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AMELIORATION OF DENTINAL HYPERSENSITIVITY USING LASER PHOTOBIOMODULATION IN A PEDIATRIC PATIENT WITH AMELOGENESIS IMPERFECTA – A CASE REPORT

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ABSTRACT

Background: Amelogenesis Imperfecta (AI) is a multifactorial but predominantly genetic defect (ENAM ,AMELX genes) characterised by loss of enamel /malformed enamel. Severe manifestations includes dentinal hypersensitivity(DH). Photobiomodulation (PBM) with diode lasers offers a non-invasive & sustained analgesia in managing DH.
Aim: To assess the standalone efficacy of diode laser PBM in reducing hypersensitivity in AI.
Case Report: A 14-year-old female diagnosed with AI exhibiting generalised enamel loss severe DH underwent dentinal desensitization harnessing laser PBM using 610 nm diode laser. Sensitivity was measured pre- and post-treatment using the Schiff Cold Air Sensitivity Scale (SCASS) followed by rehabilitative treatments.
Results: Marked reduction in sensitivity was observed, likely due to the laser's deep tissue penetration and bio stimulatory effects on free nerve endings.
Conclusion: PBM with 610-nm diode laser was safe, effective, and non-invasive approach to managing hypersensitivity in AI thereby improving patient comfort and quality of life.

KEYWORDS: Amelogenesis Imperfecta , Dentinal desensitization, Dentinal hypersensitivity , Low Level Laser Therapy , Photobiomodulation.

INTRODUCTION

Amelogenesis Imperfecta (AI) is a heterogeneous cluster of hereditary enamel dysplasia affecting both primary and permanent dentitions. The reason is attributed to genetic mutations in ENAM, AMELX genes. Pronounced enamel loss, weakened structural integrity of enamel due to diminished mineralisation patterns and post-eruptive degradation along cervical and occlusal surfaces of the teeth results in Dentinal Hypersensitivity (DH). [1,2] It is a hallmark clinical feature of AI. DH is exacerbated in AI and Molar Incisor Hypomineralization (MIH) owing to severe enamel loss warranting early management.[3] Conventional therapeutic modalities include potassium nitrate containing toothpastes, topical varnishes, resin sealants, restoratives and remineralizing agents which render transient to suboptimal relief. AI-affected teeth undergoes severe enamel loss, necessitating gentle yet efficacious alternative such as Photobiomodulation (PBM) or low-level laser therapy (LLLT). It is a non-invasive approach wherein a 610-nm diode laser is utilized for achieving neuromodulatory effects by targeted actions on multiple biochemical pathways that leads to bio-stimulation of cells causing dentinal tubular occlusion by virtue of laser's deeper penetrability into dentin, thereby alleviating DH and preserving pulp vitality.[3,4,5] This pioneer case report delineates measured clinical outcomes of 610 nm diode laser- PBM in managing DH in a pediatric patient with AI, further substantiating it as a modality of treatment.

Case Presentation

A 9-year-old female reported with chief complaint of sharp, intermittent, non-radiating tooth pain for 2–3 months. Pain was triggered by cold stimuli, brushing, or air exposure and subsided promptly on stimulus removal, with no spontaneous or nocturnal episodes. Patient gives no history of predisposing factors - aggressive toothbrushing, recent scaling, gingival recession, attrition, abrasion, erosion, or bleaching done. Further, no medications, desensitizing toothpaste were taken for the symptomatic relief. Medical history revealed childhood folic acid deficiency, anaemia, and early fatigability. Maternal history included folic acid deficiency and gestational hypothyroidism. The child was breastfed for 7 months, bottle-fed until 2–2½ years, followed by north-Indian balanced diet.

Pediatric Assessment

Patient had healthy Body Mass Index with no signs of pallor, platynychia, and submandibular lymphadenopathy. She has no systemic illnesses. Furthermore, peripheral blood smear, vitamin profile, serum iron levels, ruled out iron- and vitamin-deficiency related anaemias. All vitals monitored were stable

Extraoral Examination: Patient has straight facial profile with facial symmetry. No abnormalities in Temporomandibular Joint, chin, lips were noted.
Intraoral Examination : Clinical examination shows generalized corrugated appearance on enamel surface with wear & loss of enamel involving 16 55 54 53 52 11 61 62 63 64 65 26 , 46 85 84 83 42 41 31 32 73 74 75 36 . Furthermore, hypoplastic molars involving16, 26, 36, and pink tooth of mummery suggestive of internal resorption involving 74 and grade II mobility involving 64, 65 were seen. (refer Fig: 1 A-F)
Radiographic Findings: The orthopantomogram (OPG) reveals mixed dentition stage with radiographic features exhibiting generalized reduction in enamel thickness. Enamel appears less mineralized and exhibits reduced radiodensity with diminished distinction between enamel and dentin leading to loss of the normal enamel–dentin contrast. Irregular crown surface crustations were observed in relation to 11, 12, 21, 22, 36, and 46. Multiple retained primary teeth are present, namely 52, 53, 54, 55, 62, 63, 64, 65, 72, 73, 74, 75, 82, 83, 84, and 85. Pulp chamber of all permanent molars appear enlarged without calcifications and root development is appropriate for the patient's age, and alveolar bone shows a normal trabecular pattern with no radiographic evidence of pathology.
Diagnosis: Overall clinical and radiographic features are consistent with hypoplastic type AI.

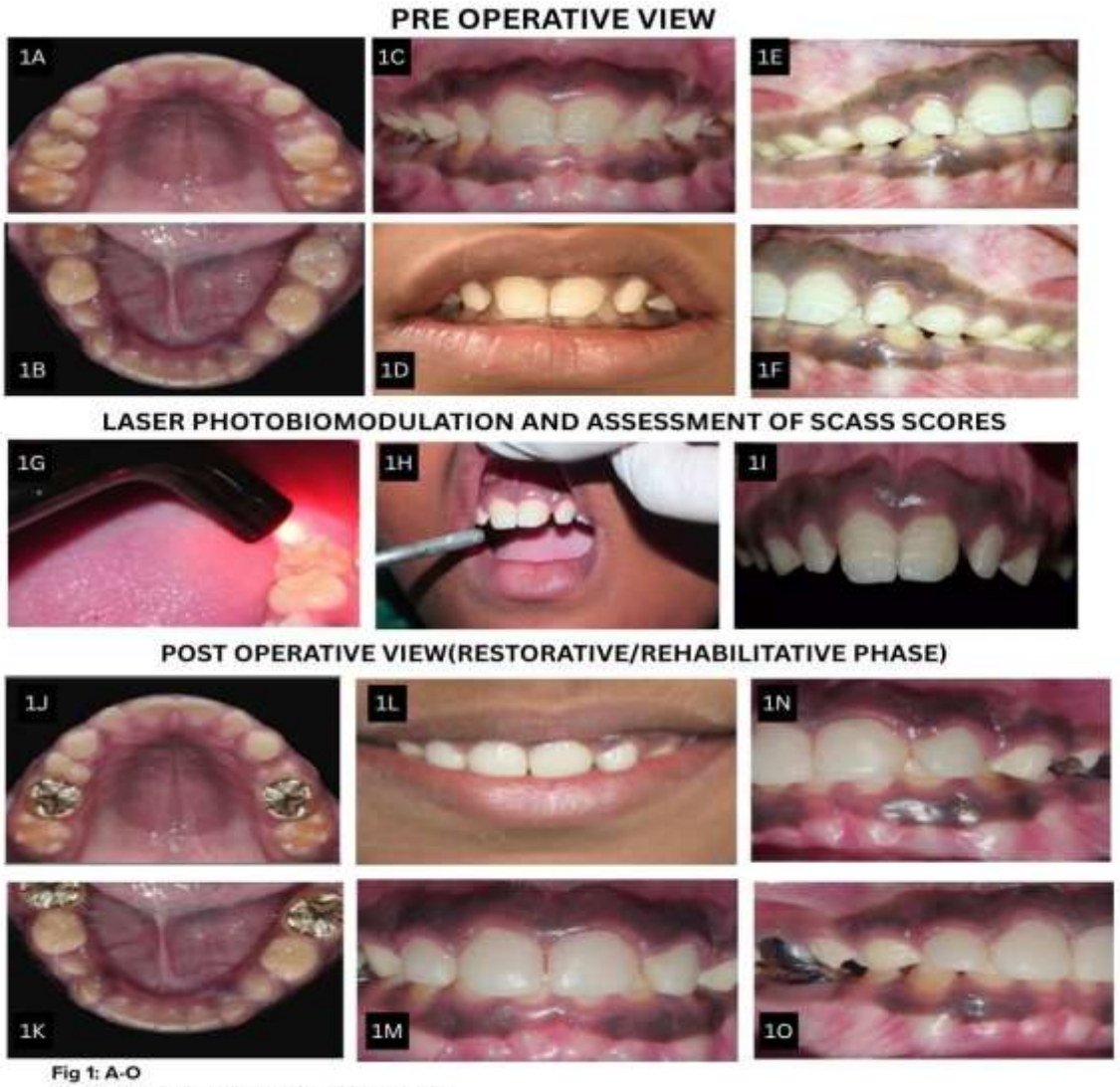


Fig 1: A-O
1A-1F Depicting Pre-Operative Records
1G-1I Laser Photobiomodulation and recording Of SCASS
1J-1O Depicting Post-Operative Records

Treatment
Twelve sessions of PBM spread over six weeks were performed using an Indilase diode laser. A 610 nm wavelength was fired using a PBM tip probe (tip diameter 0.5cm²) ,held at 45° to the coronal surface in contact mode moved in a circular motion from the cervical margin to the incisal edge and cusp tips delivering a pulsed energy at 0.5-s intervals with 1.2 W power and 245 J over 10 minutes per quadrant. (refer Fig: 1 G-I)
Following the complete reduction in DH, aesthetic rehabilitation was done using veneers, full coverage crowns and restorations. (refer Fig: 1J-O)

Measurement of Treatment Outcomes

Schiff's Cold Air Sensitivity Score Index (SCASS) was used to assess DH at various intervals by summation of SCASS for individual tooth. Sum of SCASS per appointment was added to and plotted graphically. [Graph1]

Scoring Criteria for SCASS

SCASS was recorded by measuring discomfort to forced air stimulation over exposed dentin using three-way syringe and graded as per fig.2A

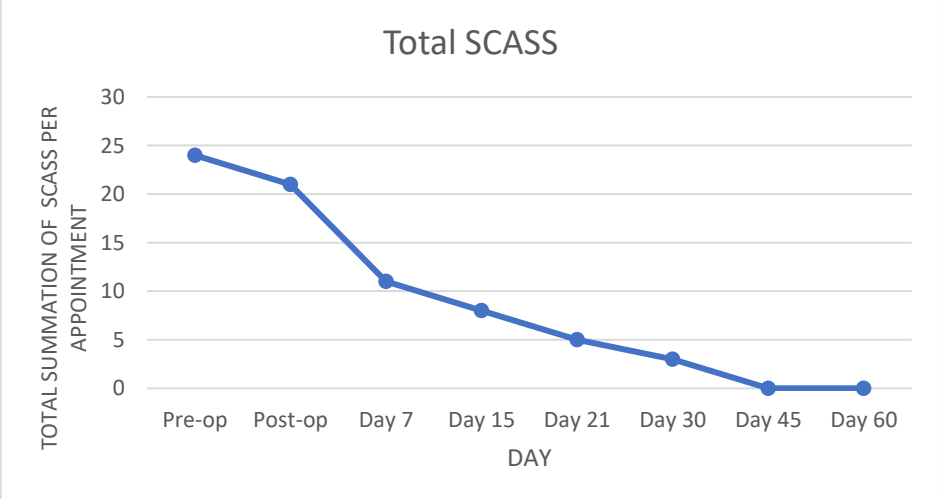
RESULTS

The results of the study show a gradual sustained progressive reduction in DH from baseline. Pre-operatively, highest SCASS indicating severe hypersensitivity was noted with slight reduction observed immediate post-operatively. However, sensitivity levels remained high.

A sharp decline in SCASS scores was evident by Day 7, suggestive of early therapeutic response to PBM. This declining trend continued steadily over Day 15 and Day 21, signifying consistent improvement. At Day 30, sensitivity was minimal, Day 45, SCASS score was noted 0 and sustained on Day 60 without any intervention signifying complete reduction of DH, indicating excellent clinical efficacy of Laser PBM. (refer Table 1 ,Graph 1)

Table 1.: SCASS scores of all teeth from baseline (Day 0) to Day 60.

FDI Tooth Number	Pre operative (Baseline)	Post Operative (Baseline)	Day 7	Day 15	Day 21	Day 30	Day 45	Day 60
21	2	2	1	1	1	0	0	0
22	2	2	1	1	0	0	0	0
3	1	1	1	1	1	0	0	0
26	2	2	1	1	1	0	0	0
36	2	1	1	1	0	0	0	0
75	2	1	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0
31	1	1	0	0	0	0	0	0
11	1	1	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0
41	2	2	1	1	1	1	0	0
42	2	2	1	1	0	0	0	0
43	2	2	1	0	0	1	0	0
85	2	2	1	1	0	0	0	0
46 (restored)	0	0	0	0	0	0	0	0
53	1	1	1	0	0	0	0	0
16	1	1	1	0	0	0	0	0
14	1	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0



Graph 1: Measurement of Treatment Outcomes showing progressive decline in total SCASS post Laser PBM over 60-Day evaluation period.

DISCUSSION

AI is a heterogeneous enamel disorder predominantly attributed to genetic mutations. Based on underlying molecular genetics, Bloch-Zupan et.al. and Smith et. al modified the Witkop's classification of four phenotypes by integration of genotypes to each type and subtypes.

These includes- 1. Hypoplastic AI which is attributed to AMELX, ENAM, AMBN, ACP4, SP6, FAM20A, ACP genes and basement membrane genes- LAMA3, LAMB3, LAMC2, COL7A1, COL17A1, ITGB6/ITGB4. 2. Hypomaturation AI is linked to MMP20, KLK4, WDR72, SLC24A4 ODAPH, SLC24A4, GPR68, and AMELX genes. 3. Hypocalcified/hypomineralized AI results due to FAM83H, AMTN, C4orf26, GPR68 and RELT genes. 4. Hypomaturation–Hypoplastic AI with taurodontism is caused by DLX3 mutations. Lastly, Syndromic AI is associated with DLX3, FAM20A, LTBP3, CNNM4, ROGDI, SLC13A5, SLC10A7, GALNS genes.[1,2]

Besides genetic mutations, enamel mineralization is regulated by other paramount factors including calcium–phosphate homeostasis, nutritional status, folate metabolism, hormonal balance, and ARNT-mediated cellular ameloblast signalling pathways. Disruptions at any stage in these biochemical pathways impairs enamel mineralization leading to developmental anomalies.[6,7] Furthermore, maternal factors and early childhood illnesses adversely affect odontogenesis. Gestational thyroid disorders, nutritional deficiencies (iron and folate), and systemic illness have strong correlation with in enamel hypoplasia and hypomineralization. However, early age exposure to drug predisposes to impaired amelogenesis and post-eruptive enamel breakdown.[5,6,7]

The clinical history pertaining to present case reveals early childhood folate-deficiency anemia, maternal gestational folate deficiency and hypothyroidism . These findings are in agreement with existing literature reported on association between nutritional–endocrine disturbances and impaired amelogenesis and post-eruptive enamel degradation. AI due to reduced structural integrity of enamel results in early dentinal tubule exposure that attenuates DH- a key diagnostic feature in AI. DH is characterized by sharp pain elicited by thermal, tactile, osmotic, chemical, evaporative , proprioceptive provocation over exposed dentin surface. This is attributed to disrupted ionic transport, altered ameloblast pH regulation, impaired hydroxyapatite maturation, increased protein content (3–15-fold), ~20% reduced mineral content, increased porosity, and reduced mechanical strength. [8] owever, pediatric patients demonstrate high dentinal hypersensitivity owing to changes in underlying dentinal microarchitecture exhibiting significantly greater dentinal tubule density in primary teeth and young permanent teeth as compared to permanent teeth, while tubule diameter increases with dentinal depth.[9] These structural diminutions exhibit observed poor and transient relief to conventional topical desensitizing agents.

Current treatment modalities , based on their mechanism of action can be categorized into pulpal nerve-blocking agents, dentinal tubule-occluding agents, and biomimetic remineralizing agents. [10] Conventional topical desensitizing agents such as potassium nitrate, arginine , fluoride varnishes, bonding agents, resin sealants, oxalates, CPP-ACP, bioactive materials, and iontophoresis. However, bioactive glass(NovaMin) and CPP-ACP outshine other agents due to enhanced tubular sealing capacity and superior remineralization ability, which is useful in AI patients.[5,10] Although, resin sealants and bonding agent offers longer relief but fail due to technique sensitivity and poor enamel quality and compromised bonding substrate in AI. Furthermore, susceptibility to mechanical and chemical dissolution requires repeated application and yields suboptimal short-term relief. [5,10]

Laser PBM addresses the limitations of the topical agents by achieving immediate and sustained analgesic effects in DH, predominantly in structurally compromised enamel such as AI and MIH.[2,4,7]This is best explained by Brännström's hydrodynamic theory. PBM attenuates DH by modulating dentinal fluid movement and pulpal nerve responses.[4] AI accentuates post-eruptive enamel degradation that exposes the densely accumulated tubular dentin, facilitating greater hydrodynamic fluid shifts and elevated pulpal nociceptor. These histological characteristics explains the severity and rationale of hypersensitivity in AI.[4]

The results of the study demonstrated a gradual, sustained reduction in dentinal hypersensitivity, with minimal immediate postoperative changes in SCASS scores. However, a marked decline by Day 7 indicates early response to PBM. Continued decrease in DH until complete resolution was noted by Day 45 and re-assessed for sustainability on Day 60, confirming excellent clinical efficacy of laser PBM.

The favourable response of Photobiomodulation is achieved through functional dentinal tubule occlusion , laser mediated analgesia through targeted actions on multiple biochemical pathways which leads to the undermentioned: (refer Fig 2B)

1. Attenuation of tubular fluid flow through neuronal depolarization by stabilizing neuronal membrane potentials.[5]
2. Stimulation of mitochondrial cytochrome-C oxidase → increased ATP production → promotes repair.[11]
3. Biomodulation of odontoblasts→ reducing tubule permeability→ enhancing tertiary dentinogenesis.[4]
4. Micro-occlusion of dentinal tubules via photothermal modification.[5]
5. Modulation of anti- inflammatory mediators → enhances microcirculation, and pulpal healing.[11]

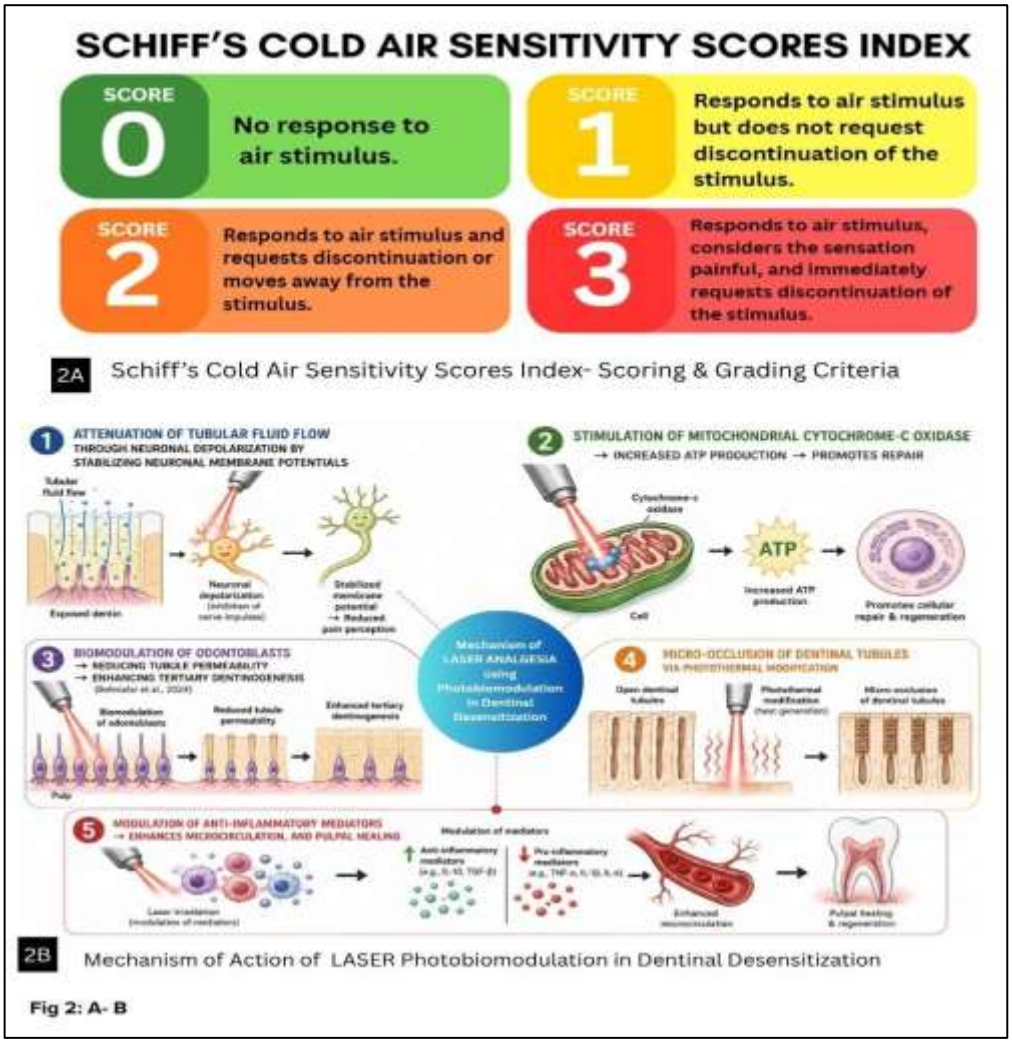


Fig 2: A- B

In present study, a clinician driven objective measurement of DH using SCASS was considered by evaluating response to forced air stimulus-based over exposed dentin surface . Considering the results obtained by Freitas et al. who demonstrated clinical reliability of VAS, FPS, NS, and VRS for pain assessment, whereas Rocha et al. reported superior diagnostic accuracy and specificity (≈91%) of SCASS for objectively quantifying dentinal hypersensitivity. Hence, SCASS was deemed appropriate to measure treatment outcomes in our study. [12,13]

This holds true for long term longitudinal follow-up in AI cases. Hence, declining SCASS scores validate clinical effectiveness of PBM in ameloriation of DH in AI-patients meanwhile authenticating index suitability.[13]

The treatment in this case was carried out in 2 phases based on findings stated by Roma et al., who underscored definitive analgesia before rehabilitative treatment in AI. In present case report, standalone efficacy of laser was measured. It can be aptly stated that gradual and sustained analgesia was observed with 610nm diode laser. A definitive gap of 2 months were deliberately maintained to assess re-occurrence. However, there was no reoccurrence of dentinal hypersensitivity in this case. [14]

The sustainability of Laser analgesia still remains debatable. In accordance to our findings, Mahdian et al. in their Cochrane systematic review comprising of 23 randomized controlled trials concluded that analgesic effects of laser lasts for short-term predominantly.[15] On contrary , D'Amario et al. demonstrated sustained analgesia with diode laser compared against ozone therapy.[16]Tevatia et. al. demonstrated sustained analgesia with laser coupled with desensitizing agents.[17] All these findings establish diode laser as a safe, non-invasive and effective treatment for dentinal hypersensitivity.

In the present case , PBM with a 610-nm diode laser markedly reduced dentinal hypersensitivity while preserving pulpal vitality. This affirms that selection of laser parameters such as wavelength, power, pulse mode, fluence, exposure time, frequency, and tip diameter directly influence treatment outcomes. Selection of proper wavelength and tip diameter are critical determinants for therapeutic success owing to ensured optimal energy density and uniform irradiation. Although longer wavelengths ranging between 808–1064 nm may provide more sustained analgesia, but in this case, 610-nm wavelength effectively achieved sustained neuromodulatory and biostimulatory effects. Above all standard laser safety protocols must be strictly adhered to.[18]

CONCLUSION

Conservative theories attenuate DH but their actions are not sustained. 610nm Photobiomodulation using diode laser shows immediate and sustained analgesic effect achieved owing to laser's deeper penetration ability , biologically driven action and minimally invasive making it highly acceptable and an alternative treatment modality.

Acknowledgements & Declaration
The authors acknowledge the use of Artificial Intelligence (AI) tools i.e. (GPT Ver 5.5 and Nano Banana 2.0) was used solely for generating original illustrations and schematic figures (Figure 2B) . This was done to enhance the clarity and understanding of the content while ensuring avoidance of plagiarism. AI-generated images were reviewed, modified, and validated by the authors.

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