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Artificial Intelligence in Orthodontic Bracket Placement: A Comparative Review of Digital Indirect Bonding Systems

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Abstract:

➢ ***Background***

Artificial Intelligence (AI) is rapidly transforming orthodontic workflows, particularly in the domain of bracket planning and placement.

➢ ***Objective***

This article presents a comparative overview of five AI-driven digital indirect bonding (IDB) systems—DIBS AI (OrthoSelect), DDP AI (with DTS), 3Shape Ortho System, uLab AI, and SoftSmile Vision—highlighting their core capabilities, clinical applications, and integration into orthodontic practice.

➢ ***Approach***

Each platform was examined based on its documented use of AI for bracket positioning accuracy, treatment planning efficiency, and digital workflow integration. Peer-reviewed literature, developer specifications, and clinical reports were critically appraised to inform the comparison.

➢ ***Findings***

DIBS AI, DDP AI, and 3Shape offer robust IDB workflows with precise bracket placement tools and established clinical utility. uLab AI and SoftSmile Vision demonstrate hybrid and aligner-focused innovations that complement bracket-based treatments and expand digital planning versatility.

➢ ***Conclusion***

AI-powered IDB systems are reshaping orthodontic care by enhancing treatment precision and streamlining planning workflows. Their integration signals a pivotal shift toward intelligent, data-driven orthodontics, with implications for future research, clinical education, and practice evolution.

Keywords: *AI in Orthodontics, Indirect Bonding, Bracket Placement, Digital Dentistry*.

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I. INTRODUCTION

The integration of artificial intelligence (AI) into orthodontic workflows marks a transformative shift in clinical practice, particularly in the domain of bracket planning and placement. Historically, orthodontic bracket positioning has relied heavily on manual techniques, which, despite their clinical utility, are prone to operator variability and subjective interpretation[1]. This inconsistency can affect treatment outcomes, prolong chairside time, and necessitate mid-course corrections. The emergence of AI-powered platforms offers a paradigm shift by introducing algorithmic precision, predictive modeling, and data-driven decision-making into orthodontic diagnostics and appliance placement[2].

AI applications in orthodontics span a wide spectrum—from automated cephalometric analysis and tooth segmentation to virtual treatment simulations and indirect bonding tray fabrication[3]. These systems utilize deep learning architectures, particularly convolutional neural networks (CNNs), to process complex datasets such as intraoral scans, panoramic radiographs, and CBCT images[4]. By training on large volumes of annotated clinical data, AI algorithms can identify anatomical landmarks, assess malocclusion severity, and recommend bracket positions with remarkable accuracy[5]. This not only enhances diagnostic reliability but also facilitates personalized treatment planning tailored to individual patient morphology[6].

Digital indirect bonding systems have become a cornerstone of AI-enhanced orthodontics. These platforms allow clinicians to virtually position brackets on 3D models, simulate tooth movement, and fabricate customized bonding trays using CAD/CAM and 3D printing technologies[7]. The integration of AI into this workflow enables real-time adjustments based on occlusal dynamics, arch form, and biomechanical constraints[8]. Comparative studies have shown that AI-assisted bracket placement yields superior outcomes in terms of torque, angulation, and rotational control when compared to conventional methods[9]. Moreover, the reproducibility of bracket positioning across multiple cases underscores the reliability of AI-driven systems[10].

Several commercial platforms—including DIBS AI (OrthoSelect), DDP AI (with DTS), 3Shape Ortho System, uLab AI, and SoftSmile Vision—have incorporated adaptive learning modules that refine bracket placement algorithms based on longitudinal treatment data[11]. These systems continuously learn from clinical feedback, improving their predictive capabilities and reducing the need for manual intervention. Such advancements support a shift toward proactive orthodontics, where AI not only assists but anticipates clinical needs, enabling earlier detection of treatment deviations and automated alerts for intervention[12].

Despite these promising developments, challenges persist in the widespread adoption of AI in orthodontics. Variability in scan quality, lack of standardized protocols, and limited transparency in algorithmic decision-making raise concerns about clinical reliability and ethical accountability[13]. Furthermore, the integration of AI systems into existing digital ecosystems requires interoperability, robust data security measures, and clinician training to ensure optimal utilization[14]. Regulatory frameworks and validation studies are essential to establish clinical efficacy and safeguard patient outcomes[15].

In conclusion, the convergence of AI and digital orthodontics heralds a new era of intelligent automation, where bracket planning and placement are guided by data rather than intuition. While human expertise remains indispensable, AI serves as a powerful adjunct that enhances precision, streamlines workflows, and personalizes care. As research continues to validate these technologies, the future of orthodontics will likely be defined by a hybrid model—one that harmonizes clinical judgment with algorithmic intelligence to deliver superior, patient-centric outcomes[16].

II. COMPARATIVE ANALYSIS OF AI-POWERED INDIRECT BONDING SYSTEMS

Building on the foundational role of AI in orthodontic bracket placement, this section presents a comparative analysis of five leading digital indirect bonding (IDB) systems: DIBS AI (OrthoSelect), DDP AI (with DTS), 3Shape Ortho System, uLab AI, and SoftSmile Vision. Each platform was selected based on its integration of artificial intelligence into bracket planning workflows, clinical adoption, and relevance to contemporary orthodontic practice. The analysis focuses on core capabilities, automation level, digital workflow compatibility, and documented clinical outcomes, offering a balanced overview of their strengths, limitations, and potential contributions to AI-enhanced orthodontics.

➢ *DIBS AI (OrthoSelect):*

DIBS AI, developed by OrthoSelect, is a leading AI-powered platform designed specifically for digital indirect bonding (IDB) in orthodontics. It automates bracket placement on 3D dental models using proprietary machine learning algorithms trained on thousands of annotated cases. The system analyzes tooth morphology, arch form, and occlusal relationships to determine optimal bracket positions, aiming to reduce human error and enhance biomechanical precision. Unlike semi-automated systems, DIBS AI offers full automation with optional clinician override, allowing orthodontists to maintain control while benefiting from algorithmic consistency. The platform supports a wide range of bracket prescriptions and slot dimensions, and its planning engine accounts for torque, angulation, and rotational control across all teeth in the arch.

One of DIBS AI's most notable features is its seamless integration with CAD/CAM workflows. After AI-driven bracket placement, the system automatically generates IDB tray designs, which can be exported in STL format and fabricated using resin-based 3D printers. This end-to-end digital workflow significantly reduces chairside time and improves reproducibility. A multicenter clinical study reported that DIBS AI achieved bracket placement accuracy within ±0.5 mm for over 90% of cases, outperforming manual and semi-digital methods[17]. Additionally, the platform's intuitive interface and cloud-based architecture allow for remote case planning and collaboration, making it suitable for both solo practitioners and multi-location practices. Recent evaluations have also highlighted its role in reducing mid-treatment repositioning rates and improving overall treatment efficiency[18].

➢ *DDP AI (with DTS):*

DDP AI, developed as part of the Digital Dental Platform (DDP) suite, integrates artificial intelligence with Digital Treatment Simulation (DTS) to offer a hybrid approach to bracket planning and orthodontic visualization. Unlike fully automated systems, DDP AI emphasizes clinician-guided planning enhanced by predictive modeling. Its AI engine analyzes intraoral scans and occlusal relationships to suggest bracket positions that optimize force distribution and arch coordination. The DTS module allows orthodontists to simulate treatment progression, visualize bracket-induced tooth movement, and assess biomechanical implications before tray fabrication. This dual-layered approach supports both precision and clinical customization, making it particularly suitable for complex malocclusion cases and hybrid treatment plans.

The platform's strength lies in its real-time simulation capabilities and modular architecture. DDP AI enables clinicians to toggle between automated suggestions and manual refinements, offering flexibility without compromising algorithmic support. It supports multiple bracket libraries and bonding protocols, and its cloud-based interface facilitates remote collaboration and multi-device access. While peer-reviewed validation of DDP AI remains limited, early clinical reports suggest improved planning efficiency and reduced repositioning rates in digitally guided cases[19]. The DTS engine also contributes to patient engagement by providing visual treatment previews, which have been shown to enhance compliance and case acceptance[20]. However, the platform's reliance on clinician calibration and its relatively steep learning curve may pose challenges for practices transitioning from analogue workflows.

➢ *3Shape Ortho System:*

The 3Shape Ortho System, anchored by its OrthoAnalyzer module, is a comprehensive digital orthodontic platform that blends clinician-driven planning with AI-assisted tools. Unlike fully autonomous systems, 3Shape offers a semi-automated bracket placement workflow that prioritizes user control while integrating algorithmic support for enhanced precision. The platform enables orthodontists to import intraoral scans, select bracket libraries, and virtually position appliances on 3D models with real-time feedback on angulation, torque, and rotational alignment. Its AI capabilities are embedded within the software's diagnostic and simulation tools, which assist in

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identifying anatomical landmarks and optimizing bracket placement based on occlusal relationships and arch form geometry[21].

A defining strength of the 3Shape Ortho System is its interoperability across the digital ecosystem. It supports seamless integration with major intraoral scanners (e.g., TRIOS), third-party CAD/CAM software, and 3D printers, allowing clinicians to transition from virtual planning to indirect bonding tray fabrication without workflow disruption. The system also facilitates aligner planning, cephalometric analysis, and treatment simulation, making it a versatile tool for hybrid orthodontic practices. Clinical studies have demonstrated that bracket placement using 3Shape's digital workflow yields comparable accuracy to fully automated systems, with added benefits of manual refinement and case-specific customization[22]. Its widespread adoption in academic and private settings underscores its reliability, though the platform's AI features remain assistive rather than predictive, requiring active clinician input throughout the planning process[23].

➤ *uLab AI:*

uLab AI is a cloud-based orthodontic platform that integrates artificial intelligence into both aligner and bracket-based treatment planning. While originally developed to support in-office aligner workflows, uLab has expanded its capabilities to include bracket placement tools that leverage AI for virtual setup optimization. The platform's planning engine uses machine learning to analyse intraoral scans and simulate tooth movement, allowing clinicians to visualize treatment outcomes before appliance fabrication. Unlike fully automated systems, uLab AI emphasizes clinician-guided refinement, offering bracket placement suggestions that can be adjusted in real time. This hybrid approach balances algorithmic support with practitioner expertise, making it particularly suitable for cases requiring nuanced biomechanical control.

A key differentiator of uLab AI is its seamless transition between aligner and bracket modalities within a unified interface. Clinicians can toggle between treatment types, simulate outcomes, and export appliance designs without switching platforms. The system supports STL imports from major scanners and integrates with 3D printers for indirect bonding tray fabrication. Although bracket-specific literature on uLab remains limited, early clinical reports suggest that its AI engine improves planning efficiency and enhances visualization of bracket-induced tooth movement[24]. The platform's intuitive design and rapid setup capabilities have also been cited as advantages in chairside planning and patient communication[25]. However, its bracket planning module is still evolving, and its AI features—while promising—are less mature than those of platforms developed exclusively for indirect bonding.

➤ *SoftSmile Vision:*

SoftSmile Vision is a next-generation orthodontic software platform that applies artificial intelligence to biomechanical modeling and treatment simulation. While primarily developed for aligner planning, Vision includes bracket placement capabilities that leverage deep learning to optimize force vectors and appliance positioning. Its AI engine analyses 3D dental models to simulate tooth movement under various bracket configurations, offering clinicians a predictive view of treatment outcomes. Unlike traditional IDB systems, SoftSmile Vision emphasizes force-based planning rather than static bracket placement, aiming to align bracket positioning with individualized biomechanical goals[26].

The platform's architecture is built around a proprietary physics engine that models orthodontic forces in real time, allowing clinicians to visualize how bracket placement affects torque, angulation, and rotational control. Vision supports STL imports and integrates with third-party printers for tray fabrication, but its IDB workflow is less streamlined than those of dedicated bracket platforms like DIBS AI or 3Shape. Early adopters have praised its intuitive interface and advanced simulation tools, though peer-reviewed validation of its bracket-specific accuracy remains limited[27]. SoftSmile's emphasis on transparency and clinician feedback loops aligns with broader calls for ethical AI in dentistry, but its current implementation is best suited for hybrid or aligner-dominant practices exploring bracket integration as a secondary modality[28].

Table 1 Comparative Summary of AI-Powered IDB Platforms

Platform	AI Capabilities	Bracket Planning Workflow	IDB Tray Integration	Clinical Validation	Limitations
DIBS AI **(OrthoSelect)**	Fully automated bracket placement using trained ML algorithms[17]	End-to-end virtual setup with minimal manual input	Auto-generated STL trays for 3D printing[18]	High reproducibility and accuracy in multicenter trials[17]	Proprietary workflow; limited customization options
DDP AI **(with DTS)**	Predictive modeling with clinician-guided refinement[19]	Hybrid planning with real-time simulation of tooth movement[20]	Modular export; supports multiple bonding protocols	Early-stage clinical feasibility reports[19]	Requires calibration; steep learning curve for new users
3Shape Ortho System	Semi-automated planning with	Manual override with bracket-by-	Integrated with TRIOS scanner	Widely adopted; accuracy comparable to automated systems[22]	AI is assistive, not predictive;

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	assistive AI tools[21]	bracket control[22]	and 3D printers[23]		requires active clinician input
uLab AI	Machine learning-based simulation engine for hybrid planning[24]	Bracket placement suggestions with real-time adjustment[25]	STL export supported; aligner and bracket synergy	Limited bracket-specific validation[24]	Bracket module less mature; aligner-focused development
SoftSmile Vision	Deep learning for force vector optimization and biomechanical modeling[26]	Physics-based simulation of bracket-induced forces[27]	STL export available; less streamlined for IDB	Underrepresented in bracket-specific literature[27]]	Primarily aligner-focused; bracket planning is secondary

III. DISCUSSION

➢ *Clinical Rationale and Technological Evolution*

The clinical imperative for precision in orthodontic bracket placement has long been recognized, with studies highlighting the limitations of manual techniques in achieving optimal torque, angulation, and rotational control[1]. Operator variability, subjective interpretation, and anatomical complexity often result in inconsistent outcomes, necessitating mid-treatment adjustments and prolonging chairside time[3]. The emergence of digital indirect bonding (IDB) systems, particularly those powered by artificial intelligence (AI), addresses these challenges by introducing algorithmic consistency and data-driven planning into orthodontic workflows[2,6].

AI-enhanced IDB platforms leverage machine learning and deep learning architectures—most notably convolutional neural networks (CNNs)—to analyse complex datasets such as intraoral scans, CBCT volumes, and panoramic radiographs[4,7]. These systems are trained on annotated clinical data to identify anatomical landmarks, assess malocclusion severity, and recommend bracket positions tailored to individual morphology[5]. The integration of AI into bracket planning not only improves diagnostic reliability but also facilitates personalized treatment strategies that align with biomechanical goals[8,10].

Among the platforms reviewed, DIBS AI (OrthoSelect) exemplifies full automation, offering end-to-end bracket placement with minimal clinician input[17]. Its proprietary algorithms optimize bracket positioning based on occlusal dynamics and arch form, and its STL-based tray export streamlines the transition from virtual planning to clinical execution[18]. In contrast, 3Shape Ortho System provides a semi-automated workflow that prioritizes clinician control, allowing for bracket-by-bracket refinement within a robust digital ecosystem[21,23]. This distinction reflects a broader philosophical divide in AI adoption: whether to delegate planning to algorithms or to augment human expertise with assistive intelligence.

Hybrid platforms such as DDP AI and uLab AI occupy a middle ground, combining predictive modeling with real-time simulation tools[19,24]. DDP AI's integration with Digital Treatment Simulation (DTS) enables visualization of bracket-induced tooth movement, enhancing planning accuracy and patient communication[20]. uLab AI, originally developed for aligner workflows, has expanded its capabilities to include bracket placement, offering clinicians a unified interface for hybrid treatment planning[25]. These platforms reflect the growing demand for flexibility in orthodontic care, where aligners and brackets are no longer siloed modalities but components of a cohesive digital strategy[16].

SoftSmile Vision, while less directly aligned with bracket-centric IDB workflows, introduces a novel approach through force-based planning and biomechanical modeling[26]. Its physics engine simulates orthodontic forces in real time, allowing clinicians to visualize how bracket placement affects treatment dynamics[27]. Although its bracket module is still evolving, Vision's emphasis on transparency and clinician feedback aligns with ethical imperatives in AI development[28]. As Krois and Schwendicke note, the opacity of algorithmic decision-making must be counterbalanced by mechanisms that ensure accountability and clinician oversight[13].

The technological evolution of these platforms is underpinned by advances in CAD/CAM and 3D printing, which enable the fabrication of customized bonding trays with high fidelity[5,6]. Studies have demonstrated that digitally fabricated trays improve bracket placement accuracy and reduce bonding errors compared to traditional methods[22]. Moreover, the interoperability of platforms like 3Shape and DIBS AI with major scanner and printer systems facilitates seamless workflow integration, minimizing technical barriers to adoption[17,23].

➢ *Clinical Implications, Patient-Centered Outcomes, and Ethical Considerations*

The clinical implications of AI-powered IDB systems extend well beyond bracket placement accuracy. These platforms are reshaping orthodontic workflows by reducing chairside time, minimizing mid-treatment repositioning, and enhancing treatment predictability[10,18]. For example, DIBS AI has demonstrated bracket placement reproducibility within ±0.5 mm across multicentre trials[17], which translates into fewer bonding errors and more consistent force application. Such precision is particularly valuable in complex cases involving rotations, torque control, or deep bite correction, where manual placement often falls short[3,22].

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Moreover, the ability to simulate treatment outcomes before appliance fabrication—offered by platforms like DDP AI and uLab AI—enables clinicians to anticipate biomechanical challenges and adjust plans accordingly[19,24]. These simulations not only improve planning efficiency but also support informed clinical decision-making. For instance, DTS modules in DDP AI allow visualization of bracket-induced tooth movement, helping practitioners identify potential interferences or anchorage issues before bonding[20]. Similarly, uLab AI's hybrid interface facilitates seamless transitions between aligner and bracket modalities, allowing clinicians to tailor treatment strategies to individual patient needs[25].

Patient-centered outcomes are also enhanced through AI integration. Visual treatment previews, such as those offered by uLab and SoftSmile Vision, have been shown to improve patient understanding, engagement, and compliance[20,26]. In a recent survey, over 70% of patients reported increased confidence in their treatment plan when shown AI-generated simulations prior to appliance placement[29]. This aligns with broader trends in digital dentistry, where transparency and personalization are increasingly valued by both patients and providers[8,16]. Platforms that incorporate patient-facing tools not only improve communication but also foster trust, which is critical in long-duration treatments like orthodontics.

However, the ethical dimensions of AI adoption in orthodontics warrant careful consideration. The opacity of algorithmic decision-making—often referred to as the "black box" problem—raises concerns about clinical accountability and informed consent[13,28]. While platforms like SoftSmile Vision have made strides in transparency by offering clinician feedback loops and force-based modeling, many systems still lack explainability in how bracket positions are determined[27]. This can be problematic in cases where treatment outcomes deviate from expectations, leaving clinicians with limited insight into the algorithmic rationale.

Data privacy and interoperability also pose challenges. AI platforms rely on large volumes of patient data to train and refine their models, necessitating robust security protocols and compliance with regulatory frameworks[14,15]. The European Commission's proposed Artificial Intelligence Act underscores the need for transparency, risk classification, and human oversight in clinical AI applications[15]. Orthodontic platforms must therefore ensure that their data handling practices align with these standards, particularly as cloud-based systems become more prevalent.

Another concern is the potential for algorithmic bias. If training datasets lack diversity in terms of age, ethnicity, or malocclusion types, AI recommendations may be skewed or less effective in underrepresented populations[30]. This highlights the importance of inclusive data curation and ongoing validation across varied clinical contexts. As AI becomes more embedded in orthodontic practice, developers and clinicians must collaborate to ensure that these systems serve all patient demographics equitably.

➢ *Future Directions, Clinical Training, and the Evolving Role of the Orthodontist*

As AI-powered digital indirect bonding (IDB) systems continue to evolve, the orthodontic profession faces a critical juncture: how to harmonize algorithmic intelligence with clinical expertise. The platforms reviewed—DIBS AI, DDP AI, 3Shape Ortho System, uLab AI, and SoftSmile Vision—each represent distinct philosophies of AI integration, ranging from full automation to clinician-guided simulation. This diversity underscores the need for orthodontists to not only understand the technical capabilities of these systems but also to critically evaluate their assumptions, limitations, and clinical implications[2,7,13].

One emerging priority is the development of standardized validation protocols for AI-assisted bracket placement. While studies have demonstrated high accuracy for platforms like DIBS AI and 3Shape[21,17], the lack of uniform benchmarks across systems makes direct comparison difficult. Future research should focus on multicentre trials that assess bracket placement accuracy, treatment efficiency, and long-term outcomes across diverse patient populations[30,31]. Such studies would help establish evidence-based guidelines for AI adoption and inform regulatory frameworks that safeguard patient care[15].

Clinical training must also adapt to the digital transformation. As AI systems become more embedded in orthodontic workflows, practitioners will need to develop competencies in digital planning, data interpretation, and algorithmic oversight[14,32]. Educational institutions should incorporate AI literacy into orthodontic curricula, emphasizing not only technical proficiency but also ethical reasoning and critical appraisal. Simulation-based training modules—such as those offered by DTS and SoftSmile Vision—could serve as valuable tools for teaching force dynamics, treatment sequencing, and bracket biomechanics in a virtual environment[20,27].

The evolving role of the orthodontist in this landscape is not one of displacement but of augmentation. AI systems can automate routine tasks, flag anomalies, and suggest optimized bracket positions, but they cannot replace the nuanced judgment required in complex cases, interdisciplinary coordination, or patient communication[9,16]. Instead, orthodontists are poised to become digital strategists—professionals who leverage AI to enhance precision while maintaining human-centered care. This hybrid model aligns with broader trends in healthcare, where clinicians increasingly collaborate with intelligent systems to deliver personalized, efficient, and ethically sound treatment[33].

Interoperability will be another key determinant of success. Platforms that integrate seamlessly with scanners, printers, and practice management software—such as 3Shape and uLab—are more likely to be adopted in busy clinical settings[23,24]. Developers must prioritize open architecture, modular design, and cross-platform compatibility to ensure that AI tools do not become siloed or restrictive. As Ahmed et al. note, the future of digital dentistry depends on systems that are not only intelligent but also interoperable and scalable[14].

Finally, the orthodontic community must engage in ongoing dialogue about the ethical use of AI. Issues such as algorithmic bias, data privacy, and explainability are not peripheral concerns—they are central to the responsible deployment of these technologies[13,28,30]. Professional societies, regulatory bodies, and academic institutions should collaborate to establish ethical standards, audit mechanisms, and clinician education programs that promote transparency and accountability. Only through such collective stewardship can AI fulfil its promise as a transformative force in orthodontic care.

IV. CONCLUSION

The integration of artificial intelligence into orthodontic bracket planning and placement marks a transformative shift in clinical practice, redefining how precision, efficiency, and personalization are achieved in digital workflows. AI-powered digital indirect bonding (IDB) systems—such as DIBS AI, DDP AI, 3Shape Ortho System, uLab AI, and SoftSmile Vision—demonstrate diverse approaches to automation, simulation, and clinician control, each contributing uniquely to the evolving orthodontic landscape.

Platforms like DIBS AI and 3Shape have established themselves through validated bracket accuracy and robust workflow integration[17,21], while hybrid systems such as DDP AI and uLab AI offer flexible planning environments that accommodate both aligners and brackets[19,24]. SoftSmile Vision, though less bracket-centric, introduces biomechanical modeling that may inform future force-driven placement strategies[26]. Collectively, these systems exemplify the convergence of AI, CAD/CAM, and 3D printing technologies in orthodontics[5,6].

Despite their promise, challenges remain. Ethical concerns surrounding algorithmic transparency[13], data security[14], and regulatory compliance[15] must be addressed to ensure responsible adoption. Moreover, the orthodontist's role is evolving—not toward obsolescence, but toward digital stewardship. Clinicians must be equipped to interpret AI outputs, guide treatment decisions, and uphold patient-centered care in increasingly automated environments[9,16,33].

As research continues to validate these technologies and educational frameworks adapt to digital competencies[32], the future of orthodontics will likely be defined by a hybrid model—one that harmonizes clinical judgment with algorithmic intelligence. AI-powered IDB systems are not merely tools; they are catalysts for a new era of intelligent, data-driven orthodontic care.

STATEMENTS AND DECLARATIONS

➢ *Ethical Approval:*
Not Applicable

➢ *Patient Consent:*
Not Applicable

➢ *Consent for publication:*
Not Applicable

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