use of retroviruses and xenogeneic materials, need to be addressed by further qualitative research in this field.

References

- 1.Khandelwal Pooja; Jadhav Rajashree; Sabane, Ajay; Gachake, Arti Induced Pluripotent Stem Cells – A New Perspective toward Regenerative Dentistry and Prosthodontics: A Narrative Review Article Journal of Dental Research and Review 10(4):p 221-227, Oct–Dec 2023.
- 2.Sayuri Hamano · Risa Sugiura , Daiki Yamashita , Atsushi Tomokiyo , Daigaku Hasegawa , Hidefumi Maeda Current Application of iPS Cells in the Dental Tissue Regeneration Biomedicines. 2022 Dec 16;10(12):3269.
- 3.Neeraj Malhotra Induced Pluripotent Stem (iPS) Cells in Dentistry: A Review Int J Stem Cells. 2016 Nov; 9(2):176–185.
- 4.Yamanaka S. Strategies and new developments in the generation of patient-specific pluripotent stem cells. Cell Stem Cell 2007;1:39-49
- 5.Amrollahi P, Shah B, Seifi A, Tayebi L. Recent advancements in regenerative dentistry: A review. Mater Sci Eng C Mater Biol Appl. 2016;69:1383–90.
- 6.Moy AB, Kamath A, Ternes S, Kamath J. The Challenges to Advancing Induced Pluripotent Stem Cell-Dependent Cell Replacement Therapy. Med Res Arch. 2023;11(11):4784.
- 7.Jalving M, Schepers H. Induced pluripotent stem cells: will they be safe? Curr Opin Mol Ther. 2009;11(4):383–93.
- 8.Wobus AM, Boheler KR. Embryonic stem cells:Prospects for developmental biology and cell therapy. Physiol Rev 2005;85:635–78.
- 9.Yamanaka S. Pluripotent Stem Cell-Based Cell Therapy-Promise and Challenges. Cell Stem Cell. 2020;27:523–531.
- 10.D. Kaigler, D. Mooney.Tissue engineering's impact on dentistry. J Dent Educ, 65 (2001), pp. 456-462



Sialoceles: Etiology, Diagnosis and Management

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Abstract

Background: Sialoceles are rare conditions characterized by the accumulation of saliva in the soft tissues due to trauma, surgery, or ductal obstruction. It most commonly affects the parotid gland and can lead to complications such as infection and persistent salivary fistula.

Objective: This article provides a comprehensive review of the etiology, pathophysiology, diagnosis, and management strategies for sialoceles, including recent advancements in treatment modalities.

Methods: A literature review was conducted, focusing on published case reports, clinical studies, and surgical techniques related to sialocel diagnosis and treatment.

Results: Diagnosis of sialocel is confirmed through clinical presentation, ultrasonography, and fine needle aspiration cytology (FNAC). Treatment varies from conservative approaches, such as aspiration and botulinum toxin injection, to surgical interventions like sialendoscopy and parotidectomy for persistent cases.

Conclusion: Early diagnosis and appropriate management significantly reduce morbidity. Minimally invasive procedures, including sialendoscopy and regenerative techniques, are promising future alternatives.

Key words: Sialocel, Salivary gland trauma, Parotid duct injury, Botulinum toxin, Sialendoscopy, Parotidectomy.

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Introduction

A sialocele is a localized accumulation of saliva in glandular or peri glandular tissue due to damage to the ductal system of a salivary gland. The most affected gland is the parotid, with trauma and surgical interventions being the primary causes. Sialoceles are presented as painless, fluctuant swellings that gradually enlarge over time. Their management ranges from conservative therapies to surgical interventions, depending on severity and persistence.



Figure 1: Clinical photograph of the patient with swelling in the right parotid region.

Etiology and Pathophysiology

Sialoceles develop due to saliva extravasation into surrounding tissues, which may be caused by:

1. **Trauma:** Facial injuries, particularly those affecting the

Stensen's duct, are a leading cause of sialocele formation.¹

2. **Surgical Procedures:**

Parotidectomies, facial reconstructions, or maxillofacial surgeries may inadvertently damage the salivary ducts.²

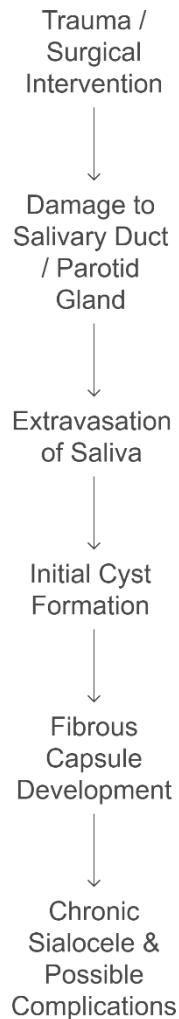
3. **Iatrogenic Causes:** Dental extractions, orthognathic surgeries, and botched aesthetic procedures are risk factors.³

4. **Inflammatory Conditions:**

Chronic sialadenitis or sialolithiasis can weaken ductal walls, predisposing patients to sialocele formation.⁴

Histologically, chronic sialoceles may develop a fibrous capsule around the extravasated saliva, making them harder to resolve conservatively.⁵

Progression of Salivary Duct injury



Clinical presentation & Diagnosis

Symptoms

- **Painless swelling** near the affected gland.
- **Gradual enlargement**, especially after meals.
- **Soft, fluctuant texture**, occasionally with skin redness or tenderness if infected.

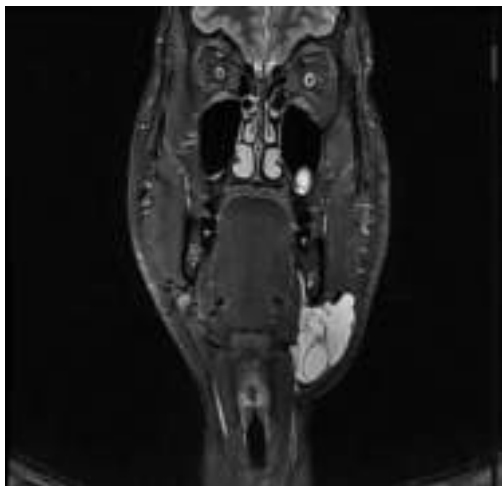
- **Fistula formation** in untreated cases, leading to continuous saliva drainage.⁶

Diagnostic Approaches

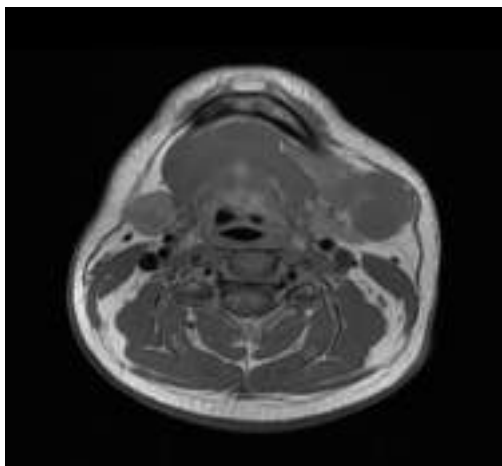
1. **Fine Needle Aspiration Cytology (FNAC):** Confirms saliva accumulation with high amylase content.⁷
2. **Ultrasonography (USG):** Identifies cystic, anechoic structures filled with saliva.⁸
3. **Sialography:** Determines ductal integrity and visualizes the extent of ductal damage.⁹
4. **MRI or CT scans:** Useful in complex cases to assess deeper involvement and rule out tumors.¹⁰
5. **Methylene Blue Injection:** Can be used intraoperatively to trace ductal leaks.¹¹



A



B



C

Figure 2: A) Ultrasound view shows the tip of the sialendoscope within a post-operative sialocele and in opposite to the proximal end of stensen's duct (green arrow), indicating a complete transection. Abbreviations: PG- Parotid Gland, SD- Stensen's duct, M- Mandible, MM- Masseter muscle, SC- Sialocele, SE- Sialendoscope.

B) & C) Multilobulated cystic mass (T1WI hypointense, T2WI, and STIR hyperintense) is seen in the left submandibular space involving the left submandibular gland.

Complications of sialocele

If left untreated, sialoceles can lead to:

- **Infection & Abscess Formation:** Bacterial colonization may result in purulent **discharge** and systemic symptoms.¹²
- **Persistent Salivary Fistula:** Chronic leakage of saliva onto the skin, complicating management.¹³
- **Facial Nerve Injury:** Surgical interventions for sialoceles near the parotid pose a risk to the facial nerve.¹⁴



- **Airway Obstruction:** Large submandibular sialoceles can cause airway compromise, requiring urgent intervention.¹

Treatment Modalities

Conservative Management:

- **Aspiration & Pressure Dressings:** Effective for small, early-stage sialoceles.²
- **Antisialagogues:** Medications such as atropine or glycopyrrolate reduce salivary secretion.³
- **Botulinum Toxin Injection:** Induces chemical denervation of the gland, with success rates up to 70–100%.⁴

Surgical Management:

- **Sialendoscopy with Stenting:** A minimally invasive technique that restores ductal patency and prevents recurrence.⁵
- **Ductal Repair & Microsurgical Anastomosis:** Involves direct suturing of the injured duct over a stent (e.g., double J stent or feeding tube stent).⁶

- **Parotidectomy:**

Reserved for recurrent or refractory cases but carries a significant risk of facial nerve injury.⁷

- **Intraoral Drainage & Fistulization:**

Redirects saliva into the oral cavity, preventing external leakage.⁸

Conclusion

Sialoceles, though uncommon, pose significant challenges due to their recurrence potential and association with facial nerve injury. Early diagnosis using ultrasound and FNAC, followed by conservative or surgical treatment, ensures optimal outcomes. Minimally invasive techniques such as botulinum toxin therapy and sialendoscopy continue to refine management strategies. Future research into bioengineered salivary tissue and regenerative techniques may further revolutionize treatment options.

References

1. Sulabha AN, Sangamesh NC, Warad N, Ahmad A. Sialocele: An unusual case report and its management. *Indian J Dent Res.* 2011;22(2):336-338.
2. Bowers EMR, Schaitkin B. Management of Mucocèles, Sialoceles, and Ranulas.



- Otolaryngol Clin N Am. 2021;54:543–551.
3. Rajeev R, Sajesh S, Jose M, Kumar ND. Sialoceles: A rare sequelae of transparotid approach in subcondylar fracture management. *Natl J Maxillofac Surg.* 2016;7:201–204.
 4. Hoehn EF, Wurster Ovalle V, Kim Y, Hariharan SL. Sialoceles following traumatic dental procedure: A case report. *Pediatr Emerg Care.* 2017.
 5. Meyer RA. Parotid sialoceles or traumatic pseudocyst. *J Oral Maxillofac Surg.* 2015.
 6. Shupak RP. Management of Salivary Gland Injury. *Oral Maxillofac Surg Clin N Am.* 2021;33:343–350.
 7. Lee E, Magge H, Thakkar PG, Joshi A. A novel treatment of sialoceles with sodium tetradearyl sclerotherapy. *Am J Otolaryngol.* 2021.
 8. Maharaj S, Mungul S, Laher A. Botulinum toxin A for parotid sialoceles and fistula management. *Laryngoscope Investig Otolaryngol.* 2020.
 9. Lin CH, Hung SH, Su CH. Sialendoscopic approach in the management of large sialoceles of the Stensen duct. *Ear Nose Throat J.* 2019;98(6):324–325.
 10. Carlson ER, Ord R. *Textbook and Color Atlas of Salivary Gland Pathology: Diagnosis and Management.* Blackwell Munksgaard; 2008. p. 290–298.
 11. Mardani M, Arabion H. Surgical management of parotid duct injury using a feeding tube. *Ann Maxillofac Surg.* 2020;10:472–474.
 12. Singh M, Rangaswamy S, Choudry S. Parotid sialoceles and fistulae: Current treatment options. *Int J Contemp Dent.* 2011;2:9–12.
 13. Sparkman RS. Laceration of parotid duct further experiences. *Ann Surg.* 1950;131:743–54.
 14. Newman SC, Seabrook DB. Management of injuries to Stensen's duct. *Ann Surg.* 1946;124:544–56.

"Evolving Strategies in Orbital Surgery: From Traditional Techniques to Modern Innovations"

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*** Salsabeel Abdul Akbar

Abstract

Background: Surgical access to the orbit is crucial for various maxillofacial, ophthalmologic and neurosurgical procedures. This article comprehensively reviews the primary surgical approaches to the orbit, including the lower eyelid, transconjunctival, supraorbital eyebrow, and upper eyelid approaches. Each technique is discussed with an emphasis on anatomical considerations, indications, advantages, and limitations. Recent advancements such as endoscopic-assisted techniques, robotic-assisted procedures, and navigation-guided surgery have significantly improved visualization, precision, and cosmetic outcomes while minimizing complications. The evolution of orbital surgery continues to focus on minimally invasive approaches, enhanced imaging, and innovative technologies to optimize patient safety and recovery.

Key words: *Orbital trauma, approaches.*

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Introduction

Approximately 40% of all midface injuries are orbital fractures.¹ These fractures fall into two categories: those that solely impact the orbit's walls and those that also impact the orbit's rim.² Additionally,

orbital fractures can occur alone or as a component of more complex injuries such as naso-orbital ethmoid fractures, Le Fort II fractures (which are orbital floor fractures), and zygomaticomaxillary complex fractures.³ Two primary

theories—the hydraulic theory and the buckling theory—have been proposed to explain the mechanics underlying orbital floor fractures.^{4,5} According to the hydraulic theory, forces acting on the globe are pushed backward, producing hydraulic pressure that causes the orbital wall to fracture where the force is applied. Because the trabecular ethmoid air cells in the medial orbital wall provide additional support, hydraulic forces are more likely to result in isolated fractures of the orbital floor than of the latter.⁶ However, experimental tests on cadavers have demonstrated that fractures of the orbital floor and medial orbital wall can occur when high-energy forces are applied to the globe.⁷ On the other hand, according to the buckling theory, an injury force that is delivered directly to the orbital rim and nearby structures travels along the orbital wall until it hits a weak spot.^{6,8,9} The most frequent site for orbital fractures is the medial orbital wall (54.9%)¹⁰, particularly at the lamina papyracea of the ethmoid bone, which is the most fragile area of the medial wall. Other types of fractures include medial orbital wall and nasal fractures combined (46%), naso-orbito ethmoid fractures combined (26.8%), isolated fractures of the inferior wall (18.3%), zygomaticomaxillary complex

fractures (3%), and inferior orbital rim fractures (1%).¹⁰ When it comes to maxillofacial injuries, the Advance Trauma Life Support recommendations should be followed in the initial treatment plan. It is crucial to conduct a comprehensive medical history and physical examination, paying particular attention to any visual problems including double or blurred vision and vision loss. When the physical examination reveals changes in sensation, instability of the orbit, or disability in extraocular movements, there should be a strong suspicion of an orbital fracture. A positive oculo-cardiac reflex is an important physical examination finding that requires immediate attention and treatment. Bradycardia, nausea, and syncope are some of the symptoms that this illness presents with. To avoid potentially fatal cardiac arrhythmias, prompt intervention is essential (1:3500).¹¹

For diagnostic confirmation, orbital computed tomography is the gold standard.

The inferior and medial rectus muscles, which are best seen in the coronal plane, are crucial to visualize while evaluating orbital floor fractures because they may show signs of diplopia and entrapment.

Because the lamina papyracea collapses or the medial rectus muscle becomes trapped, enophthalmos, or eye retreat, is intimately associated with fractures of the medial orbital wall. A computed tomography scan may show orbital apex fractures with worsening vision, globe or optic nerve damage, periorbital emphysema, retrobulbar hematoma, and approaching bone fragments, all of which require immediate surgical treatment. It is possible for the orbital floor to "spring back" into place in youngsters, which could result in entrapment—a surgical emergency. Once surgical intervention is recommended the type of surgical approach should be determined.

In order to treat orbital fractures, four surgical techniques are available: endoscopic, transcaruncular/transconjunctival, subciliary, and sub tarsal. Even though these surgical techniques come in a variety of forms, the vast bulk of the research currently available on orbital fractures concentrates on the surgical techniques themselves, with very few studies comparing the results of various surgical approaches.¹² Additionally, just one randomized controlled experiment has evaluated the distinctions between open surgical techniques that do not use the endoscopic

technology. The objectives of this review is to make clear the advantages and risks of each surgical technique and identify the one with the lowest rates of complications.

Surgical approaches

Major Surgical Approaches

1. Lower Eyelid Approach

The lower eyelid approach is widely used for accessing the inferior and lateral orbital rims, the orbital floor, and the medial orbital rim. Several variations include:

A) Subciliary incision: Placed just below the eyelashes, ensuring minimal visible scarring.

B) Infraorbital incision: Located along the infraorbital rim, offering direct access but posing a higher risk of noticeable scarring.

Approached via the conjunctiva, eliminating external incisions and reducing the risk of complications like ectropion.

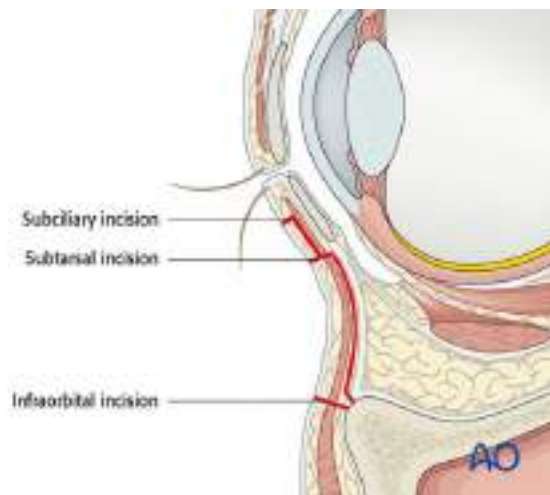


Figure 1 : Different types of lower eyelid approach

Recent Advancements:

Absorbable sutures and fibrin glue contribute to faster healing and lower complication rates.

2. Transconjunctival Approach

The transconjunctival approach, also known as the inferior fornix incision, is a minimally invasive technique that provides access to the orbital floor and infraorbital rim without leaving external scars. Two main variations exist:

Preseptal approach: Maintains the integrity of the orbital septum by placing the dissection plane anteriorly.

Retrosseptal approach: Allows direct access to the infraorbital rim but may involve periorbital fat manipulation.

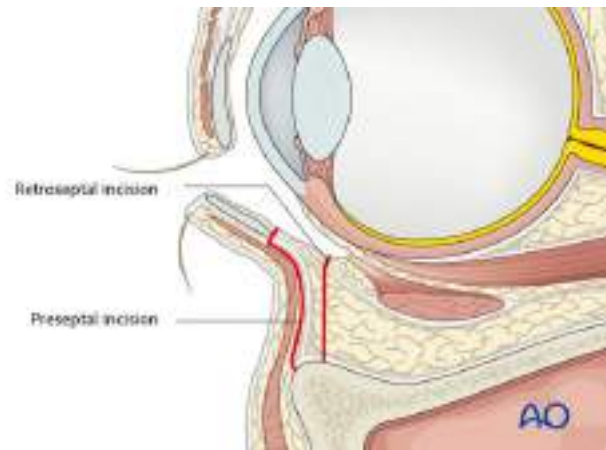


Figure 2 : Retrosseptal and preseptal incision

Recent Advancements:

Lateral canthotomy modifications improve access while preserving eyelid structure.

3. Supraorbital Eyebrow Approach

This approach provides access to the superolateral orbital rim and the frontozygomatic suture. When confined within the eyebrow, the resulting scar is typically inconspicuous. However, in individuals with limited eyebrow coverage, the incision may become more noticeable.

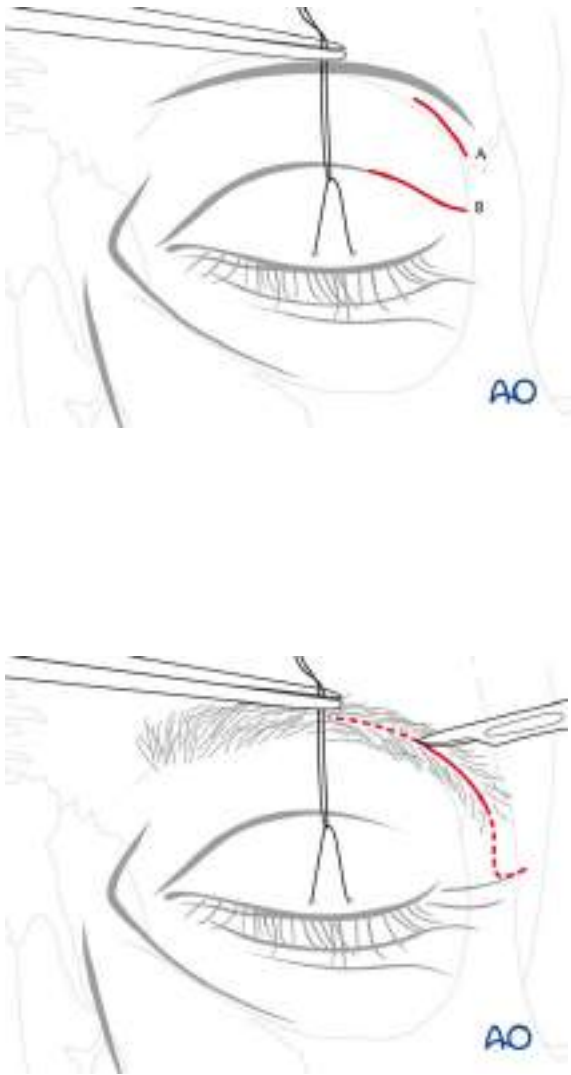


Figure 3 : Supraorbital eyebrow approach

Recent Advancements:

Tissue adhesives promote better wound healing and minimize scar formation.

4. Upper Eyelid Approach

Commonly known as the supratarsal fold or upper blepharoplasty approach, this method utilizes a natural upper eyelid

crease for incision placement, providing excellent access to the superolateral orbit.

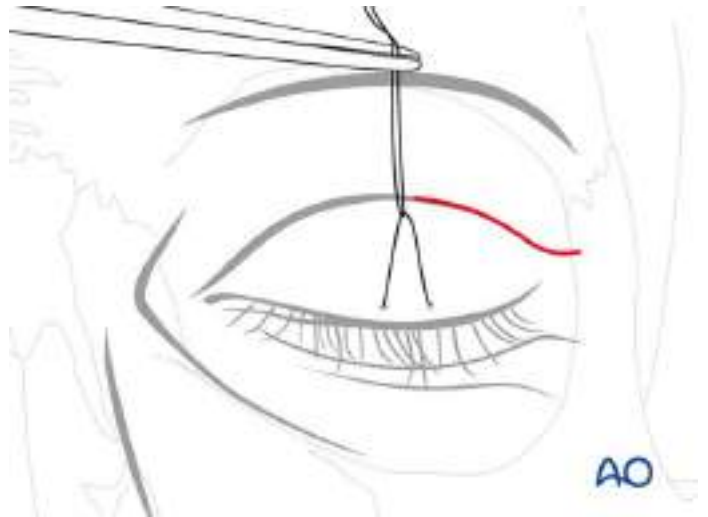


Fig 4 : Upper eyelid approach

Recent Advancements:

High-resolution imaging enhances preoperative planning and surgical precision.

Robotic-assisted procedures allow for finer dissection and improved surgical outcomes.

5. Endoscopic approach

The endoscopic approach to the orbit is a minimally invasive surgical technique that provides excellent visualization and access to the orbit while minimizing external incisions and tissue disruption. This approach is particularly useful for treating orbital fractures, tumors, and

decompression procedures for conditions such as thyroid eye disease (TED).

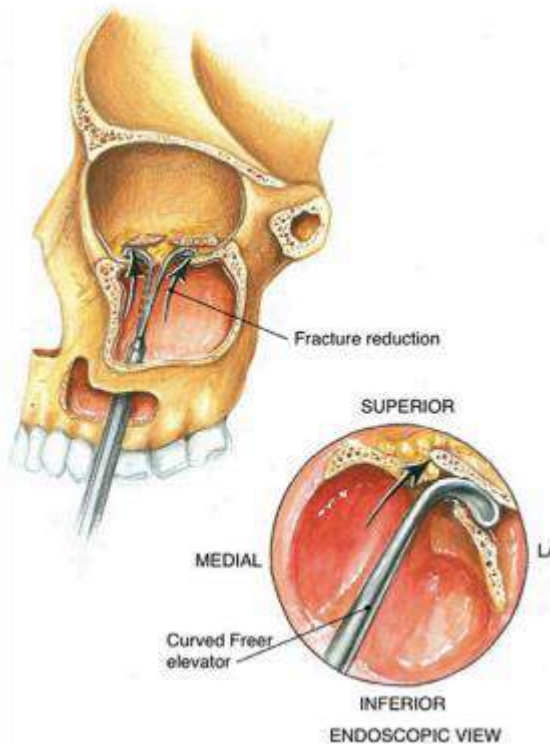


Fig 5 : Endoscopic approach

Advantages of Endoscopic Orbital Surgery

- 1. Minimal Scarring:** Since endoscopic procedures utilize small incisions, often inside the nasal cavity (endonasal approach) or through the conjunctiva, visible scarring is reduced or eliminated.
- 2. Enhanced Visualization:** High-definition endoscopic cameras provide magnified views of critical orbital structures, improving precision.

- 3. Reduced Morbidity:** Compared to traditional open techniques, endoscopic approaches reduce trauma to surrounding tissues, leading to faster recovery and less postoperative pain.
- 4. Improved Access:** Allows surgeons to approach the orbit through the nasal sinuses (e.g., transnasal/transethmoidal route), avoiding disruption of external facial structures.

Common Endoscopic Approaches

1. Endoscopic Transnasal Approach:

Used for medial and inferior orbital wall fractures, orbital decompression, and tumor excision.

Access is achieved through the ethmoid sinus, avoiding external incisions.

2. Endoscopic Transconjunctival Approach:

Ideal for procedures involving the orbital floor or infraorbital rim.

Reduces risk of eyelid malposition (e.g., ectropion) compared to subciliary or transcutaneous methods.

3. Endoscopic-Assisted Lateral Orbitotomy:

Used for lesions located in the lateral orbit or deep orbital apex.

Allows improved visualization and precision while preserving important structures.

Recent Advancements

1. **3D Navigation Systems:** Improve surgical accuracy, reducing complications.
2. **Augmented Reality (AR) Integration:** Provides real-time overlay of imaging data for enhanced intraoperative guidance.
3. **Robotic-Assisted Endoscopic Surgery:** Enhances dexterity and control, particularly for deep orbital procedures.

Discussion

The initial assessment and surgical strategy for orbital fractures are outlined and highlighted in this review. Although the likelihood of blindness occurring is low, it is crucial to report any problems associated with each surgical procedure, including retrobulbar hemorrhage, infection, intraorbital hemorrhage/hematoma, and

sensory injury.¹³ For ocular fractures, the subtarsal and transcaruncular methods have the fewest complications. When compared to conjunctival or endoscopic techniques, there were a number of scarring problems in the early days of transcutaneous orbital wall restoration. Our findings align with Bähr's 1992 study¹⁵ showing a significantly lower incidence of complications for the subtarsal approach (8.8%) compared with the subciliary (25%) and transcaruncular approaches (30.4%). The complications for the subtarsal approach include scar, scleral show, ectropion, lid edema, epiphora, keratoconjunctivitis sicca. Bähr et al¹⁵ also noted scar and scleral show as the most frequent complications for the subtarsal approach.

We have observed that scar was present more frequently in patients who had a subtarsal approach compared with those who underwent a subciliary approach. Heckler et al¹⁶ postulated that the etiology of the difference in scar formation is that the subtarsal incision has poorer muscle mobility and skin quality in comparison to the subciliary incision. Additionally, there is an increased risk for noticeable scar as the incision is further away from the lash line in comparison to a subciliary

approach.¹² Contrary to this, in 2021, Oztel et al¹⁷ found that out of a series of 67 patients who underwent subtarsal incision for orbital wall fractures, 61 had no visible scar. Although the conjunctival incision has no scar, the excellent outcomes proposed by Oztel et al¹⁷ demonstrate that scar formation may actually be limited, and that subtarsal incisions should be considered when reconstructing the orbital wall. Finally, exposure and access must be taken into account while comparing surgical techniques in order to choose the most effective one.

Comparing the transcaruncular and subtarsal incisions to the endoscopic and transconjunctival approaches, both open the orbital floor directly and widely. A lateral canthal extension can be used to extend a subtarsal incision when there is a concurrent fracture to the orbit's lateral border.¹⁸ Finally, the advancement of endoscopic procedures has led to a push for minimally invasive procedures with aesthetic results equivalent to transcutaneous methods. Han et al¹² completed a comparison study of transcaruncular approach with endoscopic endonasal reduction. After comparing the two groups, they came to the conclusion that there was no significant difference in

the degree of enophthalmos, diplopia, and extraocular movement limitation (the average decrease rate for the endoscopic technique was 89.2% against 90.7% for the transcaruncular). However, they found that the endoscopic technique was more expensive, time-consuming, and required a longer hospital stay. Subtarsal or transcaruncular treatments are now chosen due to their low complexity and inexpensive expense, but if endoscopic techniques advance, they may become the standard of care for orbital wall restoration. The orbital floor and infraorbital rim are directly approached through minimally invasive incisions in both procedures.

Conclusions

While the transconjunctival, subciliary, and endoscopic approaches were shown to have greater rates of complications, the subtarsal and transcaruncular approaches were found to have the lowest rates. The optimum course of action for patients with orbital wall fractures requires further research.

References

1. Ellis E, El-Attar A, Moos KF. An analysis of 2,067 cases of zygomatico-

- orbital fracture. *J Oral Maxillofac Surg.* 1985; 43:417–428.
2. Hsu CK, Hsieh MW, Chang HC, et al. Anatomic factors predicting postoperative strabismus in orbital wall fracture repair. *Sci Rep.* 2019; 9:14785.
3. Hopper RA, Salemy S, Sze RW. Diagnosis of midface fractures with CT: what the surgeon needs to know. *Radiographics.* 2006; 26:783–793.
4. Converse JM, Smith B. Enophthalmos and diplopia in fractures of the orbital floor. *Br J Plast Surg.* 1957; 9:265–274.
5. Smith B, Regan WF. Blow-out fracture of the orbit; mechanism and correction of internal orbital fracture. *Am J Ophthalmol.* 1957; 44:733–739.
6. Choi M, Flores RL. Medial orbital wall fractures and the transcaruncular approach. *J Craniofac Surg.* 2012; 23:696–701.
7. Rhee JS, Kilde J, Yoganadan N, et al. Orbital blowout fractures: experimental evidence for the pure hydraulic theory. *Arch Facial Plast Surg.* 2002; 4:98–101.
8. Fujino T, Makino K. Entrapment mechanism and ocular injury in orbital blowout fracture. *Plast Reconstr Surg.* 1980; 65:571–576.
9. Waterhouse N, Lyne J, Urdang M, et al. An investigation into the mechanism of orbital blowout fractures. *Br J Plast Surg.* 1999; 52:607–612.
10. Burm JS, Chung CH, Oh SJ. Pure orbital blowout fracture: new concepts and importance of medial orbital blowout fracture. *Plast Reconstr Surg.* 1999; 103:1839–1849.
11. Sires BS, Stanley RB, Jr, Levine LM. Oculocardiac reflex caused by orbital floor trapdoor fracture: an indication for urgent repair. *Arch Ophthalmol.* 1998; 116:955–956. PMID: 9682717.
12. Han K, Choi JH, Choi TH, et al. Comparison of endoscopic endonasal reduction and transcaruncular reduction for the treatment of medial orbital wall fractures. *Ann Plast Surg.* 2009; 62:258–264.
13. Jacobs SM, McInnis CP, Kapeles M, et al. Incidence, risk factors, and management of blindness after orbital surgery. *Ophthalmology.* 2018; 125:1100–1108.
14. Converse JM. Two plastic operations for repair of orbit following severe trauma and extensive comminuted fracture. *Arch Ophthalmol.* 1944; 31:323–325.

15. Bähr W, Bagambisa FB, Schlegel G, et al. Comparison of transcutaneous incisions used for exposure of the infraorbital rim and orbital floor: a retrospective study. *Plast Reconstr Surg.* 1992; 90:585–591.
16. Heckler FR, Songcharoen S, Sultani FA. Subciliary incision and skin-muscle eyelid flap for orbital fractures. *Ann Plast Surg.* 1983; 10:309–313.
17. Oztel M, Goh R, Hsu E. Subtarsal versus transconjunctival approach: a long-term follow-up of esthetic outcomes and complications. *J Oral Maxillofac Surg.* 2021; 79:1327. e1–1327.e6.
18. Wu W, Jing W, Selva D, et al. Endoscopic transcaruncular repair of large medial orbital wall fractures near the orbital apex. *Ophthalmology.* 2013; 120:404–409.

Platelet-Rich Plasma in Oral and Maxillofacial Surgery: A Regenerative Approach to Healing and Bone Repair

*Geethu Krishna S, **Vipin Das A P, *Jisha Jayakumar, *Ajna Abdul Gafoor

Abstract:

Platelet-rich plasma (PRP) is a blood-derived concentrate rich in platelets, growth factors, and cytokines that support tissue repair, bone regeneration, and wound healing. Since its introduction in the 1990s, PRP has gained widespread use in oral and maxillofacial procedures, including bone grafting, sinus augmentation, dental implant placement, and periodontal regeneration. Its ability to accelerate healing stems from its role in promoting angiogenesis, reducing inflammation, and enhancing cellular proliferation. Various preparation techniques have been developed to optimize platelet concentration and efficacy. However, inconsistencies in preparation methods, variability in clinical outcomes, and short-lived growth factor activity pose challenges to its broader adoption. To maximize PRP's potential in surgical applications, future research should focus on standardising preparation protocols, improving growth factor stability, and conducting comprehensive clinical trials. This review explores the classification, preparation techniques, mechanisms of action, and clinical benefits of PRP in oral and maxillofacial surgery.

Key words: *Platelet-rich plasma, oral surgery, maxillofacial regeneration, tissue healing, bone repair, dental implants, wound healing, growth factors, regenerative dentistry*

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Introduction

Platelet-rich plasma (PRP) is an autologous blood-derived product containing a high concentration of platelets, cytokines, and

growth factors that play a crucial role in tissue regeneration, wound healing, and bone remodeling.¹ It was introduced in the 1990s as an autologous therapy and has

since become a cornerstone of regenerative medicine. It is widely utilized in oral and maxillofacial surgery for procedures such as bone grafting, sinus augmentation, dental implant placement, periodontal regeneration, and the management of temporomandibular joint disorders (TMDs).

To enhance PRP's therapeutic potential, various preparation techniques have been developed, including modifications in centrifugation speed, platelet concentration, and activation protocols. Extensive research highlights PRP's effectiveness in promoting bone regeneration and soft tissue healing, making it a valuable asset in contemporary surgical practice. However, challenges such as variability in preparation methods, the transient nature of growth factor activity, and inconsistent clinical outcomes continue to impact its widespread application.

Standardisation of PRP protocols and further research on its long-term efficacy are necessary to maximize its regenerative potential.²

Classification of Platelet-Rich Plasma (PRP)

Ehrenfest et al. (2009) proposed a classification system that categorises PRP preparations into four main types based on their cellular content and fibrin structure: ^[3]

1. Pure Platelet-Rich Plasma (P-PRP) or Leucocyte-Poor PRP

- Contains platelets but lacks leucocytes.
- Forms a low-density fibrin network upon activation.
- Primarily used for soft tissue healing and bone regeneration.

2. Leucocyte- and Platelet-Rich Plasma (L-PRP)

- Contains both platelets and leucocytes.
- Forms a low-density fibrin network after activation.
- This category includes the most commercially available and experimental PRP systems, with many automated protocols requiring specialized kits for minimal blood sample handling and maximum standardisation.

3. Pure Platelet-Rich Fibrin (P-PRF) or Leucocyte-Poor PRF

- Contains platelets but no leucocytes.
- Characterized by a high-density fibrin network.
- Exists only as a strongly activated gel and cannot be injected or used like conventional fibrin glues.
- Promotes slow and sustained growth factor release.

4. Leucocyte- and Platelet-Rich Fibrin (L-PRF)

- Contains both leucocytes and platelets.
- Forms a high-density fibrin network.
- Ideal for tissue healing and regeneration.

This classification helps differentiate PRP formulations based on their composition and properties, aiding in their appropriate clinical application.

Preparation of Platelet-Rich Plasma (PRP)⁴

PRP is derived from a patient's blood sample collected at the time of treatment. Typically, a 30 cc venous blood draw yields 3-5 cc of PRP, depending on factors such as the individual's baseline platelet count, the device used, and the preparation technique. To prevent premature platelet activation, an anticoagulant like citrate dextrose A is added during the blood collection.

Principles of PRP Preparation⁴

PRP is obtained through **differential centrifugation**, a process in which cellular components are separated based on their specific gravity by adjusting the acceleration force. There are two primary methods for PRP preparation:

1. PRP Method (Double Centrifugation Technique)

- Whole blood (WB) is collected in tubes containing an anticoagulant.
- **First centrifugation:** This step separates the blood into three layers:
 - a. **Upper layer:** Rich in platelets and white blood cells (WBCs).
 - b. **Middle buffy coat layer:** Contains a high concentration of WBCs.
 - c. **Bottom layer:** Mostly red blood cells (RBCs).
- For **pure PRP (P-PRP)**: The upper layer and superficial buffy coat are transferred to a sterile tube.
- For **leucocyte-rich PRP (L-PRP)**: The entire buffy coat layer and a small number of RBCs are transferred.
- **Second centrifugation:** Conducted at an optimal speed to form soft erythrocyte-platelet pellets at the bottom.
- The platelet-poor plasma (PPP) from the upper portion is removed, and the remaining plasma is homogenized to produce PRP.

2. Buffy Coat Method

- Whole blood is centrifuged at high speed, leading to the formation of a

distinct **buffy coat layer**, which is rich in platelets and leucocytes.

- A challenge in this method is carefully extracting the thin buffy coat layer while avoiding contamination with the RBC layer beneath it.

Both techniques aim to maximize platelet concentration while maintaining the biological activity of PRP, making it a valuable tool in regenerative medicine and surgical applications.



Figure 1: Flowchart describing preparation of PRP ⁴

Mechanism of Action of platelet

rich plasma ^{2,5,6,7, 8}

The biological effects of PRP are primarily mediated through its high concentration of platelets, which act as reservoirs for growth factors and cytokines. The mechanism of action of PRP involves several key processes:

1. Platelet Activation and Degranulation:

- Upon injection or application, PRP undergoes activation, leading to degranulation of alpha granules within platelets.
- This releases growth factors such as PDGF, VEGF, TGF- β , and EGF, which play crucial roles in cell proliferation, angiogenesis, and tissue remodelling.

2. Angiogenesis and Increased Vascularization:

1. VEGF stimulates the formation of new blood vessels, ensuring a sufficient supply of oxygen and nutrients to the healing tissue.
- This process accelerates wound healing and enhances the regenerative potential of bone and soft tissues

3. Cell Proliferation and Differentiation:

- PDGF and TGF- β promote the proliferation and differentiation of mesenchymal stem cells (MSCs), fibroblasts, and osteoblasts.
- This leads to the formation of new extracellular matrix

components such as collagen, essential for tissue repair and regeneration.

4. Inflammation Modulation:

- PRP modulates inflammation by regulating the balance of pro-inflammatory and anti-inflammatory cytokines.

5. It enhances the activity of macrophages, which contribute to tissue repair by clearing debris and releasing additional growth factors.

Extracellular Matrix Formation and Tissue Remodeling:

- Growth factors in PRP stimulate fibroblasts and other connective tissue cells to produce collagen, fibrin, and glycosaminoglycans.
- These components help in the structural organization of healing tissues, leading to improved functional and aesthetic outcomes.

Applications in Oral and Maxillofacial Surgery

1. Effects of PRP on Alveolar Socket Healing:

- **Alissa et al. (2010)** reported improved soft tissue healing and reduced post-extraction complications in PRP-treated patients, with significantly less pain in the first three days.⁹
- **Ogundipe et al. (2011)** found PRP reduced pain, swelling, and improved bone density, though statistical significance was lacking.¹⁰
- **Ruktowski et al. (2010)** observed faster radiographic bone density increase at PRP-treated sites, though pain and bleeding remained unaffected¹¹
- Conversely, **Arenaz-Bua et al. (2010)** and **Gurbuzer et al. (2008)** found no significant impact of PRP on bone regeneration, pain, or swelling.^{12,13}

Overall, PRP improves soft tissue healing but lacks strong evidence for enhanced bone regeneration.

2. PRP in BRONJ Surgery:

Bisphosphonate-related osteonecrosis of the jaw (BRONJ) is a serious complication of bisphosphonate (BP) therapy which leads to poor vascularization and impaired healing. No standardized treatment exists,

and surgical intervention remains controversial.^{14,15}

Platelet-rich plasma (PRP) is proposed to enhance bone healing by delivering growth factors. Case studies suggest PRP may improve healing and reduce symptoms.

- **Cetiner et al. (2009)** investigated the use of PRP in six BRONJ patients undergoing surgical debridement and reported complete mucosal healing within six months, with significant symptom relief and improved bone remodeling.¹⁶
- **Bocanegra et al. (2012)** examined PRP's role in mucosal healing and pain management. The study showed faster lesion resolution within weeks, along with significant reduction in patient discomfort.¹⁷

The integration of PRP with surgical debridement appears to be a promising, minimally invasive approach for BRONJ. PRP's ability to accelerate healing, reduce symptoms, and enhance bone regeneration makes it a valuable adjunctive therapy.² However, further randomized controlled trials are needed to establish standardized protocols and confirm its long-term efficacy.²

3. Sticky Bone and Guided Bone Regeneration^{18,19,20}

- Sticky bone is formed by combining PRP with bone graft material to create a mouldable graft with enhanced osteogenic potential.
- Provides superior graft stability, promotes angiogenesis, and accelerates bone maturation.
- Useful in ridge augmentation, sinus lifts, and implant placement, as it enhances the mechanical stability of grafted material.

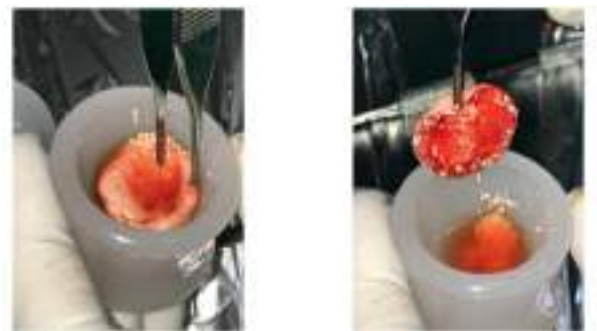


Figure 2: Sticky bone: A compact and plastic compound, evolution of the regenerative technique with CGF.¹⁸

4. Bone Regeneration: PRP has been used in mandibular fracture healing and maxillofacial bone defects, showing promising results in promoting osteogenesis and reducing healing time.^{21,22}

5. Sinus Lift Procedures: PRP has been applied in sinus augmentation surgeries to improve bone density and accelerate healing. While some studies report increased bone formation, others

indicate no significant advantage over traditional grafting materials.²³⁻²⁶

6. Implant Osseointegration: PRP has been utilized in dental implantology to enhance osseointegration by coating implant surfaces before insertion. This technique has shown potential in improving implant stability, reducing healing time, and minimizing post-surgical complications.²⁷⁻²⁹

6. Combination with Biomaterials: PRP is frequently used alongside bone grafting materials such as deproteinized bovine bone mineral (DBBM) and synthetic grafts, contributing to improved healing and graft stability.²⁶

7. TMD Management:

- **Regenerative Potential:** PRP and i-PRF release growth factors that stimulate tissue regeneration, improve cell proliferation, and promote angiogenesis, making them effective in treating TMDs^{30,31}

- **Pain Reduction:** PRP and i-PRF help decrease pain intensity in TMD patients by modulating inflammatory mediators like interleukins and tumor necrosis factor- α .³²

- **Improved Joint Mobility:** PRP and i-PRF enhance maximal mouth opening (MMO) and lateral and protrusive

movements by reducing inflammation and promoting tissue healing.³³⁻³⁵

- **Reduction in Joint Sounds:** Both PRP and i-PRF improve joint lubrication and restore intra-articular homeostasis, leading to a significant reduction in joint sounds in TMD patients.³⁶

- **MRI-Confirmed Structural Improvements:** Studies report positive effects on disc position and reduction of joint effusion, confirming PRP and i-PRF's role in structural restoration of TMJ.^{37,38}

Limitations of PRP^{1,2, 18}

1. High Variability in Preparation

- Differences in centrifugation protocols and preparation methods lead to inconsistent results across studies.
- Lack of standardization affects the quality and concentration of growth factors released.

2. Short-Term Growth Factor Release

- PRP provides an initial burst of growth factors but lacks sustained release, limiting long-term regenerative potential.

3. Cost and Equipment Requirements

- The preparation of PRP requires specialized equipment and trained personnel, increasing treatment costs.
- Not all clinics have access to PRP preparation systems, limiting its widespread adoption.

4. Limited Evidence for Certain Applications

- While PRP shows benefits in wound healing and bone regeneration, its effectiveness in certain applications, such as advanced bone defects, remains inconclusive.
- More randomized controlled trials are needed to validate its long-term efficacy.

Conclusion:

Platelet-rich plasma (PRP) and platelet-rich fibrin (PRF) have gained recognition as valuable regenerative therapies in oral and maxillofacial surgery, contributing to improved wound healing, pain relief, and tissue regeneration. PRF has demonstrated advantages in certain applications due to its gradual and sustained release of growth factors, whereas PRP provides an initial yet short-lived enhancement in the healing process.

Despite their benefits, PRP faces several challenges, including inconsistencies in preparation techniques, rapid depletion of growth factors, and the requirement for specialized equipment, which can limit its widespread use. These factors affect the reliability and accessibility of PRP in clinical settings.

To fully harness PRP's therapeutic potential, future research should focus on refining standardized preparation methods, developing advanced delivery systems to extend growth factor release, and conducting comprehensive clinical studies to evaluate its long-term efficacy. With continuous advancements, both PRP and PRF are poised to play a crucial role in regenerative medicine and surgical applications.

References:

1. Anitua E, Fernández-de-Retana S, Alkhraisat MH. Platelet rich plasma in oral and maxillofacial surgery from the perspective of composition. *Platelets*. 2021 Feb 17; 32(2):174-182.
2. Albanese A, Licata ME, Polizzi B, Campisi G. Platelet-rich plasma (PRP) in dental and oral surgery: from the wound healing to bone

- regeneration. *Immun Ageing*. 2013 Jun 13;10(1):23.
3. Dohan Ehrenfest DM, Rasmusson L, Albrektsson T. Classification of platelet concentrates: From pure platelet-rich plasma (P-PRP) to leucocyte-and platelet-rich fibrin (L-PRF). *Trends Biotechnol* 2009;27:158-67.
 4. Dhurat R, Sukesh M. Principles and Methods of Preparation of Platelet-Rich Plasma: A Review and Author's Perspective. *J Cutan Aesthet Surg*. 2014 Oct-Dec;7(4):189-97.
 5. Marx RE: Platelet-rich plasma: a source of multiple autologous growth factors for bone grafts. In *Tissue Engineering: Applications in Maxillofacial Surgery and Periodontics*. Edited by Lynch SE, Genco RJ, Marx RE. Chicago:Quintessence; 1999:71–82.
 6. Yang D, Cheng J, Jing Z, Jin D: Platelet-derived growth factor (PDGF)-AA:a self-imposed cytokine in the proliferation of human fetal osteoblasts.*Cytokine* 2000, 12:1271–1274.
 7. Cochran DL, Wozney JM: Biological mediators for periodontal regeneration. *Periodontology* 2000, 19:40–58.
 8. Rose LF, Rosenberg E: Bone grafts and growth and differentiation factors for regenerative therapy: a review. *Pract Proced Aesthet Dent* 2001,13:725–734.
 9. Alissa R, Esposito M, Horner K, Oliver R: The influence of platelet-rich plasma on the healing of extraction sockets: an explorative randomised clinical trial. *Eur J Oral Implantol* 2010, 3:121–134.
 10. Ogundipe OK, Ugboko VI, Owotade FJ: Can autologous platelet-rich plasma gel enhance healing after surgical extraction of mandibular third molars? *J Oral Maxillofac Surg* 2011, 69:2305–2310.
 11. Rutkowski JL, Johnson DA, Radio NM, Fennell JW: Platelet rich plasma to facilitate wound healing following tooth extraction. *J Oral Implantol* 2010, 36:11–23.
 12. Arenaz-Búa J, Luaces-Rey R, Sironvalle-Soliva S, Otero-Rico A, Charro-Huerga E, Patiño-Seijas B et al : A comparative study of platelet-rich plasma, hydroxyapatite, demineralized bone matrix and autologous bone to promote bone regeneration after mandibular impacted third molar extraction. *Med Oral Patol Oral Cir Bucal* 2010, 15:483–489.

13. Gürbüz B, Pıkdöken L, Urhan M, Süer BT, Narin Y: Scintigraphic evaluation of early osteoblastic activity in extraction sockets treated with platelet-rich plasma. *J Oral Maxillofac Surg* 2008, 66:2454–2460.
14. Advisory Task Force on Bisphosphonate-Related Osteonecrosis of the Jaws: American Association of Oral and Maxillofacial Surgeons position paper on bisphosphonate-related osteonecrosis of the jaws. *J Oral Maxillofac Surg* 2007, 65:369–376.
15. Montebugnoli L, Felicetti L, Gissi DB, Pizzigallo A, Pelliccioni GA, Marchetti C: Bisphosphonate-associated osteonecrosis can be controlled by nonsurgical management. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2007, 104:473–477.
16. Cetiner S, Sucak GT, Kahraman SA, Aki SZ, Kocakahyaoglu B, Gultekin SE, Cetiner M, Haznedar R: Osteonecrosis of the jaw in patients with multiple myeloma treated with zoledronic acid. *J Bone Miner Metab* 2009, 27:435–443.
17. Bocanegra-Perez S, Vicente-Barrero M, Knezevic M, Castellano-Navarro JM, Rodriguez-Bocanegra E, Rodriguez-Millares J, Perez-Plasencia D, Ramos-Macias A: Use of platelet-rich plasma in the treatment of bisphosphonate-related osteonecrosis of the jaw. *Int J Oral Maxillofac Surg* 2012, 41:1410–1415.
18. Malcangi, G.; Patano, A.; Palmieri, G.; Di Pede, C.; Latini, G.; Inchingolo, A.D.; Hazballa, D.; deRuvo, E.; Garofoli, G.; Inchingolo, F.; et al. Maxillary Sinus Augmentation Using Autologous Platelet Concentrates (Platelet-Rich Plasma, Platelet-Rich Fibrin, and Concentrated Growth Factor) Combined with Bone Graft: A Systematic Review. *Cells* 2023, 12, 1797.
19. Tony, J.B.; Parthasarathy, H.; Tadepalli, A.; Ponnaiyan, D.; Alamoudi, A.; Kapil, M.A.; Alzahrani, K.J.; Alsharif, K.F.; Halawani, I.F.; Alnfiai, M.M.; et al. CBCT Evaluation of Sticky Bone in Horizontal Ridge Augmentation with and without Collagen Membrane-A Randomized Parallel Arm Clinical Trial. *J. Funct. Biomater.* 2022, 13, 194.
20. Mitra, D.; Kandawalla, S.; Potdar, P.; Patil, S.; Naniwadekar, A.; Shetty, G. Evaluation of the Efficacy of Sticky Bone and Concentrated Growth Factor

- Membrane along with a Coronally Advanced Flap as Compared to Coronally Advanced Flap Alone in the Treatment of Miller's Class I and Class II Gingival Recession Defects. *J. Indian Soc. Periodontol.* 2022, 26, 577–584.
21. Qiao, J.; An, N. Effect of Concentrated Growth Factors on Function and Wnt3a Expression of Human Periodontal Ligament Cells in Vitro. *Platelets* 2017, 28, 281–286.
 22. Block, M.S. Treatment of the Single Tooth Extraction Site. *Oral Maxillofac. Surg. Clin. N. Am.* 2004, 16, 41–63,
 23. Clavero, J.; Lundgren, S. Ramus or Chin Grafts for Maxillary Sinus Inlay and Local Onlay Augmentation: Comparison of Donor Site Morbidity and Complications. *Clin. Implant Dent. Relat. Res.* 2003, 5, 154–160.
 24. Giannoudis, P.V.; Dinopoulos, H.; Tsiridis, E. Bone Substitutes: An Update. *Injury* 2005, 36 (Suppl. S3), S20–S27.
 25. Gheno, E.; Alves, G.G.; Ghiretti, R.; Mello-Machado, R.C.; Signore, A.; Lourenço, E.S.; Leite, P.E.C.; Mourão, C.F.; de Almeida Barros Mourão, C.F.; Sohn, D.-S.; et al. “Sticky Bone” Preparation Device: A Pilot Study on the Release of Cytokines and Growth Factors. *Materials* 2022, 15, 1474.
 26. Carlson, N.E.; Roach, R.B. Platelet-Rich Plasma: Clinical Applications in Dentistry. *J. Am. Dent. Assoc.* 1939 2002, 133, 1383–1386.
 27. Whitman, D.H.; Berry, R.L.; Green, D.M. Platelet Gel: An Autologous Alternative to Fibrin Glue with Applications in Oral and Maxillofacial Surgery. *J. Oral Maxillofac. Surg.* 1997, 55, 1294–1299.
 28. Marx, R.E.; Carlson, E.R.; Eichstaedt, R.M.; Schimmele, S.R.; Strauss, J.E.; Georgeff, K.R. Platelet-Rich Plasma: Growth Factor Enhancement for Bone Grafts. *Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod.* 1998, 85, 638–646.
 29. Grassi, F.R.; Ciccolella, F.; D'Apolito, G.; Papa, F.; Iuso, A.; Salzo, A.E.; Trentadue, R.; Nardi, G.M.; Scivetti, M.; De Matteo.; et al. Effect of Low-Level Laser Irradiation on Osteoblast Proliferation and Bone Formation. *J. Biol. Regul. Homeost. Agents* 2011, 25, 603–614.
 30. Ehrenfest DM, Rasmusson L, Albrektsson T. Classification of platelet concentrates: From pure

- platelet-rich plasma (P-PRP) to leucocyte-and platelet-rich fibrin (L-PRF). Trends Biotechnol 2009;27:158-67.
31. Albilia J, Herrera-Vizcaino C, Weisleder H, Choukroun J, Ghanaati S. Liquid platelet-rich fibrin injections as a treatment adjunct for painful temporomandibular joints: preliminary results. CRANIO 2020;38:292-304.
 32. Pihut M, Szuta M, Ferendiuk E, Zeńczak-Więckiewicz D. Evaluation of pain regression in patients with temporomandibular dysfunction treated by intra-articular platelet-rich plasma injections: A preliminary report. BioMed Res Int 2014;2014:132369.
 33. Yuce E, Komerik N. Comparison of the efficiency of intra-articular injection of liquid platelet-rich fibrin and hyaluronic acid after in conjunction with arthrocentesis for the treatment of internal temporomandibular joint derangements. J Craniofac Surg 2020;31:1870-4.
 34. Teama UA. Evaluation of Injectable platelet rich fibrin for the management of Tempromandibular joint internal derangement. (clinical evaluation). Egypt Dent J 2020;66:883-91.
 35. Kiliç SC, Güngörmüş M, Sümbüllü MA. Is arthrocentesis plus platelet-rich plasma superior to arthrocentesis alone in the treatment of temporomandibular joint osteoarthritis? A randomized clinical trial. J Oral Maxillofac Surg 2015;73:1473-83.
 36. Hegab AF, Ali HE, Elmasry M, Khallaf MG. Platelet-rich plasma injection as an effective treatment for temporomandibular joint osteoarthritis. J Oral Maxillofac Surg 2015;73:1706-13.
 37. Khallaf MG, Sidebottom AJ, farouk Elrawy H, Elmasry MS. Evaluation of platelet- rich plasma effect on treatment of temporomandibular joint anterior disc displacement. Am J Oral Maxillofac Surg 2019;6:14-26.
 38. Pasqual PG, Poluha RL, Setogutti ÊT, Grossmann E. Evaluation of effusion and articular disc positioning after two different arthrocentesis techniques in patients with temporomandibular joint disc displacement without reduction. CRANIO 2020;38:256-63.

Caldwell Luc Surgery

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Abstract

Background: The Caldwell-Luc procedure is a surgical technique used to access the maxillary sinus for various indications, including chronic sinusitis, antrochoanal polyps, and maxillary sinus tumors. Despite its widespread use, the procedure remains associated with significant morbidity and complications.

Objective: This review aims to provide a comprehensive overview of the current literature on Caldwell-Luc surgery, including its indications, surgical techniques, outcomes, and complications.

Methods: A systematic search of major databases, including PubMed, Scopus, and Web of Science, was conducted to identify relevant studies published in the last two decades. Studies were included if they reported on the outcomes, complications, or surgical techniques of Caldwell-Luc surgery.

Conclusion: Caldwell-Luc surgery remains a valuable technique in the management of maxillary sinus conditions. However, the procedure is associated with significant morbidity and complications. Further studies are needed to optimize surgical techniques, reduce complications, and improve patient outcomes.

Key words: *Caldwell-Luc Surgery, Maxillary sinus, Chronic sinusitis.*

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Introduction

The Caldwell-Luc operation, first introduced by George Caldwell in 1893

and later modified by Henry Luc in 1897, has historically been a primary surgical approach for treating chronic and recurrent maxillary sinusitis. This procedure

involves accessing the maxillary sinus through a gingivolabial incision in the canine fossa, enabling the removal of diseased mucosa and improving sinus drainage. Traditionally, it was considered a cornerstone treatment until the advent of functional endoscopic sinus surgery (FESS), which provided a less invasive alternative for managing sinus diseases.

The standard Caldwell-Luc technique includes the creation of a counter-opening in the inferior nasal meatus, promoting passive drainage of accumulated mucus. However, the addition of an inferior meatal antrostomy (IMA) remains controversial, as studies indicate that mucociliary transport naturally directs mucus towards the natural ostium, making additional openings unnecessary. While some modifications, such as the modified Caldwell-Luc without IMA, reduce surgical trauma, concerns remain regarding complications like nasolacrimal duct injury and increased operative time.

Despite its declining popularity due to the emergence of minimally invasive techniques, the Caldwell-Luc procedure remains relevant in specific cases, such as treating intranasal tumors, trauma, and providing access to the pterygomaxillary fossa. Additionally, it is still utilized by oral and maxillofacial surgeons for the removal of dental roots and antral foreign

bodies, and by head and neck surgeons for pterygomaxillary space surgeries. Modern adaptations have focused on refining the technique to ensure safer patient outcomes with minimal morbidity, reinforcing its continued role in maxillary sinus surgery.

Indication

- Treatment of upper jaw cystic lesions with antral extension
- Treatment of orbital floor fracture
- Foreign body removal
- Maxillary antral tumor biopsy
- Sinus augmentation
- Control of several hemorrhages after trauma
- Endoscopy of antral tumor
- Access to sphenoid and pterygomaxillary fossa

Maxillary Sinus

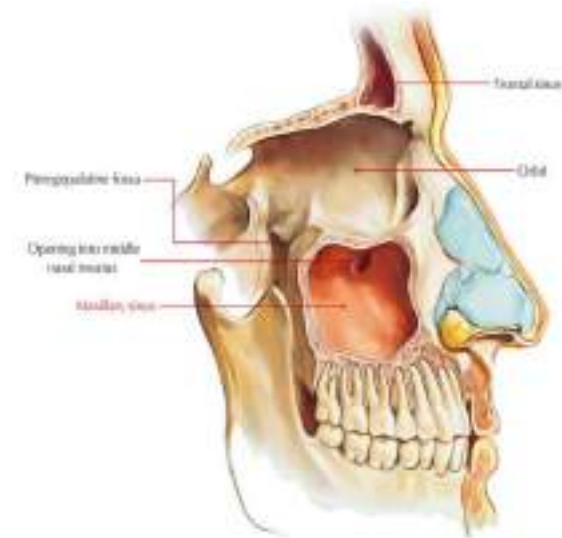
(*Sinus maxillaries*’ or *antrum of Highmore*)

The maxillary sinus is the largest of the paranasal sinuses and is located within the body of the maxilla. It has a pyramidal shape and was first described by Highmore in 1651, although its existence was known before his description. There is a possible relationship between dental pathology and the spread of infections to the maxillary



antrum, a concept later described by John Hunter.

Anatomy



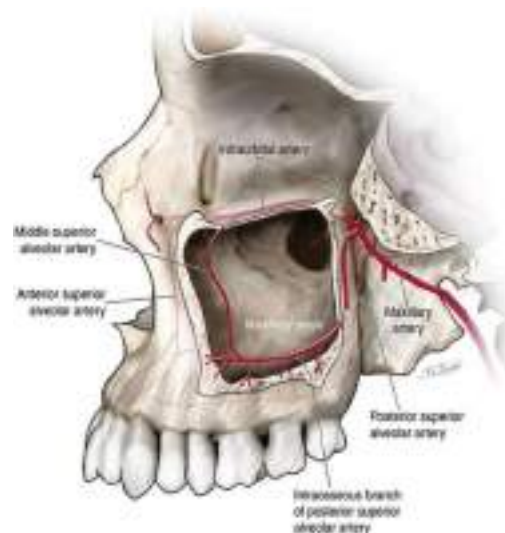
- The maxillary sinus is pyramidal in shape and the largest of the paranasal sinuses.
- Its apex is directed laterally, formed by the zygomatic process.
- The base, directed medially, is formed by the lateral wall of the nose.
- The alveolar process of the maxilla forms the floor of the sinus.
- Many projections on the floor of the antrum correspond to the roots of the first and second molar teeth.
- The nasal wall/base has a large, irregular aperture that communicates with the nasal cavity.

- In an articulated skull, this aperture is reduced in size by adjacent bones:

- o Uncinate process of the ethmoid (above)
- o Ethmoidal process of the inferior nasal concha (below)
- o Vertical part of the palatine process (behind)

Small part of the lacrimal bone (above and in front)

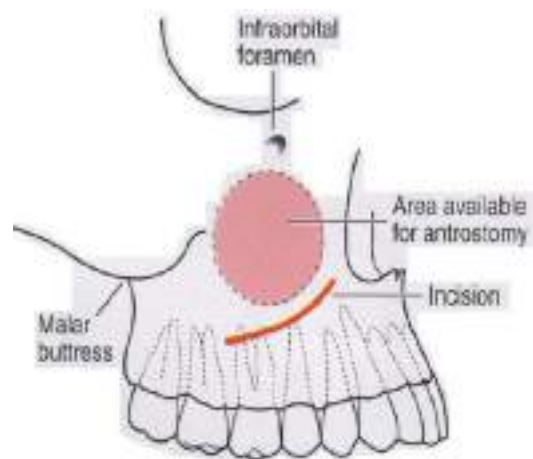
Communication with the Nasal Cavity



- The maxillary sinus communicates with the middle meatus of the nose, usually through two small apertures.
- In its fresh state, only one small opening typically exists near the upper part of the cavity, while the other opening is closed by mucous membrane.



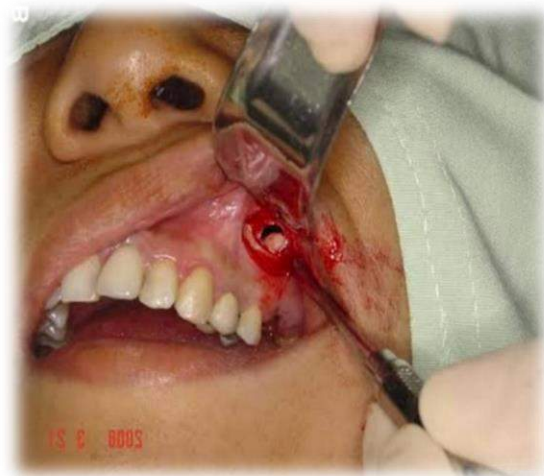
- On the posterior wall are the alveolar canals, transmitting the posterior superior alveolar vessels and nerves to the molar teeth.
- The infraorbital canal usually projects into the cavity as a well-marked ridge extending from the roof to the anterior wall. Additional ridges are sometimes seen in the posterior wall of the cavity and are caused by the alveolar canals.
- The size of the cavity varies in different skulls and even on the two sides of the same skull.



Instruments required for surgery

- Retractors
- Nasal speculum
- Periosteal elevator
- Gouge
- Nasal trocar
- Kerrison or back biting forcep
- Rongeurs
- Antral forceps
- Antral rasp
- Antrum curettes

Surgical Procedure



Preoperative amoxicillin with clavulanic acid 625 mg twice a day and steam inhalation was started 3 days before surgery.

□ Incision:

- Extends from the apex of the canine down to the gingival margin and posteriorly to the second molar.
- In edentulous cases, the incision is extended along the alveolar ridge.
- The incision must be larger than the bone window to be cut.
- The mucoperiosteum is detached and retracted up to the infraorbital ridge, taking care to preserve the integrity of the infraorbital nerve.
- A small gouge is used to perforate the center of the canine fossa.
 - The hole is enlarged using rongeurs or Kerrison forceps to allow introduction of at least the index fingers.
 - The finger is used to palpate the lining of the sinus.
- Blood and pus are removed using an aspirator.
 - Bleeding may be arrested by inserting small sponges saturated with adrenaline.
- The antrum is inspected using a nasopharyngoscope to visualize the antral walls and identify any foreign bodies (e.g., cotton, gauze, or debris pushed into a tooth socket).

□ If the antral membrane is thickened, hyperplastic, or cystic degeneration has occurred, all diseased tissue should be removed.

Granulomatous tissue may be found on the floor of the sinus if an abscessed tooth has caused the infection.

- Perforation may occur during tooth extraction, leading to sinus complications.
- A curette may be used to remove inflammatory granulation tissue.

Postoperative Management

- The socket should be allowed to fill with a healthy blood clot to support proper healing.
- Finally, gingival margins may be approximated by suturing.

Following the operation ice packs may be used to reduce swelling and the chance of bleeding. Discomfort managed by pain medication

Complication

- Cheek discomfort
- Facial swelling
- Facial parasthesia
- Oroantral fistulae
- Dacryocystitis
- Devitalized tooth
- Recurrent polyps
- Recurrent sinusitis

Discussion

More than a century ago, George Caldwell and Henri Luc introduced a surgical approach to the maxillary antrum, which remains valuable even after the advent of functional endoscopic sinus surgery (FESS). The Caldwell-Luc procedure, in its original form, involves creating an opening in the anterior maxillary wall, superiorolateral to the canine bulge, followed by removal of diseased mucosa from the inner antral wall. Additionally, it includes an opening in the nose, positioned below the inferior turbinates. Essentially, this procedure requires intraoral antrostomy with an inferior meatal antrostomy (IMA). However, in specific situations, such as the removal of a displaced tooth in the antrum, a modified Caldwell-Luc procedure is preferred. In such cases, the operation may be limited to an intraoral antrostomy, without the need for an inferior meatal antrostomy or extensive stripping of antral mucosa.²¹

The Caldwell-Luc operation, a time-tested surgical technique, has played a crucial role in treating sinus diseases for over a century. Although endoscopic sinus surgery has largely taken center stage due to its safety and effectiveness in managing chronic sinusitis, the Caldwell-Luc procedure remains a powerful tool in the

surgical arsenal. Thanks to the advancement of antibiotics and minimally invasive techniques, the need for this procedure has diminished, yet it continues to hold significant clinical value. Despite the widespread success of endoscopic techniques, the Caldwell-Luc operation still shines in cases where direct surgical access is required. It provides unparalleled exposure to the sinus, perisinus, and pterygomaxillary fossa, making it indispensable in complex clinical scenarios. Even today, surgeons rely on the Caldwell-Luc approach to tackle intrasinus cysts and tumors, foreign bodies lodged within the sinus, oroantral fistulae, and maxillary osteonecrosis. It also remains a go-to option for managing severe epistaxis, sinusitis with irreversible mucosal changes, mycotic fungal balls, and facial trauma, proving that while newer techniques evolve, some classics never fade.^{3,5}

In the Caldwell-Luc procedure, Inferior Meatal Antrostomy (IMA) is often performed to enhance postoperative drainage, allowing blood and sloughs to exit through gravity. However, the necessity of IMA in this procedure remains a topic of ongoing debate among surgeons. When dealing with odontogenic maxillary sinusitis, a multifaceted approach that combines medical and

surgical interventions is typically required. Unlike rhinogenic sinusitis, which has a distinct underlying cause, odontogenic sinusitis demands a tailored management strategy. The condition usually arises when the ciliary function of the Schneiderian membrane is disrupted, often due to odontogenic infections or iatrogenic factors like tooth extraction. To achieve optimal recovery, treatment must not only target the sinus infection but also address the underlying odontogenic source—ensuring a comprehensive and effective resolution.^{13,14}

The Caldwell-Luc operation has been utilized for various indications over the years, with its applications evolving across multiple studies. It is frequently employed in the management of orbital floor fractures, treatment of upper jaw cystic lesions such as dentigerous cysts with antral extension, foreign body removal, and maxillary antral tumor biopsy. Additionally, this procedure is valuable in sinus augmentation, controlling severe hemorrhage following facial trauma, and facilitating endoscopic evaluation of antral tumors while also providing access to the sphenoid and pterygomaxillary fossa. Today, the modified Caldwell-Luc procedure serves as a strategic approach for hemorrhage control, particularly in cases requiring immediate surgical access.

A notable example is its use in managing traumatic injuries, such as the withdrawal of an impaled knife from the maxillary antrum, where CT scans can be instrumental in identifying the posteromedial antral wall involvement. Despite its effectiveness, a significant drawback of the procedure is the high incidence of Inferior Meatal Antrostomy (IMA) closure or stenosis. Clinical reports indicate a 70% patency rate for IMAs, whereas middle meatal antrostomy achieves a higher success rate of 90%, making it a preferred alternative in many cases.^{15,17}

In 1887, Miculiker described the Caldwell-Luc operation, along with Inferior Meatal Antrostomy (IMA), as a widely used surgical procedure for managing maxillary sinus diseases. However, its popularity has declined due to a better understanding of mucociliary transport, which naturally directs mucus towards the maxillary ostium.

Several concerns have been raised against the use of IMA, including persistent sinus diseases post-surgery, low patency rates, and the risk of injury to the nasolacrimal duct or developing canine teeth. Additionally, the technical complexity of the procedure has contributed to its reduced preference. Hilding suggested that creating an inferior meatal window may

have a negative impact on long-term mucociliary clearance. Kennedy and Shaaken further observed that the mucociliary clearance pattern does not naturally reorient, even after separate antrostomy or radical mucosal removal. When mucociliary clearance is intact, it follows the natural ostium. Any widening of the ostium can disrupt the normal clearance pattern, emphasizing that the ciliary mucosa near the natural ostium should remain untouched to preserve its function.²²

The Caldwell-Luc procedure is associated with several reported complications, including cheek discomfort (33%), facial swelling (90%), fever (10%), hemorrhage, facial asymmetry, paresthesia, oroantral fistulae, dacryocystitis, devitalized teeth, recurrent polyps, and recurrent sinusitis. The modified Caldwell-Luc operation is primarily performed for odontogenic sinusitis and related odontogenic pathologies, focusing on the removal of diseased sinus mucosa. Unlike the classic approach, the Inferior Meatal Antrostomy (IMA) is not performed in the modified technique, as the pathophysiology of odontogenic sinusitis differs from rhinogenic sinusitis. To manage postoperative bleeding and facial swelling, the sinus cavity is packed with iodoform gauze impregnated with

bacitracin-neomycin, ensuring immediate hemostasis and reducing complications.²²

Conclusion

The Caldwell-Luc procedure is a surgical technique used to access the maxillary sinus for various indications, including chronic sinusitis, Antro choanal polyps, and maxillary sinus tumors. The procedure involves creating an opening in the anterior wall of the maxillary sinus through the canine fossa, allowing for direct access to the sinus cavity. Although The Caldwell-Luc procedure remains an important surgical technique in the management of maxillary sinus conditions. While endoscopic approaches have reduced the need for traditional Caldwell-Luc procedures in some cases, the technique remains a valuable tool in the armamentarium of the otolaryngologist and oral and maxillofacial surgeon.

References

1. Barzilai G, Greenberg E, Uri N. Indications for the Caldwell-Luc approach in the endoscopic era. *Otolaryngol Head Neck Surg*, 2005; 132: 219-20.
2. Tange RA. Some historical aspects of the surgical treatment of the infected maxillary sinus. *Rhinology*, 1991; 29: 155-7.

3. Matheny KE, Duncavage JA. Contemporary indications for the Caldwell-Luc procedure. *Curr OpinOtolaryngol Head Neck Surg*, 2003; 11: 23-5.
4. Brook IL. Sinusitis: From Microbiology to Management. New York, Taylor & Francis, 2006.
5. Defreitas J, Lucente FE. The Caldwell-Luc procedure: Institutional review of 670 cases: 1975-85. *Laryngoscope*, 1297; 98: 78-9.
6. Al-Belasy FA. Inferior meatal antrostomy: Is it necessary after radical sinus surgery through the Caldwell-Luc approach? *J Oral MaxillofacSurg*, 2004; 62: 559-61.
7. Lal D, Stankiewicz JA. Primary sinus surgery, in Cummings Otolaryngology: Head & Neck Surgery (ed 5): 740-58, St. Louis, Mosby, 2010.
8. Saito H, Takanami N, Saito T. Studies on the Caldwell-Luc operation with or without counteropening at the inferior meatus. *ORL J OtorhinolaryngolRelat Spec*, 1990; 52: 249-53.
9. Linuma T, Oosawa H, Jaruyama K. Morphology of the inferior nasal meatus. *PractOtolKyoo*, 1982; 75: 931-3.
10. Arnes E, Anke IM, Mair IW. A comparison between middle and inferior meatal antrostomy in the treatment of chronic maxillary sinus infection. *Rhinology*, 1985; 23: 65-7.
11. Kennedy DW, Shaalan H. Reevaluation of maxillary sinus surgery: Experimental study in rabbits. *Ann OtolRhinolLaryngol*, 1989; 98: 901-6.
12. Bailey BJ, Johnson JT. Head and Neck Surgery—Otolaryngology (ed 4). Lippincott Williams & Wilkins, 2006.
13. Car M, Juretic M. Treatment of oroantral communication after tooth extraction. Is drainage into the nose necessary or not? *Acta Orolaryngol (Stockh)*, 1998; 118: 844-8.
14. Kretzschmar DP, Kretzschmar JL. Rhinosinusitis: Review from a dental perspective. *Oral Surg Oral Med Oral Pathol Oral RadiolEndod*, 2003; 96: 128-31.
15. Lund VJ. Inferior meatal antrostomy. Fundamental considerations of design and function. *J Laryngol Otol Suppl*, 1998; 15: 1-3.

16. Hilding AC. Experimental sinus surgery: Effects of operative windows on normal sinuses. *Ann OtolRhinolLaryngol*, 1941; 50: 379-81.
17. Benninger MS, Kaczor J, Stone C. Natural ostiotomy vs. inferior antrostomy in the management of sinusitis: An animal model. *Otolaryngol Head Neck Surg*, 1993; 109: 1034-49.
18. Davis WE, Templer JW, Lamear WR. Patency rate of endoscopic middle meatus antrostomy. *Laryngoscope*, 1991; 101: 416-9.
19. Han JK, Smith TL, Loehrl TA. Surgical revision of the post-Caldwell-Luc maxillary sinus. *Am J Rhinol*, 2005; 19: 478-81.
20. Dong J, Lu M, Zhou H, Zhang W, Li Y, Dong W. Clinical analysis of primary nasal sinus osteoma. *Journal of clinical otorhinolaryngology, head and neck surgery*, 2015; 50: 8-13.
21. Xu W, Zhao C, Jin L, Ge R. Clinical analysis of simple orbital lowout fracture. *Journal of clinical otorhinolaryngology, head and neck surgery*, 2015; 29: 418-21.
22. Messerklinger W. On the drainage of the human paranasal sinuses under normal and pathological conditions, 1966; 100: 56-68.
23. Huang, Wen-Ho-Chen. Caldwell-Luc operation without inferior meatal antrostomy: A retrospective study of 50 cases, 2012; 98: 45-9.
24. Matheny KE, Duncavage JA: Contemporary indications for the Caldwell-Luc procedure. *Curr Opin Otolaryngol Head Neck Surg* 11:23, 2003
25. Brook I: Sinusitis: From Microbiology to Management. New York, Taylor & Francis, 2006
26. Defreitas J, Lucente FE: The Caldwell-Luc procedure: Institutional review of 670 cases: 1975-1985. *Laryngoscope* 98:1297, 1998

Photogrammetry

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Abstract

This review article provides a comprehensive review that underscores the potential for Photogrammetry, a non-invasive imaging technique, that has become indispensable in modern dentistry. This technique utilizes photographs to create accurate 3D models of patients' oral cavities, facilitating meticulous pre-surgical planning and ensuring superior patient outcomes. Recent advancements in artificial intelligence and augmented reality promise to further refine photogrammetric applications, making dental procedures more predictable and aesthetically pleasing. The integration of photogrammetry in dental practices signifies a leap towards personalized, patient-centric care.

Key words: *Photogrammetry, coordinates, 3D models, 2D photographs and objects*

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Introduction

Advancements in dental technology have continuously reshaped the landscape of modern dentistry, enhancing precision, efficiency, and patient outcomes. In the ever-evolving landscape of dental technology, photogrammetry has emerged as a pivotal innovation, transforming the

way practitioners capture and utilize dental images.

This technique, based on the science of capturing accurate measurements through photography, marks a significant advancement from traditional impression methods to a digital realm of precision and efficiency. By obtaining detailed three-dimensional data through photographs,

this method has transformed the way dental professionals approach implant procedures. It provides unmatched accuracy in measuring implant positions and facilitates the transfer of these coordinates into clinical practice.¹

With over a million implant procedures conducted annually worldwide, the integration of photogrammetry with virtual implant planning systems and cone beam computed tomography (cbct) data has significantly enhanced the project planning phase for dental implants.² research has shown that photogrammetry devices are more accurate for complete-arch implant rehabilitation than intraoral scanners and traditional impression methods.³

Principles of photogrammetry

Photogrammetry is a technique that involves the application of photographic images to measure and map the dimensions and spatial relationships of objects. This technique allows for the accurate interpretation of photographic images to provide detailed information about real-world objects and its surrounding space.⁴

It has been applied into clinical dental research as a non-invasive tool that uses photographs to create three-dimensional

models of teeth and oral structures, providing a detailed visual representation that is crucial for accurate diagnostics and treatment planning.⁵

The fundamental principles of photogrammetry involves the following processes:

1) Image acquisition

□ Photography: photogrammetry begins with capturing multiple overlapping photographs of the subject from different angles. In dental applications, intraoral scanners or cameras are used to take detailed images of the patient's oral structures.

□ Lighting: proper lighting is crucial for obtaining high-quality images. Consistent and adequate illumination helps to minimize shadows and reflections, ensuring that the photographs accurately represent the dental structures.



2) Image processing

□ Feature detection: specialized software identifies and extracts unique features from the images, such as edges, corners, and textures. These features serve as reference points for aligning and matching the images.

□ Image matching: the software matches corresponding features across multiple images,

Establishing a network of points that relate the photographs to each other spatially.

3) 3D reconstruction

□ Triangulation: by using the matched points, the software performs triangulation to calculate the 3d coordinates of each point. Triangulation involves determining the location of a point in 3d space by measuring angles from known reference points.

□ Model generation: the calculated 3d coordinates are used to generate a detailed digital model of the dental structures. This model can be visualized, manipulated, and analyzed using various software tools.

4) Accuracy and precision

□ Calibration: to ensure accuracy, photogrammetry systems must be calibrated. Calibration involves defining the parameters of the imaging system, such

as camera position, orientation, and lens distortion.

□ Error minimization: techniques such as bundle adjustment are employed to minimize errors and improve the precision of the 3d model. Bundle adjustment refines the 3d coordinates by optimizing the alignment of all images in the dataset.

Equipment and technology in photogrammetry

The technological backbone of photogrammetry in dentistry is comprised of advanced equipment and software that work in tandem to produce accurate 3d models. The primary tool used in this technique is a photogrammetry camera, which is specifically designed to capture high-resolution images with precise calibration to ensure measurement accuracy. These cameras are often accompanied by a series of coded targets placed on the object of interest, which serve as reference points for the software during image processing. In addition to the camera, photogrammetry uses sophisticated software that can do intricate calculations to create a 3d model from 2d photos.

This software utilizes algorithms that identify and match patterns across multiple photographs, permitting the development

of a digital model that precisely captures the geometry of the oral cavity¹⁰

In recent times, photogrammetry systems have also incorporated facial scanning technologies. Facial scanners provide a comprehensive view of the patient's face, which is essential for procedures that require a detailed understanding of both dental and facial structures.

These scanners have been evaluated in terms of their importance, applications, limitations, and future directions within dental practice. The combination of these technologies has proven to be a game-changer in implant dentistry. By leveraging virtual implant planning systems alongside cbct data, dental professionals can now plan implant projects with a level of precision previously unattainable.¹²

Application in dentistry

1) Orthodontics:

Photogrammetry is employed in orthodontics for precise measurements and evaluation of facial profiles, which are necessary for diagnosing malocclusions and planning treatment strategies. This technology aids in the accurate assessment of tooth movement, alignment, and occlusion, critical

for designing custom orthodontic appliances and braces.

The precision of photogrammetry ensures that these appliances are tailored to the unique contours of each patient's oral cavity, leading to improved treatment outcomes and patient satisfaction.

Chitra et al, based on their studies concluded that photogrammetry can be effectively employed as a tool to aid orthodontic diagnosis and treatment planning.¹¹

Normando et.al in their investigation, found that with the exception of the mesio-distal width of upper first molar, photogrammetric method on standardized occlusal photographs are a reliable instrument for clinical and scientific application to measure dental arch dimensions and tooth size.¹³

2) Prosthodontics:

In prosthodontics, photogrammetry has been transformative in verifying occlusal contacts and analyzing jaw relations. It allows for a non-invasive and distortion-free capture of complete arches, which is essential for creating precise prosthodontic devices such as

crowns, bridges, and dentures.

The technology also facilitates the assessment of tooth preparations to ensure that prosthetic components fit accurately within the patient's existing dental structure. By providing a detailed 3d reconstruction of teeth and facial anatomy, photogrammetry assists prosthodontists in achieving a higher level of aesthetic and functional restoration.¹⁴

3) Implantology:

The application of photogrammetry in implantology has significantly enhanced the precision of implant placement. By creating detailed three dimensional models of the oral cavity, implantologists can plan surgical interventions with greater precision.

this technology allows for the assessment of bone quality and quantity, as well as the spatial orientation needed for optimal implant positioning.

Photogrammetry supports the virtual transfer of implant locations to needed for optimal implant positioning. Photogrammetry also supports the virtual transfer of implant locations to cad software, streamlining the design and fabrication process for implant-supported restorations. The application

of this technology minimizes errors and improves the predictability of implant procedures.



4) Oral surgery:

In oral surgery, photogrammetry provides surgeons with a comprehensive view of the surgical site. This level of detail is vital for complex procedures such as bone grafting or corrective jaw surgery, where spatial orientation and measurements must be exact to ensure successful surgical outcomes¹⁵

5) Maxillofacial reconstruction:

This approach is used for analysis of the maxillofacial defects and recording adequate details of the defect by means of various reference points as the geometrically complex anatomy of the orofacial structures is difficult to reproduce by conventional

means.

Also, this non-invasive technique gives better esthetics required for rehabilitation of large defects. The 3d reconstruction of large defects including ocular, orbital, nasal and auricular deformities is possible by means of photogrammetry with better accuracy and color characterization can also be done with high precision.¹⁶



6) Occlusal registration:

The first step is to place in 3d models of upper and lower teeth arches during a given position according to their location and orientation during a mouth. For this aim plaster models are installed in given posture enlist a dental articulator or silicon mould for grouping. Dental articulator is used for registering centric(normal) occlusion. Silicone mold is constructed by dentist during a mouth, jaws being in given

position conforming to left or right side occlusion. Then the silicon molds are placed between plaster teeth arch models providing plaster models being within an equivalent mutual position as real teeth arches during a mouth. During this inclination the front surface of upper and lower teeth rows is scanned. The scanned front surface of the teeth is then used as a credentials surface for jaw 3d models translating into comparable real jaws occlusion.

7) Occlusal contacts:

The conventional 2d-analysis methods have various limitations regarding the details about tooth morphology required for analysis of occlusal contacts. Photogrammetry governs 3d positional details of occlusal contacts from 2d-photos. The image is formed using the black silicone method along with the photogrammetric technique that generates facets for image construction.

These facets generate a 3d image from the data of occlusal records obtained by 2d photographs. The occlusal surface configuration was reproduced with polygons. The

textures of the occlusal contacts were drawn to each of the polygon. Establishment of occlusal facets with 3d polygons from 2d-photos with the help of photogrammetry was a drawing features of this image processing technique.

It allowed us for observing better findings of the black silicone method. On comparison with conventional 3d analysis using a 3d scanner, details of conventional 3d models did not duplicate the anatomical configuration. Even though, by integrating the findings of the interocclusal record, the dislocation of mandible and the displacement of periodontal ligaments under occlusal force were reflected in our model.

Using the polygons in the conversion of 2d images to 3d images, we would be able to define the relation between the location and direction of the occlusal contacts and facets, which was earlier difficult to detect via conventional methods. Thus, this method of making a 3d polygon model is useful for, finding the inter-occlusal records which considered the jaw/teeth behaviour under occlusal force could be observed 3-dimensionally.¹⁷

8) Evaluation and facial reconstruction:

Use of digital photos of the face became the part of the usual procedure at the planning of the dental aesthetic treatments. Some features like symmetry, smile line, contour line of the face position of the upper and lower lip, visibility of the teeth etc. Can be determined on the frontal images.

Photos must be standardized, and the position of the head and distance from the camera precisely determined in order to decrease the possibility of the mistake. At the time of determination of the symmetry of the face and teeth are used imagined horizontal and vertical lines, which could be observed in the frontal and sagittal direction.

In symmetry assessment is essential that the line which goes by the mid of the face is homogeneous to the line of the contact of the upper central incisors (interincisal line). Imagined horizontal lines significant in the aesthetic evaluation are line of the hair, line of the eye brow, inter-pupillary line, inter-alar line.¹⁴

9) 3D duplication of teeth and face:

Photogrammetric systems used in dental research are of the similar, as the object-camera distance is less than 300mm. the proposition of remodelling a 3d surface by photogrammetry is based on a method called bundle adjustment.

This method involves simultaneously refining the 3d coordinates of surface points, the different positions of the camera and the camera's optical characteristics. Virtually, positioning the intra-oral camera at angles $\alpha_1, \alpha_2, \alpha_3 \dots \alpha_{50}$ to take 50 photographs of the tooth from divergent points of view in a 15 mm radius hemisphere.

An overlaying of 60% between the sequential photographs is considered necessary to automatically find some correspondences between the points of a photograph and the subsequent photograph. The supreme results are obtained when we do not change the distance to the tooth between successive photographs.

All photographs are unified on the tooth, with approximately half of the adjacent tooth in the field of view. All the obtained photographs

are then sent to the autodesk cloud via the internet to be transformed into 3d models. Three uploads are performed separately for each image acquisition series (images of the tooth of interest and adjacent teeth, images of the opposing teeth, and images of the teeth in occlusion).

10) Production of 3d models:

Photogrammetric technique has been used considerably in a diversity of regulation to give rise to models across a extent of scales, from landscapes to small objects within physical anthropology, it is viable to take precise assessment of larger skeletal elements, such as crania, employing photogrammetric models instead of the original specimens.

Gross tooth shape was captured effectively using sfm photogrammetry and hold up foregoing studies that have found moderately low levels of variation between point clouds of small articles derived from sfm and sls systems, the adjacent approximation of the overall size and shape of the sfm virtual models is close to the 0.1 mm accuracy that has been put forward as necessary

for virtual models to hold diagnostic value for clinical treatment.



Advantages of photogrammetry

Photogrammetry stands out in the field of dentistry for its precision and efficiency. Here are a few specific benefits that have been proven by research:

1. Precision in data acquisition: high accuracy in getting 3d data is a well-known feature of photogrammetry. This is especially helpful in implantology, where accurate measurements are necessary to achieve favourable results.¹⁷
2. Non-invasive nature: the contactless application of photogrammetry ensures a non-invasive experience for patients. This is a significant advantage over traditional impression methods that can be uncomfortable, especially for those with a sensitive gag reflex.⁵
3. Rapid processing capabilities: photogrammetry allows for the digital

processing of vast amounts of information swiftly, which is necessary in today's fast-paced clinical settings. The acquisition of virtual models with high accuracy in a short period is essential component in reducing the treatment duration.¹⁸

4. Cost-effectiveness: the simplicity and affordability of photogrammetry make it a cost-effective alternative to other more complex imaging techniques. This is especially crucial in environments with limited resources and concerns about budgetary restrictions.¹⁹

Challenges and limitations of photogrammetry

While photogrammetry offers numerous advantages in dentistry, it is not without its challenges and limitations. The following are some main imitations that are backed up by research:

1. Limited recording capabilities: photogrammetry primarily records the position information of implant abutments but requires additional procedures to capture soft tissue information. This limitation can affect comprehensive treatment planning.¹
2. Photographic challenges: the process of recording the surface shape of a living tooth in the mouth presents significant photographic challenges, such as

achieving adequate lighting and managing patient movement during image capture.

3. Precision concerns: although photogrammetry can achieve levels of trueness and precision comparable to conventional methods, there is limited assessment on the accuracy when combining screw-retained optical markers with photogrammetry technology for recording implant positions.¹⁴

4. 3D representation limitations: conventional dental photography, which provides high degree of spatial resolution and color, is limited to 2d information. Without a comprehensive 3d representation, diagnosis and treatment can be complicated, necessitating multiple photos from different angles.¹³

5. Need for further studies: while photogrammetry is accurate for transferring implant positions during multiunit implant prostheses treatment, further research are required to enhance its 3d scanning capabilities and address its limitations.

Conclusion:

The photogrammetric system of images accession has long been used in various fields of science and industry. Its advantages include the clarity and cost effectiveness of technical execution, high

accuracy of the obtained data, complete contactless application and the chances for the digital processing of a wide amount of information over a short period of time, acquisition of a virtual model of high accuracy.

The developed techniques allow fast and precise information generating full 3d model of a teeth arches in given occlusion and a multi-resolution face 3d model for treatment planning and visualisation. The developed software gives to a dentist new effectual and convenient means for teeth occlusion study, treatment planning and documenting. This technology is a boon for prosthodontics, while this technology still does not provide enough precision or proven accuracy for incorporation into the treatment flow, it is a fascinating tool for the diagnosis, planning, and storing of documentation.

More studies are needed before this methodology can be designated for a clinical application, such as for the preparation of guides for guided implant surgery. Upcoming agreements should be tested with the acquisition of new tools, such as the integration of target references, other photographic settings and alternative software.

References

1. Hussein MO. Photogrammetry technology in implant dentistry: a systematic review. J prosthet dent. 2023 Sep;130(3):318-326.
2. Ma B, Yue X, Sun Y, Peng L, Geng W. Accuracy of photogrammetry, intraoral scanning, and conventional impression techniques for complete-arch implant rehabilitation: an in vitro comparative study. BMC Oral health. 2021 Dec 10;21(1):636.
3. Lie A, Jemt T. Photogrammetric measurements of implant positions.description of a technique to determine the fit between implants and superstructures. Clin oral implants res. 1994;5 Mar;5(1):30–6.
4. Jemt T, Back T, Petersson A. Photogrammetry: an alternative to conventional impressions in implant dentistry? A clinical pilot study. Int J Prosthodont. 1999;12:363–8.
5. Chadwick RG. Close range photogrammetry--a clinical dental research tool. J dent. 1992 Aug;20(4):235-9.
6. Mitchell HL, Chadwick RG. Challenges of photogrammetric intra-oral tooth measurement. The international archives of the photogrammetry, remote sensing and spatial information sciences, kyoto, japan. 2008 Jan 1:779-82.
7. Deepika B. Capturing precision: the growing role of photogrammetry in implant dentistry. Iosr J Dent Med Sci. 2023;22(4):46-49
8. Yang B, Schinke J, Rastegar A, Tanyeri M, Viator Ja. Cost-effective full-color 3d dental imaging based on close-range photogrammetry. Bioengineering. 2023; 10(11):1268.
9. Divya B, Deshraj J, Mukesh S, Neelam N. Photogrammetry in prosthodontics - a review - IJFMR volume 5, issue 4, july-august 2023.
10. Chitra P, Prakash A. Photogrammetry as a tool to aid orthodontic diagnosis and treatment assessment. Journal of contemporary orthodontics. 2017;1(2):46-51.
11. Normando D, Da Silva PL and Mendes ÁM, 2011. A clinical photogrammetric method to measure dental arch dimensions and mesiodistal tooth size. Eur J Orthod, 33(6):721-6.
12. Matsuo M, Mine Y, Kawahara K, Murayama T. Accuracy evaluation of a three-dimensional model generated from patient-specific monocular video data for maxillofacial prosthetic rehabilitation: a

pilot study. *Journal of Prosthodontics*. 2020 Oct;29(8):712-7.

13. Unkovskiy A, Spintzyk S, Beuer F, Huettig F, Röhler A, Kraemer-Fernandez P. Accuracy of capturing nasal, orbital, and auricular defects with extra-and intraoral optical scanners and smartphone: an in vitro study. *Journal of dentistry*. 2022 Feb 1;117:103916.

14. Vukovic A, Jakupovic S, Zukic S, Secic S, Bajsman A. Computer aided photogrammetry for evaluation of facial and dental symmetry. *Acta informatica medica*. 2010 Apr 1;18(2):88.

15. Korol DM, Kindiy DD, Kindiy PD, Odzhubeiska OD, Toncheva KD. Photogrammetry in dentistry: a literature review. The medical and ecological problems. 2022 Apr 15;26(1-2):32-6.

16. Revilla-León M, Att W, Özcan M, Rubenstein J. Comparison of

conventional, photogrammetry, and intraoral scanning accuracy of complete-arch implant impression procedures evaluated with a coordinate measuring machine. *J prosthet dent*. 2021 Mar;125(3):470-478.

17. Magnani M, Douglass M, Schroder W, Reeves J, Braun Dr. The digital revolution to come: photogrammetry in archaeological practice. *American antiquity*. 2020 Oct;85(4):737-60.

18. Yang b, schinke j, rastegar a, tanyeri m, viator ja. Cost-effective full-color 3d dental imaging based on close-range photogrammetry. *Bioengineering (basel)*. 2023Oct31;10(11):1268.

19. Menezes md, sforza c. What's new in dentistry three-dimensional face morphometry. *Dental press Journal of Orthodontics*. 2010;15:13-5.

Maturation index of the oral mucosa in normal menstruating females of younger age group.

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Abstract

Background: Oral cavity represents a target organ for various hormones specially the sex hormones. Maturation of the mucosa is quantitatively proportional to the amount of sex hormones. This study was done to determine the cytology with regard to maturation of exfoliated cells of the oral mucosa during the course of normal menstrual cycle. Thus to evaluate effect of ovarian steroid hormones on the maturation of buccal mucosa during the various phases of menstrual cycle.

Method: Study comprised of forty healthy young females with normal menstrual cycle. Smears were collected from their buccal mucosa twice per week for a period of three months. Cytological smears were stained using Papanicolaou stain and different cell populations were counted. Mean maturation index or percentage relation of parabasal-intermediate-superficial cells were calculated during various phases of the menstrual cycle. Data was subjected to statistical analysis wherein descriptive statistics was performed.

Results: Increase in superficial cell count is observed in bleeding, proliferative and ovulation phase of menstrual cycle, where as secretory phase showed more or less an equal amount of superficial and intermediate cells. Good correlation was found between maturation index and staging of menstrual cycle.

Conclusion: In our study maturation index results suggested a normal pattern of maturation of oral mucosa. Thus oral cytology may reflect hormonal pattern.

Key Words: *Maturation Index, Oral Cytology, Sex hormones, Menstrual cycle*

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Introduction

Hormones are specific regulatory molecules that modulate reproduction, growth, development and maintenance of the internal environment as well as energy production, utilization and storage (Mariotti 1994).¹ For several hormones, the oral cavity serves as a target organ² and squamous cells of the oral mucosa mature as a result of sex hormones. The oral cavity is affected differently by changes in hormonal levels throughout adolescence, pregnancy, menstruation, and menopause. Many researchers have proposed a direct link between changing hormonal status and oral health among females.³

A woman's menstrual cycle, with the exception of pregnancy, is the outcome of a series of hormonal impacts from adolescence through menopause.⁴ First phase of menstruation is bleeding which lasts 4-5 days. Proliferative stage starts from sixth to fourteenth day, ovulation occurs at about the fourteenth day, followed by progestation or secretory phase.⁵ During the early half of the menstrual cycle, oestrogen gradually rises before falling. The progesterone level gradually increases throughout the second half of the menstrual cycle.⁶ During menstrual period there is a decline in the level of two hormones. Based on the level

of cellular maturity or cell pattern morphology, which is quantitatively proportional to the actual amount of sex steroids present, the basic principal of hormonal evaluation by vaginal cytology is based on the amount of sex steroids.⁷

Maturation Index (MI) is the count of the parabasal, intermediate and superficial cells expressed in percentage, it was first described by Nyklicek and expresses the maturation of squamous epithelial cells.⁴ MIs are useful for evaluating hormonal function. Maturation Index (MI) is based on the assumption that the sex hormones estrogen, progesterone and androgens (testosterone) bring about maturation in squamous cells that can be detected by cytological examination. The higher the number of mature cells that is superficial and intermediate indicates higher the maturation index or estrogen effect in the body.⁸

Vaginal and buccal epithelia are microscopically similar.⁹ Both have pure stratified epithelium and a desquamative growth pattern.¹⁰ There is still debate on whether the oral mucosa shares any characteristics with the vaginal mucosa in terms of susceptibility to ovarian steroids.^{9,10}

Methodology

Study Participants: Healthy young female volunteers of age group 18-40 years with normal menstrual cycle without any local or systemic diseases, abnormal endocrinal or immunological status without any habits or consumption of drugs like oral contraceptives and non anemic were selected for the study. None of them had any fixed or removable appliances.

Sample Size and Sampling technique: A total of 40 young female volunteers were included in the study. Thorough oral examination was done to rule out clinically evident and habit related lesions. Hemoglobin estimation was done to rule out anemia. A proper menstrual history was recorded from the study subjects. The entire cycle was divided into four phases comprising of bleeding, proliferative, ovulation and secretory. All the study subjects had a menstrual cycle of 28-30 days.

Data collection and Laboratory method: Oral smears were collected at regular intervals of twice per week for a period of three months. Smears were taken using a cyto brush from the buccal mucosa anterior to the stenson's duct, which

according to Timonen¹¹ is histologically similar to vaginal epithelium. Smears were stained using Rapid-papTM Papinicolau stain kit.

Smears were observed under a binocular light microscope, different cell populations (superficial, intermediate, parabasal) were counted in a stepwise manner moving the microscope stage from left to right and then down and across in such a way to avoid counting the same cell again. Total of five hundred well preserved cells either single or in groups were counted in different areas of the smear. Clearly defined cells were counted avoiding clumped or folded cells and unusually distorted nuclei and cells. Count of superficial, intermediate and parabasal cells were recorded. Cell types were expressed in mean percentage. Mean maturation index [percentage relation of parabasal-intermediate-superficial cells] was calculated during various phases of the menstrual cycle.

Ethical approval and consent to participate: An informed written consent was obtained from each volunteer prior to the study. Ethical clearance was obtained from the institution where the study was done.

Results

In our study mean maturation index or percentage relation of parabasal-intermediate-superficial cells were calculated during various phases of the menstrual cycle (Table 1).

Table 1: Showing percentage of various types of cells exfoliated during various phases of all the three menstrual cycles in young females for maturation index (n=40)

Cycle	Phase	N	Parabasal cell	Intermediate cell	Superficial cell
1	Bleeding Mean	40	1.0400	26.6800	71.5600
	S.D*		0.9229	5.6863	6.2297
	Proliferative Mean	40	1.0150	28.4850	70.4750
	S.D		1.0172	5.8541	5.9785
	Ovulation Mean	40	1.0050	33.0350	65.9700
	S.D		0.9030	6.7711	5.2560
	Secretory Mean	40	0.9150	47.5100	51.0750
	S.D		0.8604	5.3343	4.3261
	Total Mean	160	0.9938	33.9275	64.7700
	S.D		0.9201	10.0916	9.8481
2	Bleeding Mean	40	0.9300	29.7200	70.2950
	S.D		1.2115	5.4490	5.5261
	Proliferative Mean	40	1.3100	30.9200	68.0650
	S.D		1.4507	7.9392	6.1736
	Ovulation Mean	40	1.5500	30.1900	67.6850
	S.D		1.5397	6.9146	7.2669
	Secretory Mean	40	0.5600	48.4500	50.9900
	S.D		0.6887	3.6607	3.8564
	Total Mean	160	1.0875	34.8200	64.2587
	S.D		1.3102	10.0128	9.6693
3	Bleeding Mean	40	1.0800	31.1515	67.1050

	S.D		1.0773	7.4350	8.3248
	Proliferative Mean	40	0.9650	29.0000	68.5600
	S.D		0.8520	6.6487	7.2774
	Ovulation Mean	40	1.3000	31.0000	65.6550
	S.D		0.9902	6.0556	7.8787
	Secretory Mean	40	1.5750	52.4850	46.4950
	S.D		1.5651	11.6237	11.5152
	Total Mean	160	1.2300	35.9350	61.9538
	S.D		1.1656	12.6163	12.6079

Total mean maturation index in the first cycle- P.B/I.C/S.C-1/34/65.

Total mean maturation value in the second cycle P.B/I.C/S.C - 1/35/64

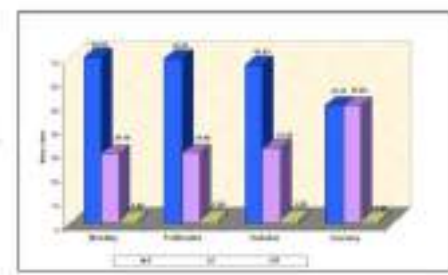
Total mean maturation value in the third cycle - P.B/I.C/S.C -1/36/62

*S.D – Standard Deviation

Total mean maturation index in the first cycle was 1/34/65 indicating that out of the total number of exfoliated cells during the entire cycle, 1% were parabasal cells, 34% were intermediate cells and 65% were superficial cells. Mean maturation index in the other two cycles were almost the same showing lesser parabasal and more superficial cells.

Comparing the cell type during various phases of menstrual cycle in all the three cycles more superficial cell count is

seen in bleeding phase and more intermediate cells in secretory phase of menstrual cycle (Graph -1).



Graph 1- Mean Maturation Index in oral smears of young females during various phases of menstrual cycle in three cycles studied

Discussion

Maturation index expresses a percentile relationship of parabasal cell to intermediate to superficial cell as described by Nyklicek. To minimize variation and to obtain uniformity in our study we obtained all smears from the buccal mucosa anterior to stenson's duct. Comparing mean maturation index in various phases of the menstrual cycle, in all the three cycles increase in superficial cell count is observed in bleeding, proliferative and ovulation phase, whereas secretory phase showed a more or less equal amount of superficial and intermediate cells. Good correlation was found between maturation index and staging of menstrual cycle. Estrogen affects cell growth and maturation of the mucosa, maturation of epithelium is characterized by the appearance of superficial cells.⁵ Higher number of mature superficial cells indicates higher the maturation index or estrogen effect in the body

Increase in superficial cells in the first half of the cycle where estrogen is high indicates complete maturation of the mucosa. Increased intermediate cells observed in the secretory phase reveals a diminished estrogenic effect, suggesting a predominance of progesterone influence.

Oral mucosa is capable of metabolizing gonadal hormones.¹² Previous research on the impact of hormones on the buccal mucosa have generated controversy. Some researchers¹⁰ have reported a positive association between oestrogen and the cellular proliferation and keratinization of buccal mucosa, but many others have been unable to substantiate this correlation. Previous reports on hormonal influence on buccal mucosa have been controversial.^{13,14}

Although the hormonal patterns differ greatly amongst individuals, they are usually mirrored in repetition for a given individual.¹⁵ Trott^{12,16} discovered a constant change in the degree of keratininsation, which was thought to be caused more by saliva and food's stimulatory effects than by the oestrogen's effect on the body. Russel (1947)¹⁴, Ziskin and Moulton (1948)⁵ Main (1967) and Croley (1978)¹² have disclosed well expressed rhythmic alterations in cells of the oral cavity reflecting the hormonal state of the menstrual cycle.

Dolcini F et al¹⁷ discovered that the cellular maturation index changes where according to the menstrual cycle stage and the rate of hormonal influence, The growth and maturation of the cells lining the genital tract is facilitated by oestrogen's

proliferative impact. The first half of the menstrual cycle is when there is a noticeable increase in oestrogen activity.¹⁸ In the first half of the cycle, there is an increase in the superficial cell count, which peaks at ovulation in vaginal smears. As estrogen influence increases smear pattern changes to become at first predominantly intermediate cell type and progressing finally to a count composed largely of superficial cells. The second half of the cycle shows increased progesterone secretion, the epithelium in this phase undergoes regressive changes marked by a decrease in the number of surface cells and an increase in the number of intermediate cells.⁵ Our study is consistent with these observations. Since oral and vaginal epithelium consists of stratified squamous epithelium, it would be reasonable to support that there might be some biological similarity between them.¹⁸

Parabasal cells are the least mature cells having not been affected by estrogen or progesterone. Intermediate cells display mild maturation, having been affected by progesterone, and superficial cells display the most maturity, having been affected by estrogen. MI can vary in an individual on a daily basis, and also varies among individuals. In MI cellular parameters

with predominance of parabasal cells indicates an absence of estrogen stimulation, and predominance of superficial cells indicates estrogen stimulation.¹⁹

Other than hormonal factors, factors that may affect maturation or proliferation of oral mucosa are nutritional status^{18,20}, habits like smoking¹³, age²¹, mechanical and chemical irritants or mild inflammatory conditions.^{22,23}

It is well-known that sex hormones affect the physiology of the mouth cavity both directly and indirectly.²⁴ Maturation of mucosa due to the above factors could not be ruled out in our study. A study of longer duration including more number of subjects and using automated image analysis methods would be more appropriate to confirm maturation of oral mucosa to be reflected by sex hormones.

In conclusion maturation index results in this study suggested normal pattern of maturation of oral mucosa. The mean maturation values in various phases of the menstrual cycle, showed increase exfoliation of mature superficial cells in first half of menstrual phase whereas secretory phase of the cycle showed a more or less equal amount of superficial and intermediate cells. These findings

were consistent in all the three cycles studied. Complete maturation of the mucosa in the first half of the cycle indicates high estrogen levels. Increased intermediate cells or mild maturation in the second half reveals a diminished estrogenic effect, suggesting a predominance of progesterone influence.

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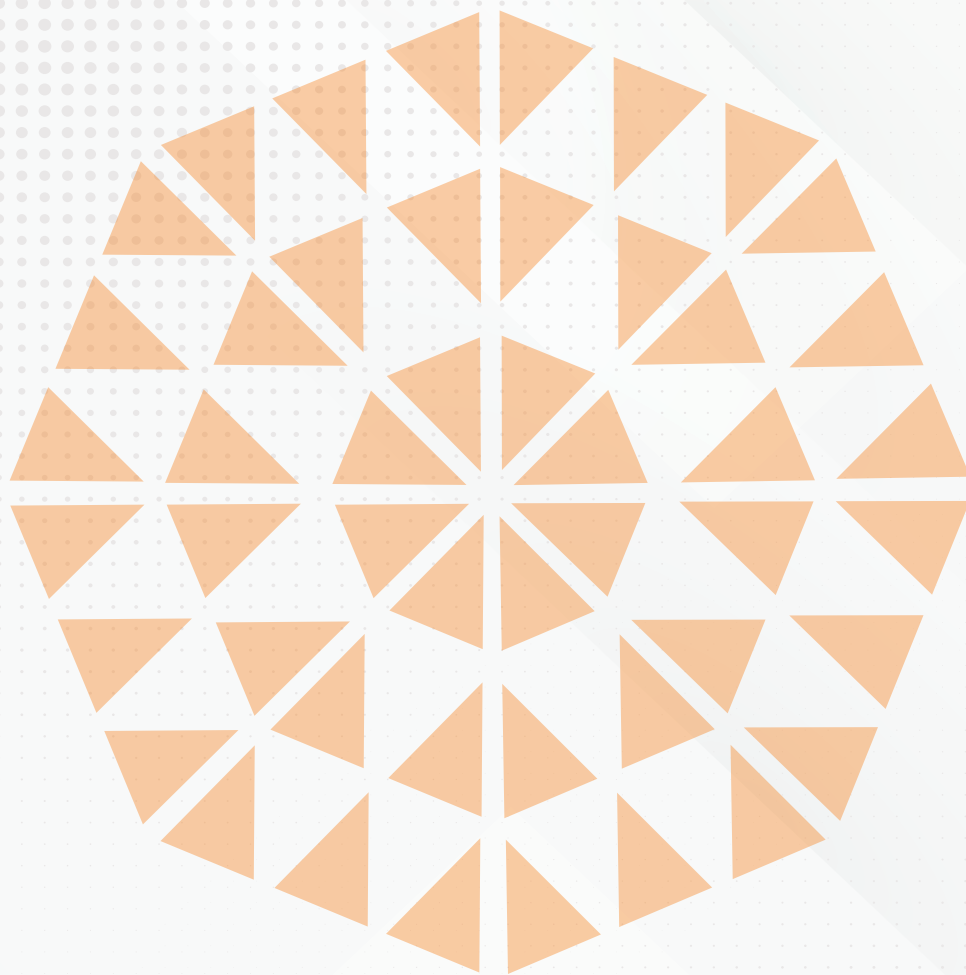
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References

1. Mascarenhas P, Gapski R, Al-Shammari K, Wang H. Influence of sex hormones on the periodontium. *J Clin Periodontol*. 2003;30:671-81.
2. PM Donald, George R, Sriram G, Kavitha B, Shivapathasundharam B. Hormonal changes in exfoliated normal buccal mucosal cells. *J Cytol*. 2013;Oct-Dec:30(4):252-256
3. Preckshot J. Women's Oral Health: Is There a Hormonal Link. *Int J of Pharm Compd*. 2004;8(1):11-14.
4. Koss GL, Melamed MR. Koss' Diagnostic cytology and its histopathologic bases. 5th ed. J.B. Lippincott Williams and Wilkins comp. Philadelphia; 2005.
5. Main DMG and Ritchie GM. Cyclic changes in oral smears from young menstruating women. *Br J Dermatol*. 1967;79:20-30.
6. Laufer N, Navot D, Schenker JG. The pattern of luteal phase plasma progesterone and estradiol in fertile cycles. *Am J Obstet Gynecol*. 1982;143(7):808-813.
7. Wied GL, Bibbo M. Comprehensive Cytopathology. 2nd ed. W.B. Saunders Company;1997.
8. McEndree B. Clinical application of the vaginal maturation index. *Nurse Pract*. 1999 Sep; 24(9):48,51-2, 55-6.
9. Vittek J, Hernandez MR, Wenk EJ, Rappaport SC, Southern AL. Specific estrogen receptors in human gingiva. *J Clin Endocrinol Metab*. 1982;54(3):608-12.
10. Forabosco A, Criscuolo M, Coukos G, Uccelli E, Weinstein R, Spinato S et al. Efficacy of

- hormone replacement therapy in post menopausal women with oral discomfort. Oral Surg Oral Med Oral Pathol. 1992;73(5):570-4.
11. Bercovici B, Gron S, Pisanty S. Vaginal and oral cytology of the menopause, A comparative study. Acta cytol. 1985;29: 805-9.
 12. Ferguson DD. Current Diagnostic uses of saliva. J Dent Res. 1987;66(2):420-24.
 13. Jacobs A. Cornification in buccal smears. Br Dent J. 1959;106:249-50.
 14. Dokumov SI, Spasov SA. A comparison of oral and vaginal smears in women with normal menstrual cycles. Acta Cytol. 1970;14:31-34.
 15. Novake. Text book of Gynaecology. 10th ed. William and Wilkins;1979.
 16. Friedlander AH. The physiology, medical management and oral implications of menopause. J Am Dent Assoc. 2002;133:73-79.
 17. Dolcini F, Sabbatini RC, Paolinelli C. Oral mucosa and hormonal stimulation during the menstrual cycle. Dent Cadmos. 1989;57(16): 98-102.
 18. Artvinli LB. Iron deficiency and smoking. Comparative criteria for buccal mucosa keratinisation in menstruating and postmenopausal women. Acta Cytol. 2002;46(4): 664-6
 19. Van der Laak JA, Schijf CP, Kerstens HM, Heijnen-Wijnen TH, de Wilde PC, Hanselaar GJ. Development and validation of a computerized cytomorphometric method to assess the maturation of vaginal epithelial cells. Cytometry. 1999 Mar 1;35(3):196-202.
 20. Cowpe JG, Longmore RB, Green MW. Quantitative exfoliative cytology of normal oral squames an age, site and sex related survey. J R Soc Med. 1985;78(12):995-1004.
 21. Krejci CB, Bissada NF. Women's health issues and their relationship to periodontitis. J Am Dent Assoc. 2002; 133:323-29.
 22. Pisanty S, Rafaely B, Polishuk W. The effect of steroid hormones on buccal mucosa of menopausal women. Oral Surg Oral Med Oral Pathol. 1975;40(3):346-53.

23. BAUMGART, Cristina da Silva et al. Influence of factors in the oral mucosa maturation pattern: a cross-sectional study applying multivariate analyses. Braz. J. Oral Sci. [online]. 2016, vol.15, n.1, pp. 27-34.
24. Gebri E, Kiss A, Tóth F, Hortobágyi T. Female sex as an independent prognostic factor in the development of oral mucositis during autologous peripheral stem cell transplantation. Sci Rep. 2020 Sep 28;10(1):15898.



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