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Review Article

Foundations and future directions in orthodontic treatment planning

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ABSTRACT

Effective management of malocclusion involves precise diagnosis, strategic treatment planning, and careful execution. Diagnosis identifies issues, treatment planning devises solutions, and execution follows the plan. Orthodontic treatment is complex, focusing on esthetics, function, and stability. The goal is to resolve functional issues, align displaced teeth, and improve aesthetics, including correcting overjet and overbite. Success depends on the clinician's skill, patient cooperation, and managing expectations. Modern orthodontics emphasizes comprehensive outcomes, integrating facial aesthetics, occlusal function, periodontal health, and stability, rather than merely fitting teeth. This article explores the detailed process of orthodontic treatment planning and available options.

Keywords: Diagnosis, Treatment planning, Malocclusion, Comprehensive treatment, Future trends

INTRODUCTION

Effective management of malocclusion and other dental conditions relies on accurate diagnosis, meticulous treatment planning and careful execution. Diagnosis identifies the skeletal and dental issue, while treatment planning involves developing strategies to address these concerns, with execution following the established plan.

Achieving the main treatment goal-esthetics, function and stability requires precision in diagnosis and a logical plan. The primary goals include resolving functional issues that could lead to temporomandibular disorders (TMD), facilitating the eruption and alignment of displaced teeth and enhancing both facial and dental aesthetics.

Successful orthodontic treatment depends on the clinician's expertise, patient cooperation and effective management of patient expectations, including parental involvement in pediatric cases. Accurate history-taking, thorough examination and record collection are crucial for personalized treatment plans. Modern orthodontics now focuses on comprehensive outcomes, integrating facial aesthetics, occlusal function, periodontal health and long-term stability.[1] For planning comprehensive treatment, it is important to consider treatment possibilities.

TREATMENT POSSIBILITIES

Extraction verses expansion

Treatment of crowded dental arches typically involves gaining space, with approaches like extraction or expansion depending on factors such as crowding severity, lip prominence and arch dimensions.

Factors to be considered regarding extraction or expansion decision are Facial esthetics and Stability. Considering facial esthetics, a profile that is either overly protrusive or retrusive can be esthetically challenging. Additionally, the relationship between nose and chin size affects lip prominence. Treatment decisions in cases with prominent noses or chins often favor moving incisors forward rather than extracting and retracting them, provided it maintains lip harmony. Regarding stability,

the lower arch poses tighter constraints for expansion compared to the upper arch. Data indicate that moving lower incisors forward more than 2 mm can compromise stability due to increased lip pressure.

Expansion across canines tends to be unstable even with retraction, whereas expansion across premolars and molars can be stable when carefully controlled.[2]

Macroesthetic considerations in skeletal problems

Macroesthetic considerations in orthodontics encompass the overall facial appearance in three-dimensional space. Facial length, chin prominence and other features are evaluated during clinical examination to identify concerns and positive attributes. Solutions are then tailored to address these issues while preserving positive facial features.[3]

Treatment modalities for dentoskeletal corrections vary based on the severity of the discrepancy and includes orthodontic camouflage which involves repositioning teeth to mask skeletal discrepancies, suitable for non-growing patients with moderate class II and class III malocclusion and acceptable facial esthetics.[4]

Orthognathic and/or plastic surgery which is reserved for severe dentofacial deformities, this includes procedures like maxillary or mandibular advancement or setback, genioplasty, rhinoplasty and cheiloplasty to achieve optimal dentoskeletal and facial esthetics.[2] Growth modification which is utilized during growth to intercept skeletal discrepancies, promoting favorable facial aesthetics and reducing the need for surgical correction later.[5]

Improving the smile considering mini esthetics

Miniesthetics in orthodontics focuses on evaluating the smile framework, which includes assessments such as incisor display, gingival exposure during smiling and overall smile aesthetics. The clinician evaluates whether the patient displays an adequate amount of central incisor crowns during smiling. Insufficient incisor display, typically less than 75% of the crown, may result from factors like vertical maxillary deficiency or short clinical crown height.[6]

Gingival Display involves assessing the relationship between the incisal edges of the maxillary incisors and the lower lip, as well as the positioning of gingival margins relative to the upper lip. The gingival margins of the canines should be coincident with the upper lip and the lateral incisors positioned slightly inferior to the adjacent teeth.[6]

The transverse dimensions of the smile encompass several critical elements like arch form, buccal corridor and transverse cant of occlusal plane.[6]

Micro aesthetic considerations

Micro aesthetic considerations in orthodontics focus on enhancing the appearance of individual teeth, encompassing various aspects such as tooth proportions, shade and color and gingival characteristics.

Reshaping teeth to change tooth proportions

Correcting tooth proportions is crucial for achieving an aesthetically pleasing smile according to the golden proportion, where the width of each tooth correlates with its neighboring teeth. This may involve resizing lateral incisors or adjusting canines to replace congenitally missing laterals. Maintaining micro aesthetics is essential, particularly after extraction treatments, which can alter these proportions significantly.

Height-width relationships

Proper width-height ratios ensure teeth appear natural; excessive height can make teeth look tapered, while insufficient height can give a square appearance. Factors like sulcular depth, lip level and incisal wear influence treatment strategies for correcting disproportionate lengths.

Connectors and embrasures

Ideal proportions between maxillary anterior teeth ensure harmonious appearance, with interdental spaces and papillae filling correctly. Orthodontic treatments may address issues like black triangles caused by crowded or rotated teeth, often involving interproximal stripping and root alignment to close spaces and improve aesthetics.

Tooth shade and color

Aesthetic smiles have a gradation of shade from central incisors to premolars, with central incisors being lighter and canines darker.

Gingival height, shape and contour

Gingival proportions are crucial for smile aesthetics, with considerations for gingival levels and contours around each tooth. Surgical interventions like gingivectomy or crown lengthening adjust gingival height and shape, while recession may require grafts or guided tissue regeneration for correction.[7]

Orthodontic-restorative considerations

Occasionally, patients require restorative treatment during or after orthodontic therapy. Patients with worn or abraded teeth, peg-shaped lateral incisors, fractured teeth, multiple edentulous spaces or other restorative needs may require tooth positioning that is slightly different from a non-restored, non-abraded, completely dentulous adolescent.[8]

COMPREHENSIVE ORTHODONTIC TREATMENT PLANNING

Comprehensive orthodontic treatment in primary dentition

Comprehensive orthodontic treatment planning for primary dentition encompasses early identification, intervention and management of various dental conditions and habits. Early intervention not only improves aesthetic outcomes but also enhances overall oral health and function, promoting lifelong dental well-being.

Comprehensive orthodontic treatment planning for primary dentition involves following.

Reasons for treatment

Treatment in primary dentition is initiated to facilitate normal growth of the face and dentition and to restore or maintain normal function. This early intervention can prevent potential complications and facilitate a more favorable outcome during permanent dentition development.

Conditions that should be treated

Several conditions necessitate treatment during the primary dentition phase like anterior and posterior crossbites, premature loss of primary teeth, unduly retained primary incisors, mispositioned teeth and habits and dysfunctions.

Contraindications to treatment in the primary dentition

Factors such as patient cooperation, overall health considerations and expected growth patterns may influence decisions regarding treatment initiation or delay.[9]

Treatment approaches for primary dentition

Anterior and posterior crossbites

Crossbites can be corrected using functional appliances like Planas direct tracks (PDTs), which encourage mandibular growth and correct malocclusions early. This approach minimizes the need for invasive treatments later in mixed or permanent dentition phases.[10] In the primary dentition, plate appliances in combination with a headchin cap or Rapid Palatal Expansion combined with a Delaire mask can be used.

Premature loss of primary teeth

Maintaining space after premature tooth loss is crucial to prevent crowding and maintain arch length. Options include band and loop space maintainers or Nance maxillary holding arches depending on the specific tooth loss scenario.[2]

Unduly retained primary incisors

Retained primary teeth should be monitored closely and if necessary, extracted to facilitate normal eruption of permanent successors. This prevents complications like gingival inflammation and irregular tooth alignment.[2]

Mispositioned teeth

Functional issues arising from malpositioned teeth can be addressed early to prevent further complications such as bruxism or abnormal jaw growth patterns.

Orthodontic appliances or interceptive treatments may be employed depending on the severity of the malocclusion.[11]

Habits and dysfunctions

Effective management of oral habits involves behavioral approaches such as counseling, reminder therapy (using bandages or bitter substances) and reward systems to motivate children to discontinue detrimental habits. In cases where habits persist, adjunctive therapies like intraoral appliances (e.g., quad helix, palatal crib) may be necessary to physically deter the habit.[12]

Steps in comprehensive orthodontic treatment in mixed dentition

Orthodontic treatment during the mixed dentition phase is crucial for managing growth and development of teeth and jaws and directing occlusal development towards a more desirable outcome.

This period typically involves a combination of preventive measures and interceptive treatments to address various dental issues early on, thus minimizing the need for extensive corrections in later stages.

Loss of space

Premature loss of primary teeth due to caries, infection, trauma or other reasons can disrupt the normal exfoliation pattern, leading to arch length deficiency. This deficiency exacerbates malocclusions such as crowding, rotations, crossbite and overjet issues. Whenever possible, restoring carious primary teeth is preferred over extraction to prevent subsequent malocclusions.

Several methods can be employed to regain or maintain arch length involves Proximal Stripping, expansion of dental arch, distalization, uprighting of molars and proclination of anterior teeth for better alignment.

Selective removal of small amounts of enamel from the proximal surfaces of teeth to create space.[13] For space regaininig appliances like Hotz Lingual Arch, Pendulum Appliance, Distal Jet Appliance, NiTi Bonded Space Regainer can be utilized.[14-17]

Developing anterior and posterior crossbites

Crossbites, whether anterior or posterior, should be addressed promptly to prevent dental wear, improve aesthetics, redirect skeletal growth, enhance tooth-to-alveolus relationship and prevent potential temporomandibular joint disorders.

Interceptive measures to correct anterior crossbites include acrylic incline planes which are used to correct simple anterior crossbites by guiding jaw closure, Acrylic Retainers with Lingual Springs which provide continuous pressure to teeth to correct crossbites and Expansion Appliances to expand the dental arch to create space and correct crossbites.[13]

Interceptive measures to correct posterior crossbites includes cross elastics or other fixed appliances for single tooth crossbite and removable screw appliances, rapid palatal expansion devices or fixed lingual arches for bilateral posterior crossbite.[2,13]

Crowding

Crowding occurs when teeth have insufficient space within the dental arch, leading to overlapping or misalignment of teeth. Management of crowding is done by observation and monitoring when there is mild crowding to determine if intervention is necessary, proximal disking of primary teeth or by extraction of teeth with planned removal of deciduous or permanent teeth to alleviate crowding.[18-20]

Interception of oral habits

Non-nutritive sucking habits (e.g., thumb sucking) and mouth breathing can contribute to dental and skeletal deformations if not addressed early.

Treatment modalities for oral habits

For thumb sucking dunlop's beta hypothesis helps the child understand the psychological factors contributing to thumb sucking by conscious and purposeful repetition of habit.[21] Removal Appliances like Thumb Guards and Fixed Thumb Spikes can be used to discourage thumb sucking.[21]

For mouth breathing habit oral screen (A myofunctional appliance that helps correct oral posture) and Exercises like holding a pencil between the lips or taping the lips together at night to encourage nasal breathing can be practiced.[22]

Skeletal malocclusion

Class II and class III malocclusions can be intercepted early using myofunctional and orthopedic appliances. Myofunctional appliances can be removable functional appliances such as Andersen activator, Bionator and others, which guide jaw growth and tooth alignment or Fixed functional appliances like Herbst appliances, which modify jaw position and growth.[23]

Orthopedic appliances

These appliances use neck or cranial anchorage to modify jaw growth patterns, especially during growth spurts.[24] Headgear, Facemask and Chin Cup provide extraoral anchorage for orthopaedic correction.

Steps in comprehensive orthodontic treatment in permanent dentition

Treatment planning in permanent dentition involves the use of fixed orthodontic appliances. The treatment can be done with a complete fixed orthodontic appliance that aims at maximum improvement of esthetics, occlusal function and stability and requires more than six months for its completion. Fixed orthodontic appliances have active components, which generate tooth moving forces engaged in passive components fixed on the tooth surface and transmit these forces to the dento-alveolar structures. Active components are separators, arch wires, elastics, elastomerics, springs etc. Passive components are bands, brackets, lingual attachment, buccal tubes, lock pins, ligature wires, etc.

Fixed appliances can move the teeth in all directions. These appliances are fixed to the teeth and forces are applied by archwires or auxiliaries through these attachments. Fixed appliances can tip, torque, rotate teeth and bodily move the teeth. Treatment phases with fixed appliances are bonding and banding, levelling and alignment, overbite reduction, overjet reduction, space closure, finishing and detailing, debonding and retention.[25]

PATHOLOGIC VERSUS DEVELOPMENTAL PROBLEMS

Pathologic problems must be addressed before treatment of orthodontic (developmental) problems can begin. Thus, in a treatment sequence, orthodontic treatment must appear after control of systemic disease, periodontal disease and caries.

Treatment plan should be decided after multidisciplinary opinions which includes periodontal therapy to maintain good oral hygiene, endodontic therapy to treat any periapical pathology, periodontal flap surgery to eliminate existing pockets and achieve good oral hygiene and orthodontic therapy to achieve facial aesthetics and to obtain stable occlusion with optimal overjet and overbite.[26]

PRIORITIZING ORTHODONTIC PROBLEM LIST

Prioritizing orthodontic problems begins with separating any underlying health issues, such as uncontrolled

diabetes or active periodontal disease, which must be managed before orthodontic treatment can commence to avoid complications like accelerated bone loss. Once health concerns are addressed, orthodontic issues are prioritized based on the patient's chief concerns. This step is crucial because it directly influences the treatment plan's focus and success from the patient's perspective.

Additionally, identifying the naturally ideal aspects of the patient's dentofacial appearance is essential to avoid unintentionally worsening favorable features. These natural features serve as benchmarks to guide treatment decisions, ensuring that correcting one problem does not compromise overall dentofacial harmony. Treatment possibilities are then evaluated in order of priority, addressing each orthodontic issue systematically to achieve optimal outcomes aligned with patient expectations and natural aesthetics.[23]

FACTORS WHILE CONSIDERING TREATMENT POSSIBILITIES

Considering treatment possibilities in orthodontics involves a systematic approach to address various factors that influence the planning and execution of effective treatment.

Firstly, identifying possible solutions for each orthodontic problem prioritized is essential. This could range from aligning malaligned incisors to addressing skeletal Class II discrepancies through growth modification or orthognathic surgery if skeletal growth is unfavorable. Each solution is tailored to meet the specific needs and concerns of the patient, ensuring a comprehensive approach to treatment planning.[2]

Secondly, understanding the type of tooth movement required guides the selection of appropriate appliances. Whether translation, pure rotation or combined movements are needed dictates whether fixed or removable appliances are more suitable movements.[2]

The growth potential of the patient plays a significant role in treatment timing and effectiveness. Patients in growth stages present both opportunities and challenges; achieving stable results during growth is possible, but there is also a risk of relapse if growth patterns are unfavorable post-treatment. Timing treatments to coincide with growth peaks optimizes outcomes, particularly in Class II and Class III cases.[27]

Cost considerations are also significant. Assessing the complexity of treatment procedures against their benefits helps balance treatment choices in terms of financial costs, patient cooperation, discomfort and treatment duration. Opting for more complex procedures like orthognathic surgery may offer substantial benefits in certain cases despite higher costs and risks, compared to less invasive alternatives.[2] Lastly, the skills and training of the clinician influence treatment outcomes. A proficient clinician not only ensures accurate diagnosis and treatment planning but also navigates complex treatment scenarios effectively. Their decision-making skills and expertise significantly impact treatment duration and success.[23]

RETENTION PLAN

The retention phase is a critical component of orthodontic treatment and understanding the factors affecting retention is essential for long-term stability. Orthodontists can enhance treatment outcomes, minimize relapse and ensure the longevity of corrected tooth positions by implementing appropriate retention protocols.

Forces and factors that affect the post-treatment occlusion and retention are the forces from periodontal and gingival tissues, forces from soft tissues, occlusal forces and arch form.[28]

Appliances that are used for retention are fixed Retainers, removable Hawley-Type Retainers, vacuum-formed retainers, spring Retainers and Begg's Wraparound Retainer.

DISCUSSION WITH PATIENT AND PATIENT CONSENT

After considering all the treatment possibilities discussion with patient and informed consent should be done. Consent is of two types—informed and implied. Implied consent is generally required when undertaking surgery. Informed consent can and should be taken after providing the patient with enough information to have an understanding of the condition (malocclusion), its severity and the proposed treatment—its goals and objectives. He/she should be made to understand the commitment required on his/ her part—both regards to the time and finances.[29]

FINAL TREATMENT PLAN

For any patient, the selected treatment procedures must meet two criteria, effectiveness in producing the desired result and efficiency in doing so without wasting either doctor or patient time.

For a relatively simple treatment plan, the associated treatment procedures are also reasonably simple or at least straightforward. Nevertheless, choices must be made and clearly specified in the treatment plan. For example, if the plan is to expand a narrow maxillary arch, it would be possible to do this with an expansion lingual arch, an expansion labial arch or a banded or bonded maxillary palatal expander. The most serious errors in orthodontic treatment planning are those that result from first thinking of which appliance to use, not what the appliance is supposed to accomplish. The treatment mechanics should not be allowed to determine the treatment result.[2]

TREATMENT PLANNING IN SPECIAL CIRCUMSTANCES

Orthodontic treatment involves more than just straightening teeth; it requires consideration of a patient's overall health, especially when systemic diseases are present. Here's an exploration of various systemic conditions encountered in orthodontic practice and their management implications.

Infective endocarditis

Infective endocarditis is a severe infection of the heart's inner lining. Orthodontic procedures can potentially cause bacteremia, increasing the risk of IE, particularly in patients with underlying cardiac issues. The American Heart Association (AHA) recommends prophylactic antibiotics before certain orthodontic procedures to mitigate this risk. Orthodontists must communicate closely with a patient's physician to ensure proper management.[30]

Bleeding disorders

Patients with bleeding disorders, such as hemophilia, require meticulous planning to avoid complications during orthodontic treatment. Special considerations include using non-invasive methods for wire securing, maintaining excellent oral hygiene to prevent gingival bleeding and adjusting treatment duration to minimize risks associated with prolonged treatment periods.[30]

Renal disorders

Chronic renal failure affects oral health, leading to soft and hard tissue manifestations. Orthodontic treatment for these patients should be cautious, considering altered bone metabolism and potential complications from medications like immunosuppressants. Treatment timing is crucial, especially in relation to hemodialysis schedules to avoid complications related to bleeding and medication interactions.[30]

Thyroid and parathyroid disorders

Patients with thyroid disorders, such as hyperthyroidism or hypothyroidism, may experience challenges during orthodontic treatment due to bone turnover alterations. This can affect tooth movement and root resorption risk. Orthodontists should adjust treatment plans accordingly and monitor patients closely for any oral manifestations related to these conditions.[31]

Bronchial asthma

Asthmatic patients require careful management during orthodontic appointments to prevent exacerbations triggered by dental materials or stress. Appointments should be scheduled to minimize exposure to potential triggers and emergency measures like availability of oxygen and bronchodilators should be ensured.[31]

Juvenile rheumatoid arthritis

JRA can impact craniofacial growth and temporomandibular joint (TMJ) function, necessitating a tailored orthodontic approach. Functional appliances and heavy class II elastics should be used cautiously and orthodontic forces should be adjusted to account for joint involvement and pain management strategies.[30]

Diabetes mellitus

Diabetic patients require strict glycemic control during orthodontic treatment to prevent complications like periodontal disease and delayed wound healing. Orthodontic forces should be light to minimize periodontal breakdown and close collaboration with endocrinologists is essential to manage any acute fluctuations in blood glucose levels.[31]

Jaw injuries

Orthodontic management of jaw injuries involves various approaches depending on the severity and type of fracture. Techniques range from conservative splinting to surgical interventions like open reduction and internal fixation (ORIF). Each method aims to restore function and aesthetics while ensuring patient comfort and long-term stability.[32]

Hemimandibular hypertrophy

This condition requires a multidisciplinary approach involving orthodontics and surgery to manage unilateral mandibular overgrowth effectively. Surgical procedures such as condylectomy may be necessary to correct asymmetry and restore facial harmony.[33]

Sleep apnea

Orthodontic treatment plays a crucial role in managing obstructive sleep apnea (OSA), focusing on skeletal modifications like mandibular advancement devices (MAD) or maxillomandibular advancement (MMA). These devices aim to improve airway patency and reduce nighttime respiratory disturbances.[34]

Cleft lip and palate

Patients with cleft lip and palate require extensive multidisciplinary care throughout their lives. Orthodontic interventions aim to correct malocclusions and facilitate surgical procedures for optimal facial aesthetics and function. Treatment involves staged approaches from infancy through adulthood, including presurgical orthopedics, maxillary expansion and orthognathic surgery.[35]

TREATMENT PLANNING WITH NEWER TECHNOLOGY

Digital technology in orthodontics

Digital technology is transforming orthodontics, enhancing diagnosis, treatment planning and patient care. Innovations like cone beam computed tomography (CBCT) and 3D facial imaging offer precise anatomical representations, leading to more accurate and effective treatments. 3D printing technology, which fabricates objects layer by layer from computer-aided design (CAD), is increasingly used to create custom aligners and other orthodontic devices.

It allows for precise measurements, such as Bolton tooth size and arch length discrepancies and facilitates the evaluation of various treatment options. Orthodontists can assess different extraction patterns, anchorage needs and potential expansion or uprighting of dental segments.

Software like uLab, SureSmile, OrthoAnalyzer and ArchForm allows clinicians to digitally align teeth, generate 3D print models and fabricate thermoplastic aligners in their practices. These tools streamline the planning process, providing accurate representations and predictions of treatment outcomes.[23]

Digital dental models

Digital 3D models, created through advanced scanning technologies, have revolutionized dental model production and usage. These models, stored digitally, simplify storage and transfer and support new diagnostic and treatment methods, including 3D planning for orthognathic surgery and clear aligner therapy.

Advanced 3D technologies enable the merging of multiple 3D images from various sources to create comprehensive models which helps clinicians in treatment planning by displaying individual crowns, roots and craniofacial structures. It also allows for accurate monitoring of treatment progress and outcome prediction.[36]

Digital orthognathic surgery planning

Digital orthognathic surgery planning involves integrating CBCT images, digital dental models and stereophotogrammetry to create a "virtual patient." This method eliminates many traditional model surgery steps, such as facebow transfers. The digital planning process consists of osteotomy and wafer production phases. Digital models provide superior occlusal data, enhancing planning accuracy.[37]

Miniscrew insertion guides

Miniscrew anchorage has advanced orthodontic treatment by reducing the need for patient compliance. However, manual insertion poses risks, which digital insertion guides aim to mitigate. These guides, using CBCT data and digital models, allow precise screw placement by superimposing 3D root images. This technique significantly reduces the risk of root damage compared to manual insertion methods.[38]

Clear aligners

Clear aligners utilize 3D digital models to plan and execute tooth movements. Align's ClinCheck® software enables clinicians to view, modify and plan tooth positions, interproximal reductions and composite resin attachments. The treatment plan, once approved, leads to the production and delivery of custom aligners. Clear aligners offer aesthetic and comfortable alternatives to traditional fixed braces, improving periodontal health and reducing white spot lesions.[39]

Artificial neural networks

Artificial neural networks (ANNs) are machine learning algorithms inspired by the human brain. They learn from data to provide predictions and classifications by identifying complex patterns. In orthodontics, ANNs assist in treatment planning by offering objective criteria for decisions like tooth extractions. Recent models have demonstrated high accuracy in predicting extraction needs, treatment plans and anchorage requirements, making ANNs valuable tools for orthodontic practitioners.[40]

CONCLUSION

Treatment planning in orthodontics is intricate, requiring clinicians to master patient history, examination and record collection. They must understand growth, development, aesthetics, occlusion, malocclusion causes, orthodontic appliances, tooth movement, treatment risks and retention. Initial treatment addresses pathological issues before focusing on orthodontic problems, including aesthetics, alignment and occlusion in various dimensions.

Skeletal issues may need orthodontic camouflage, growth modification or combined orthodontic and orthognathic surgery. After listing problems, clinicians decide which to address and consider aesthetic, functional, health and stability factors. Space analysis aids in planning and feasibility assessment. Discussing treatment options with patients ensures informed consent, highlighting risks, benefits, costs and commitment. Advances in digital imaging and orthodontic software have enhanced diagnosis and treatment planning, aiding in patient education and informed decision-making.

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