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# Integrating Articulating Paper and Emerging Digital Technologies

## Clinical Decision-Making in Occlusal Adjustment

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## Abstract

Occlusal adjustment is significant in restorative, prosthodontic, and implant dentistry, given its effects on the comfort, success, and functional longevity of both prosthodontic therapy and dental implants. The traditional methods used for occlusal adjustment analysis involved the use of articulating paper. However, it has limitations, such as the absence of quantitative information related to the distribution and timing of forces. Recent advances include the introduction of digital occlusal analysis systems, such as T-Scan and OccluSense, as well as intraoral scanners, for creating occlusal distribution maps. This article aims to present the clinical use of traditional methods, present an evaluation study for digital occlusal analysis, and provide a clinical guideline for interpreting occlusal adjustment in natural, dental, implant-supported, and TMD conditions. This article can direct clinicians on how to choose the appropriate technique according to the specific requirements for each case.

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### Introduction

Effective occlusion analysis is the backbone of any successful procedure in restorative and prosthodontic dentistry. The accuracy and reliability of occlusal analysis are crucial in ensuring the longevity of any form of prosthodontic work, while also ensuring that the prosthesis does not cause any harm to the occlusion, temporomandibular joint, function, or feeling [1-5]. Even in past decades, the use of articulating paper has dominated prosthodontic analysis for its ease, economy, and advantage of instant analysis for the interpretation of occlusal discrepancies, including the location of cusps [1-4,6].

However, the significance of the interpretation of the marks present on the articulating paper remains subjective by nature. This is because evidence suggests that the size and intensity of the mark bear little relation to the intensity of occlusal forces, and discrepancies can depend on various factors, such as thickness, moisture, and the experience level of the individual [7–9]. Such discrepancies remain particularly significant in implant prosthodontics, in that a lack of periodontal ligament can lead to unintended overload when adjustment is made only by use of the occlusal marks [10,11]. To overcome the limitations, digital occlusal analysis systems were introduced, making it possible for professionals to provide quantitative and reproducible data on occlusal force, timing, and sequence. Dinâmica, TScan, and OccluSense help evaluate dynamically, while the use of intraoral scanners helps for precise 3D evaluation of static occlusion for prosthodontic analysis [12-15].

However, achieving clinical integration, despite the benefits offered by digital technology, also necessitates knowledge related to the principles, limitations, and indications for the use of digital occlusal evaluation methods. The costs, learning curve, and complexity of occlusal cases also need consideration [16-20]. This perspective study aims to provide an integration of existing knowledge related to traditional and digital occlusal evaluation methods.

### Historical background of occlusal analysis


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The evaluation of occlusion has undergone a tremendous transformation during the past century. According to the account given by Dawson, "The use of articulating paper, introduced in the early 1900s, offered a simple, quick way to assess occlusal contact," and it "became the standard clinical instrument for evaluating occlusion to identify contacts, improve restorative surfaces, and balance occlusion in both natural and prosthodontic situations for several decades during the last century [21,22].

However, despite its usefulness, several authors pointed to its inherent limitations too. Many studies confirm that only the location of contact is expressed by marks on the articulating paper, whereas information on occlusal load, the timing of contact, and any functional interactions is not specified [23,24].

However, by the end of the twentieth century, along with the growth in CAD/CAM prosthodontics, new computerized occlusal analysis software also came into existence. With the T-Scan system and, more contemporary, OccluSense, it has become feasible to evaluate occlusal forces and the sequence of occlusal contact. The relevance of these recent enhancements, according to Kerstein et al., has become particularly important in achieving greater success in implant dentistry [25-27].

**Articulating paper in dentistry**

The use of articulating paper has remained the definitive tool for diagnosing occlusal analysis because it is simple, cheaper, and easier to use. Commonly made from thin strips coated with ink, the articulating paper will indicate occlusal contact points. This helps the dentist judge through sight, for example, where the occlusal contact has occurred, and adjustments can then be made through grinding [28]. Despite its limitations, it has remained widely used in clinical settings since it is simple, providing instant results without requiring any specialized equipment [29].

**Types of Articulating Papers**

The type of dental articulating paper that can be used also has different formulations that depend on its thickness, coating, and composition. This is aimed at providing for the different clinical situations that arise during prosthodontic, restorative, and occlusal treatment [30]. The type of dental paper depends on the clinical situation, type of restorative material, and level of required accuracy, making it crucial for the clinician to know the types that exist [31]. Table 1 summarizes the available types.

**Digital occlusal technologies**

Digital occlusal technologies provide objective, quantifiable, and reproducible data that complement traditional articulating paper methods. They allow clinicians to evaluate occlusal force, timing, and contact sequence, which are difficult to assess visually. Major systems include T-Scan, OccluSense, and IOSs (Table 2).

**Interpretation of Articulating Paper Marks**

The darker or larger marks do not necessarily indicate higher occlusal loads. Clinicians must consider contact distribution, patient symptoms, and adjunctive tools to avoid inappropriate adjustments. Figure 1 summarizes the understanding of articulating paper marks.

**Making clinical decisions for special situations**

Conventional articulating paper effectively identifies contact points, while digital occlusal analysis provides objective force and timing data, especially valuable in complex, implant-supported, or TMD cases. An optimal approach integrates both methods, marking contacts with paper, validating them digitally, and making selective adjustments for balanced occlusion. Figure 2 illustrates the suitable occlusal diagnostic technology.

This perspective draws on heterogeneous trials with varying devices, protocols, and outcome measures, preventing reliable comparison or pooling. Many included studies are small, short-term, or in vitro rather than well-powered, blinded clinical trials. Operator-dependent techniques, inconsistent sensor calibration, and inadequate blinding introduce measurement and observer bias. Crucially, few trials report long-term, patient-centered outcomes or address cost and implementation, so clinical impact remains uncertain.

## References


1. Mohamed MH, Soliman SI. Computerized Assessment of Articulating Paper Occlusal Adjustment for Implant Crowns Restoring Modification Spaces of Kennedy Class II Cases. Advanced Dental Journal. 2023;5(3):639-50.
2. Dizayee WM, Ikram FS. Comparison between digital and conventional occlusal indicators. Erbil Dental Journal (EDJ). 2023;6(1):10-9.
3. Borgard H. Predicting occlusal force and area through a biomechanical simulation of mastication and controlled study: University of British Columbia; 2020.
4. Najeeb M, Islam S. Artificial intelligence (AI) in restorative dentistry: current trends and future prospects. BMC Oral Health. 2025;25(1):592.
5. Kui A, Dumbrovca B, Oriot P, Negucioiu M, Taut M, Manziuc M, et al. Comparative Effectiveness of Intraoral Scanners and Articulating Paper in Occlusal Contact Analysis. Medicine in Evolution. 2024;30(4).
6. Qadeer S, Özcan M, Edelhoff D, Van Pelt H. Accuracy, reliability and clinical implications of static compared to quantifiable occlusal indicators. The European journal of prosthodontics and restorative dentistry. 2021;29(3):130-41.
7. Saud M, Alafandy M, Osama AM, El-Sadat OA. Effect of T-scan Occlusal Analysis and Adjustment Versus Articulating Paper on Stresses Transmitted to Single Mandibular Implant Supported Prosthesis. Open Access Macedonian Journal of Medical Sciences. 2023;11(D):78-87.
8. Oberoi D, Hegde C. Evaluation and comparison of occlusal interference markings with articulating papers of varying thicknesses: An in vivo study. Journal of Prosthodontics. 2025.
9. Qadeer S. The Limitations of Static Traditional Occlusal Indicators Compared to the Advantages of Quantifiable Dynamic Occlusal Indicators. Handbook of Research on T-Scan Technology Applications in Dental Medicine: IGI Global Scientific Publishing; 2025. p. 107-86.
10. Bento VAA, Rosa CDDRD, Lopes LFdTP, de Araújo Lemos CA, Miyashita E, Pellizzer EP. Digital analysis of occlusion variations in single posterior implant-supported fixed prostheses: a systematic review and meta-analysis of clinical trial studies. The Journal of Advanced Prosthodontics. 2025;17(4):247.
11. Jauregi M, Amezua X, Iturrate M, Solaberrieta E. Repeatability and reproducibility of 2 digital occlusal analyzers for measuring the right-and left-side balance of occlusal contact forces: An in vitro study. The Journal of Prosthetic Dentistry. 2024;132(1):179-87.
12. Sutter B. Digital occlusion analyzers: a product review of T-Scan 10 and OccluSense. Advanced Dental Technologies & Techniques. 2019:1-31.
13. Chowdhary R, Sonnahalli NK. Clinical applications of the T-Scan quantitative digital occlusal analysis technology: a systematic review. International Journal of Computerized Dentistry. 2023:0-.
14. Kerstein RB. The Evolution of the Science of Measured Digital Occlusion: From the T-Scan I to the T-Scan 10 Computerized Occlusal Analysis Systems. Handbook of Research on T-Scan Technology Applications in Dental Medicine: IGI Global Scientific Publishing; 2025. p. 1-106.

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15. Revilla-León M, Kois DE, Zeitler JM, Att W, Kois JC. An overview of the digital occlusion technologies: Intraoral scanners, jaw tracking systems, and computerized occlusal analysis devices. Journal of Esthetic and Restorative Dentistry. 2023;35(5):735-44.
16. Huckvale K, Venkatesh S, Christensen H. Toward clinical digital phenotyping: a timely opportunity to consider purpose, quality, and safety. NPJ digital medicine. 2019;2(1):88.
17. Seth-Johansen C, Gotfredsen K. Validity and reliability of digital occlusal analyzing methods in Dentistry. A systematic review. Journal of Dentistry. 2025:106124.
18. Morsy N, El Kateb M. Accuracy of intraoral scanners for static virtual articulation: A systematic review and meta-analysis of multiple outcomes. The Journal of prosthetic dentistry. 2024;132(3):546-52.
19. Toser I, Faur A-B, Anghel-Lorinți A-E, Jivănescu A. A Comprehensive Digital Workflow to Enhance Predictability and Precision with Fixed Dental Prostheses in the Posterior Region. Frontiers in Dental Medicine. 2025;6:1625405.
20. Gözen M, Güntekin N. Comparison of occlusal force distribution and digital occlusal analysis methods of single posterior implant restorations: an in vivo study. BMC Oral Health. 2025;25(1):795.
21. Dawson PE. New definition for relating occlusion to varying conditions of the temporomandibular joint. The Journal of prosthetic dentistry. 1995;74(6):619-27.
22. Kimmel SS. Rationale and technique for achieving occlusal harmony. New York State Dental Journal. 2009;75(1):39.
23. Reddy S, Kumar PS, Grandhi VV. Relationship between the applied occlusal load and the size of markings produced due to occlusal contact using dental articulating paper and T-Scan: comparative study. JMIR Biomedical Engineering. 2018;3(1):e11347.
24. Carey JP, Craig M, Kerstein RB, Radke J. Determining a relationship between applied occlusal load and articulating paper mark area. The Open Dentistry Journal. 2007;1:1.
25. Kerstein RB, Radke J. Clinician accuracy when subjectively interpreting articulating paper markings. CRANIO®. 2014;32(1):13-23.
26. Klineberg I, Trulsson M, Murray G. Occlusion on implants–is there a problem? Journal of oral rehabilitation. 2012;39(7):522-37.
27. Lerner H, Mangano C, Luongo G, Mangano A, Luongo F, Van Stralen K, et al. Implant Complications After Installation with Traditional Vs Digital Occlusal Indicators. Advanced Dental Technologies & Techniques. 2024:1-15.
28. Aldhuwayhi S. Occlusal indicators: A key to achieving stomatognathic system harmony during prosthodontic and restorative treatments-a literature review. Annals of Dental Specialty. 2019;7(1):16-23.
29. Khulud A, Alshahrani AM, Algassm RY, Zameem ZS, Alkhayri AH. A review of the application of computers in the field of prosthodontics and related specialities. Journal of Advanced Medical and Dental Sciences Research. 2024;12(7):19-27.
30. Fraile C, Ferreiroa A, Romeo M, Alonso R, Pradíes G. Clinical study comparing the accuracy of interocclusal records, digitally obtained by three different devices. Clinical oral investigations. 2022;26(2):1957-62.
31. Millstein P, Maya A. An evaluation of occlusal contact marking indicators: A descriptive quantitative method. The Journal of the American Dental Association. 2001;132(9):1280-6.
32. Brizuela-Velasco A, Álvarez-Arenal Á, Ellakuria-Echevarria J, Río-Highsmith Jd, Santamaría-Arrieta G, Martín-Bianco N. Influence of Articulating Paper Thickness on Occlusal Contacts Registration: A Preliminary Report. International Journal of Prosthodontics. 2015;28(4).
33. Rovira-Lastra B, Khoury-Ribas L, Flores-Orozco E-I, Ayuso-Montero R, Chaurasia A, Martinez-Gomis J. Accuracy of digital and conventional systems in locating occlusal contacts: A clinical study. The Journal of Prosthetic Dentistry. 2024;132(1):115-22.
34. Mpungose S, Geerts G. Analyzing Complete Denture Occlusal Contacts: Accuracy and Reliability. The International Journal of Prosthodontics. 2016;29(1):50-2.
35. Davies S, Gray R. The examination and recording of the occlusion: why and how. British dental journal. 2001;191(6):291-302.
36. Andrus R, Qian F, Schneider R, Huber L, Kerstein RB. Comparison of results of traditional occlusal adjustment technique with computer-aided occlusal adjustment technique. Advanced Dental Technologies & Techniques. 2019:43-53.
37. Malta Barbosa J, Urtula AB, Hirata R, Caramês J. Thickness evaluation of articulating papers and foils. Journal of Esthetic and Restorative Dentistry. 2018;30(1):70-2.
38. Lerner H. Digital Occlusion's Role in Implant Rehabilitation. Handbook of Research on T-Scan Technology Applications in Dental Medicine: IGI Global Scientific Publishing; 2025. p. 2163-274.
39. Chan H, Alimujiang A, Fong SI, Wu M-L, Liang R, Lai P-Y, et al. Use of T-Scan III in analyzing occlusal changes in molar fixed denture placement. BMC oral Health. 2024;24(1):264.
40. Aradya A, Nagarajagowda RSK, Basavaraju RM, Srinivas S, Kumararama SS. Influence of T-scan system on occlusion correction of Implant supported prostheses: a systematic review. J Contemp Dent Pract. 2022;23(1):105-17.
41. Nicolae XA, Preoteasa E, Murariu Magureanu C, Preoteasa CT. Cross-Sectional Study of Occlusal Loading and Periodontal Status of Teeth with Deflective Occlusal Contacts. Bioengineering. 2025;12(7):766.
42. Saad SA, Shalaby YA, Azer AS. Reliability of the digital functionally generated path technique for assessing occlusal interferences and adjusting CAD-CAM zirconia crowns: an in vivo study. BMC Oral Health. 2024;24(1):1425.
43. Revilla-León M, Gómez-Polo M, Barmak AB, Kois JC, Yilmaz B, Pérez-Barquero JA. Influence of occlusal collision corrections completed by two intraoral scanners or a dental design program on the accuracy of the maxillomandibular relationship. The Journal of Prosthetic Dentistry. 2024;132(1):191-203.
44. Peng T, Yang Z, Ma T, Zhang M, Ren G. Comparative evaluation of the volume of occlusal adjustment of repositioning occlusal devices designed by using an average value digital articulator and the jaw movement analyzer. The Journal of Prosthetic Dentistry. 2025;133(5):1268-74.
45. Elkady AAM, Ameen SA, Sami RN. Intraoral occlusal adjustment time and volume required for CAD/CAM crowns fabricated with different virtual mounting methods (A randomized crossover trial). BDJ open. 2023;9(1):19.

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**Table 1. Types of articulating papers and their clinical applications.**

| Type of Articulating Paper | Thickness Range | Clinical Use | Advantages | Limitations | Reference |
|---|---|---|---|---|---|
| **Micron-thin papers/films** | 8–12 µm | Precision detection in FPDs and implants | Highly accurate, fine marks, minimal false positives | Fragile, may not mark well in moist environments | [32] |
| **Medium-thickness papers** | 20–40 µm | Routine occlusal adjustments in natural dentition, and FPDs | Balanced visibility and precision, widely available | Moderate false positives in uneven surfaces | [33] |
| **Thick papers** | 80–200 µm | Gross adjustments in complete dentures or major occlusal discrepancies | Durable, leaves visible marks even in saliva | Less precise, can overestimate contact areas | [34] |
| **Single-sided coated** | Variable | Localized contact marking | Controlled and precise marking | Limited to one arch at a time | [35] |
| **Double-sided coated** | Variable | Bilateral simultaneous marking of arches | Efficient, quick assessment of intercuspation | May smudge in moist conditions | [36] |
| **Foils and silk ribbons** | 8–20 µm | High-precision adjustments, especially in implants | Strong, resistant to tearing, accurate | Expensive, less available in some regions | [37] |
| **Digitally compatible foils** | 10–20 µm | Used with computerized occlusal analysis (e.g., T-Scan) | Compatible with digital systems, consistent markings | Higher cost, limited clinical accessibility | [38] |

**Table 2. Comparative features of digital occlusal diagnostic tools.**

| Device | Principle | Force Quantification | Timing Data | Clinical Use | Advantages | Limitations | Reference |
|---|---|---|---|---|---|---|---|
| **T-Scan** | Flexible pressure-sensitive sensor; software maps force and timing | Yes | Yes | Implant occlusion, full-mouth rehab, TMD | Dynamic mapping, objective, reproducible | High cost, training required | [39,40] |
| **OccluSense** | Thin foil with embedded micro-pressure sensors; 2D visual + quantitative output | Yes | Yes | Chairside occlusal adjustments, implants | Portable, visual + quantitative | Less detailed than T-Scan | [41,42] |
| **Intraoral Scanner** | Optical/laser scanning; generates 3D digital models for static occlusion mapping | No | No | Digital prosthetic workflow | High-resolution, CAD/CAM integration | Cannot measure force directly | [43-45] |

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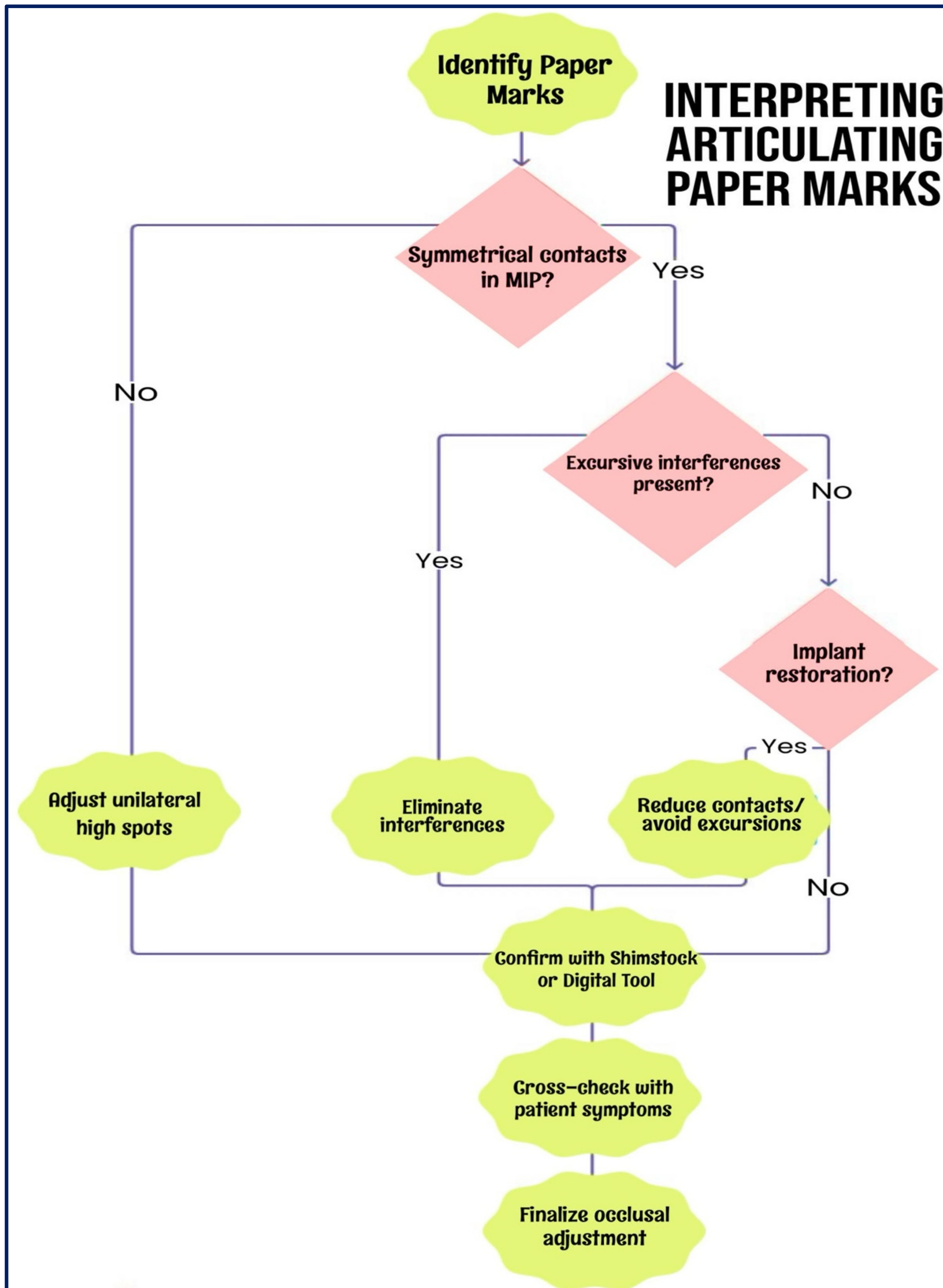


**Figure 1. A flowchart illustrates the interpretation of articulating paper marks.**

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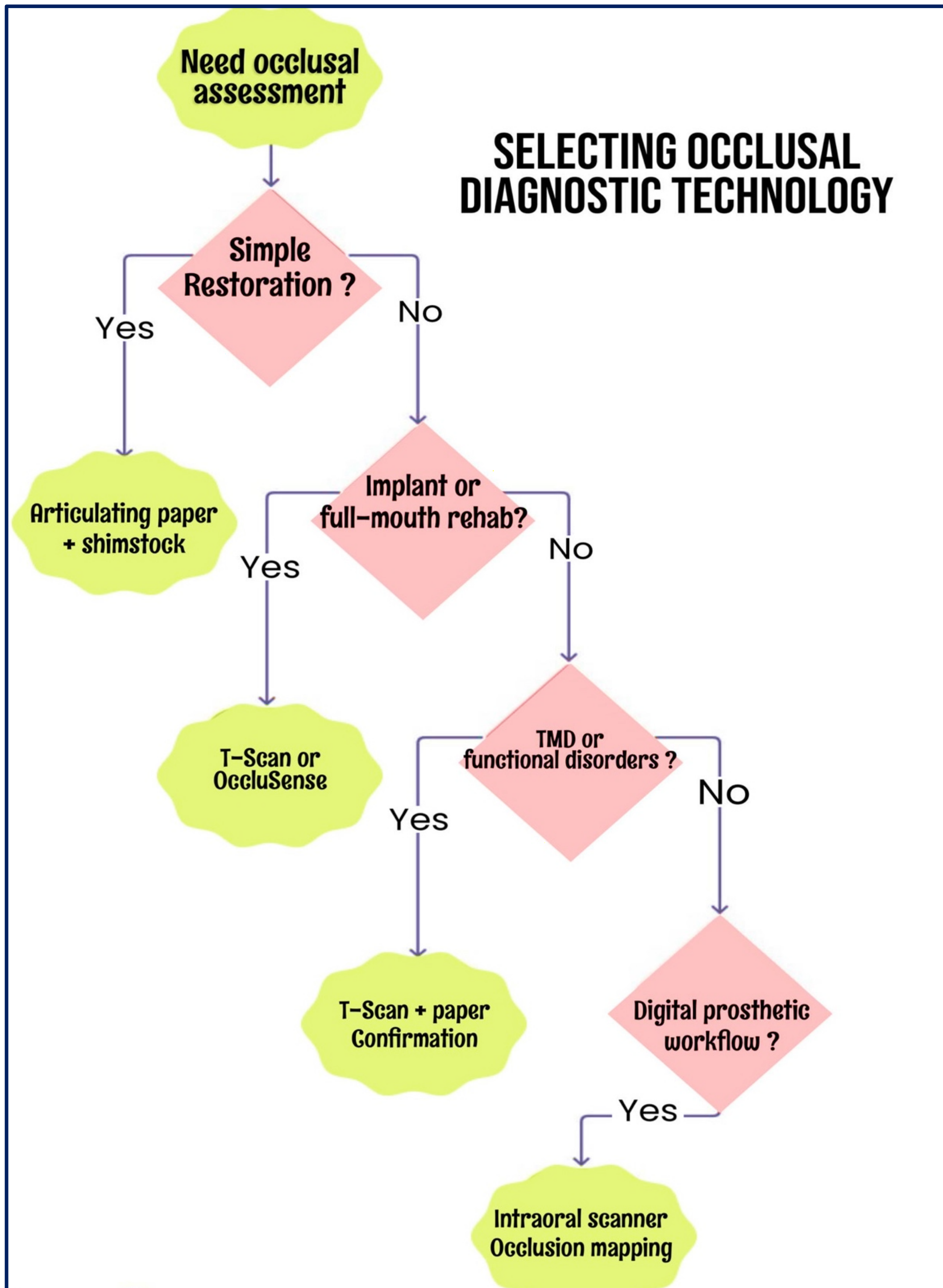


**Figure 2. A flowchart depicting the process of selecting occlusal diagnostic technologies.**