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Role of the Broadrick Occlusal Plane Analyzer (BOPA) and the Simplified Occlusal Plane Analyzer (SOPA) in Fixed Partial Denture Rehabilitation: A Systematic Review.

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ABSTRACT

Background: When several posterior teeth are to be restored with fixed partial dentures (FPDs), a deranged occlusal plane — produced by supra-eruption, tipping, drifting, wear or earlier restorations — can introduce protrusive and lateral interferences. The Broadrick occlusal plane analyzer (BOPA, the "Broadrick flag") and the Dénar Simplified Occlusal Plane Analyzer (SOPA) are articulator-mounted instruments, both derived from Monson's 4-inch spherical theory, that generate an arc for the mandibular buccal-cusp line on diagnostic casts.

Objective: To review and summarize the evidence on the accuracy, reliability, usefulness, and limitations of BOPA and SOPA for fixed prosthodontic treatment in patients with some or all of their teeth.

Methods: This systematic review followed PRISMA 2020 guidelines. We searched PubMed/MEDLINE through 20 October 2026, as well as web sources, DOAJ, publisher websites, and reference lists. Studies using BOPA or SOPA on casts, cephalometric data, clinical cases, educational settings, or case reports were included.

Results: Out of 37 records, 25 studies were included. 10 on accuracy and reliability, 3 on function using BOPA curvature, 9 clinical reports on FPD or full-mouth rehabilitation, 2 on articulator adaptation, and 1 narrative review of SOPA. In 100 complete sets of teeth, the Broadrick curve averaged 0.13 mm from the natural cusp line. The difference increased in arches with missing teeth and after five or more years without opposing teeth.

Conclusions: BOPA closely matches the Spee curve in complete arches and is a useful tool for diagnosing and guiding preparation for multi-unit back-tooth FPDs, but the evidence is not strong. SOPA works the same way as BOPA when using the condyle as the back reference, but it has not been clinically tested. Both devices should be used as starting points, with final decisions based on anterior guidance, esthetics, and clinical checks.

Keywords: Broadrick flag; curve of Spee; fixed partial denture; Monson's sphere; occlusal plane analyzer; simplified occlusal plane analyzer; systematic review.

Introduction

The occlusal plane is defined as the average plane established by the incisal and occlusal surfaces of the teeth; it is not a true plane but an averaged curvature of those surfaces.[1] In the sagittal dimension, that curvature is the curve of Spee, first described by von Spee in 1890 as the arc on which the cusps of the mandibular teeth lie, tangent to the anterior border of the condyle.[2] Monson extended this idea in 1920 into a three-dimensional sphere of approximately 4-inch (101.6 mm) radius, centred near the glabella, on whose surface the cusps and incisal edges were proposed to lie. [3] Although the universality of Monson's sphere has always been debated, its 4-inch radius became the operating constant of every analog occlusal plane analyzer that followed. [4]

In fixed prosthodontics, the curve's importance is primarily functional, not merely geometric. A properly shaped plane allows the anterior guidance, with help from the condylar path, to separate all the back teeth during forward and sideways movements. [5,6] If the anterior guidance is flatter, it cannot separate a steep or uneven back curve as well, so the occlusal plane becomes more important as the guidance gets shallower. [7,8] If long-span posterior FPDs are placed on abutments that are tipped, rotated, or over-erupted without adjusting the plane, interferences are built into the prosthesis. [9]

Tools for planning the occlusal plane on articulated casts were developed as part of the Pankey–Mann–Schuyler (PMS) approach. In 1960, Mann and Pankey introduced the P-M instrument for planning and restoring lower back teeth. [10] Later, Lawson Broadrick made this simpler by creating a flat card, or "flag," that attaches to the top of the articulator. Two 4-inch arcs are drawn on it to locate the curve's center. [9,11] The Broadrick occlusal plane analyzer (BOPA) was later adapted for different articulator systems, and custom versions were made for those without a specific attachment. [11–14] At the same time, the Dénar Simplified Occlusal Plane Analyzer (SOPA), linked to Dawson's teachings, places the center 4 inches from the condylar axis, allowing the arc to be drawn with a single scribe aligned with the canine tip in one step. [5,8,15]

Both devices are commonly taught in postgraduate prosthodontic programs and are often mentioned in case reports. However, their evidence base has not been systematically reviewed. It is still uncertain how closely the curve created by these analyzers matches the natural curve, whether the fixed 4-inch radius works for all populations and skeletal types, how the devices perform in the irregular arches they are meant for, and if there are any real differences between the two devices.

Objectives and focused question

This review set out to: (i) describe the geometric principles and operating protocols of BOPA and SOPA; (ii) summarise evidence on how accurately and reliably they reproduce the curve of Spee; (iii) report on their clinical use in FPD and fixed full-mouth rehabilitation; and (iv) compare the two analyzers and highlight any evidence gaps. The main research question, using the PICOS format, was: In dentate or partially dentate patients (or their articulated casts) who need posterior fixed prostheses (P), how accurately and usefully does occlusal plane determination with BOPA or SOPA (I), compared with the natural or existing occlusal curve, expert judgement, other devices or no analyzer (C), create an occlusal plane that allows for posterior disclusion and restorative space (O), across experimental, observational and clinical-report studies (S)

Materials and Methods

1 Protocol and reporting

The review followed the PRISMA 2020 statement. [16] Since the evidence base was expected to be small and varied, we used the Synthesis Without Meta-analysis (SWiM) guideline. [17] The certainty of the evidence was rated using the GRADE approach. [18] The protocol was not registered in advance.

2 Eligibility criteria

Table 1. Eligibility criteria (PICOS).

Domain	Inclusion	Exclusion
Population	Dentate or partially dentate humans, or their articulated diagnostic casts; patients requiring posterior fixed restorations, FPDs or fixed full-mouth rehabilitation	Completely edentulous patients treated with conventional complete dentures; animal studies
Intervention	Occlusal plane analysis/determination with BOPA (proprietary or custom-made) or SOPA	Devices orienting the occlusal plane to ala–tragus or interpupillary lines only (Fox-plane-type analyzers); template-only methods without BOPA/SOPA
Comparator	Natural/existing occlusal curve, cephalometric curve, expert-drawn curve, alternative devices (e.g., Yurkstas template), no analyzer, or none (case reports)	—
Outcomes	Deviation from analyzer curve; validity of radius/centre; agreement with expert; tooth-reduction amount; functional correlates; clinical outcome of FPD/fixed rehabilitation	Outcomes unrelated to occlusal plane determination
Study design	Cast-based, in vivo, cephalometric, randomised and non-randomised studies; case reports/series; technique articles; narrative reviews describing device protocols	Manufacturer literature (used as background only); editorials without data

3 Information sources and search

We searched PubMed/MEDLINE from its start until 20 October 2026 without language restrictions. We also used a general web search engine, the Directory of Open Access Journals (DOAJ), and publisher websites to find regional journals not in MEDLINE. Reference lists of all included reports were checked by hand. The search strings are in Table 2.

Table 2. Search strategy.

Source	Search string / approach	Records
PubMed #1	Broadrick occlusal plane analyzer	9
PubMed #2	Broadrick flag	14
PubMed #3	occlusal plane analyzer curve of Spee	6
PubMed #4	"occlusal plane analyzer"[Title/Abstract] OR "occlusal plane analyser"[Title/Abstract]	17
PubMed (combined)	Union of #1–#4 after removal of duplicates	31
Supplementary	"simplified occlusal plane analyzer"; SOPA occlusal plane; Broadrick flag comparison; Broadrick flag radius; DOAJ and publisher-site queries; reference lists	6

4 Study selection and data extraction

Titles and abstracts were screened against the eligibility criteria, and full texts (or the most complete available record) were assessed for the remainder. Data extracted were: author, year, country, design, sample, articulator and analyzer version, anterior and posterior survey points, radius, outcome measure and principal finding. For clinical reports, the clinical indication, prosthesis type, method of transferring the planned plane intraorally, and reported outcome were recorded.

5 Quality appraisal

We appraised analytical cross-sectional and case–control studies using the relevant JBI critical appraisal checklists. For case reports, we used the JBI case-report checklist. [19] The single randomised trial was assessed with the Cochrane RoB 2 tool. [20] We rated overall risk of bias as low, moderate, or high (or “some concerns” for RoB 2).

6 Synthesis and certainty of evidence

Because the studies used different outcome metrics (such as millimetric deviation, radius agreement, reduction depth, and masticatory parameters) and designs, we did not perform a meta-analysis. Instead, we grouped studies by research question and summarized them narratively, using vote counting to assess the direction of effect when relevant.

Results

1 Study selection

The search yielded 31 PubMed records and 6 records from other sources (37 in total, no further duplicates). Eight were excluded on title/abstract: five concerned custom analyzers that orient the plane to the ala–tragus or interpupillary lines rather than the curve of Spee, one described an ocular prosthesis device, one a periodontal morphology study, and one a curve-of-Spee depth measurement without an analyzer. One German-language laboratory article could not be retrieved. Of 28 reports assessed in full, three were excluded — a complete-denture application, a template technique not using BOPA/SOPA. [21-23] and the manufacturer’s SOPA instructions (retained as background).15 Twenty-five studies were included (Fig-1)

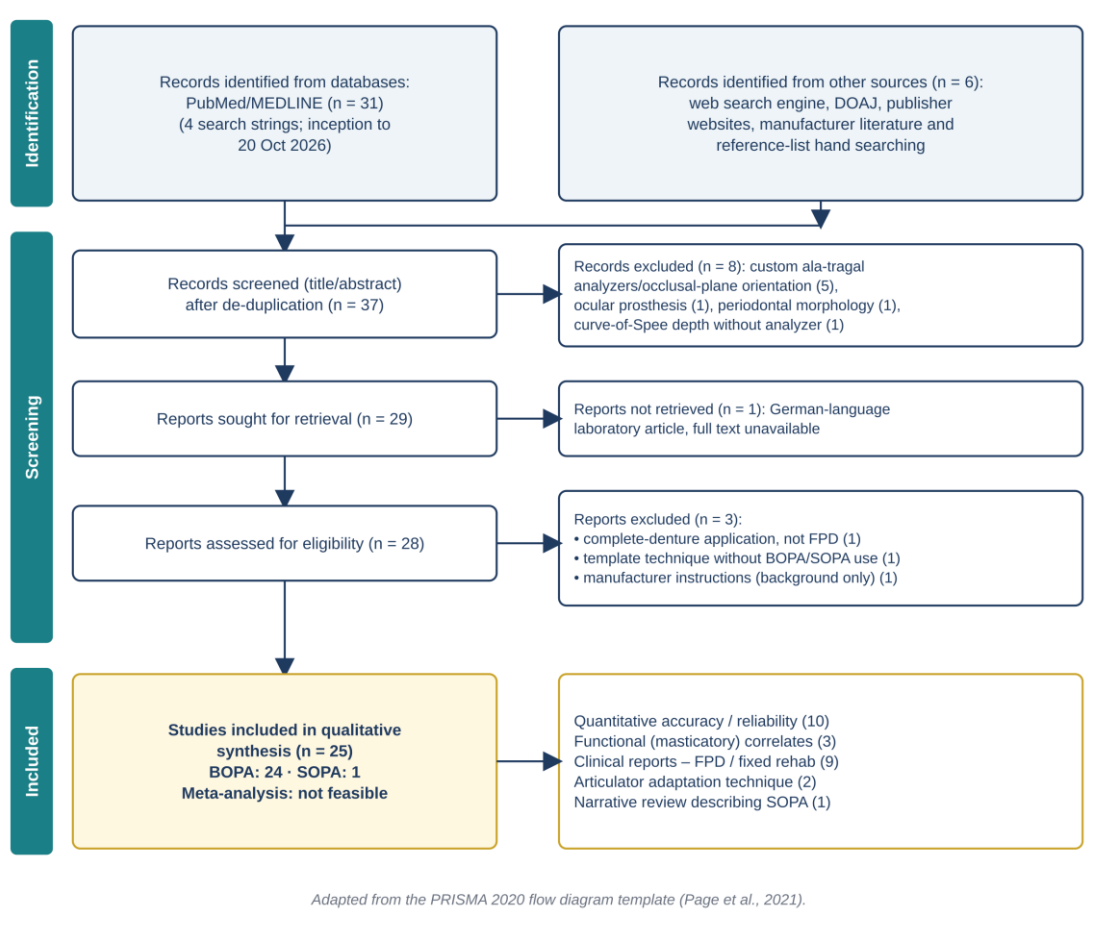


Figure 1. PRISMA 2020 flow diagram of study identification, screening and inclusion.

2 Characteristics of included studies

The 25 studies ranged from 1972 to 2025. Most were from India (11), while the rest came from the United Kingdom/Ireland, the United States, Japan, Morocco, Saudi Arabia, France, and China. Twenty-four studies focused on BOPA, either proprietary or custom-made. Only one, a narrative review, described SOPA. The main features of the quantitative studies are in Table 3, and those of the clinical reports are in Table 4.

Table 3. Characteristics and principal findings of quantitative and functional studies (n = 13).

Study (country)	Design / sample	Analyzer & references	Outcome	Principal finding
A. Agreement of the Broadrick curve with the natural curve				
Craddock 2005 (UK/Ireland)[24]	Cross-sectional; 100 intact arches	BOPA, 4-in radius; scanned casts	Cusp deviation from curve (software)	Mean deviation 0.13 mm; good intra-examiner reliability (Bland–Altman)
Craddock 2006 (UK)[25]	Case–control; arches with unopposed posterior teeth vs controls	BOPA	Deviation after tooth loss	Teeth unopposed ≥5 years deviate, sometimes extremely; moderate tipping of the posterior determinant barely alters radius
Manvi 2012 (India)[26]	Case–control; 20 subjects	Custom BOPA on semi-adjustable articulator	Farthest cusp deviation along long axis	Significantly greater deviation in patients with lost posterior teeth vs complete dentitions ($p < 0.05$)

Study (country)	Design / sample	Analyzer & references	Outcome	Principal finding
Jaiswal 2015 (India)[27]	Case–control; 40 subjects	BOPA	Deviation; sex comparison	Significant difference between partially edentulous and control groups
Kumar V 2025 (India)[28]	Case–control; 52 subjects	Custom-built BOPA	Deviation, paired t-test	Significant difference between missing-posterior-teeth and intact groups
B. Validity of the radius and centre				
Jagadeesh 2012 (India)[29]	Cross-sectional; dentate subjects, different skeletal classes	BOPA on face-bow-mounted casts; radii varied in ½-in steps	Fit of radius (caliper)	Minor variation, but most subjects conformed to the radii proposed in the Lynch–McConnell technique
Ousehal 2012 (Morocco)[30]	Cephalometric; 31 dentate normo-occlusions	Anatomical vs geometric radius vs 104 mm	Agreement with theoretical radius	104 mm not a valid universal mean; gap to the plane up to 3 mm (anatomical) and 3.5 mm (geometric)
Kumar TK 2013 (India)[31]	Cephalometric	Centre of anteroposterior curve	Location of centre relative to cranial landmarks and condyle	Provides anatomical context for the analyzer centre; does not test device accuracy directly
C. Operator, education and comparison with other devices				
Alsaileek 2019 (Saudi Arabia)[32]	In vitro; 8 casts on Hanau articulator	BOPA vs Yurkstas metal template	Reduction needed for over-erupted teeth	Results broadly comparable; Yurkstas template significantly more conservative of tooth structure
Gerard 2025 (France)[33]	RCT; 37 undergraduate students vs expert reference	3D-printed flag support (Quick Master articulator); Class II models with edentulous spaces	Distance from expert-drawn plane	Significant benefit only at the right second molar of one model; students' molar curves tended to lie above the expert's
D. Functional correlates of BOPA-derived curvature				
Okano 2011 (Japan)[34]	Cross-sectional; 46 young adults	Sphere fitted per BOPA principle (3D gauge)	Chewing kinematics	Occlusal curvature significantly associated with masticatory movement
Fueki 2013a (Japan)[35]	Cross-sectional; 50 young adults	BOPA method, 3D analysis	Comminution and mixing ability	Flatter curvature (larger sphere) predicted better comminution and mixing
Fueki 2013b (Japan)[36]	Cross-sectional; 46 young adults	BOPA method, 6-DOF recording	Mandibular movement parameters	Sphere radius predicted closing velocity and cycle durations across test foods

Table 4. Clinical reports applying BOPA in FPD or fixed rehabilitation (n = 9).

Study (country)	Clinical situation	Fixed prosthesis	Analyzer use and intraoral transfer	Reported outcome
Lynch 2002 (Ireland)[9]	Deranged plane: rotated, tipped, extruded posterior teeth	Multiple posterior crowns/inlays and FPD	Broadrick flag to design curve commensurate with Spee; protrusive and lateral excursions considered	Harmonious disclusion; follow-up described

Study (country)	Clinical situation	Fixed prosthesis	Analyzer use and intraoral transfer	Reported outcome
Small 2005 (USA)[11]	Occlusal plane analysis for restorative case	Posterior restorations	Monson radius as starting point, individualised; adapted to Hanau, Dénar, Artex, Protar	Fewer posterior interferences emphasised
Bedia 2007 (India)[14]	Posterior teeth requiring restoration; no proprietary analyzer for articulator	Fixed posterior restorations	Custom-made clear BOPA on semi-adjustable articulator	Correct curve of Spee established
Anuroopa 2012 (India)[37]	Hypohidrotic ectodermal dysplasia, young patient	Long-span FPD	Custom-made Broadrick flag	Functional and esthetic rehabilitation
Small 2012 (USA)[38]	Periodontal defects, inadequate restorative environment	Fixed restorations with interim partial denture	Crown lengthening combined with BOPA planning; VDO considered	Improved restorative environment
Gounder 2014 (India)[39]	Generalised tooth wear	PFM FPDs, telescopic denture, extracoronal attachments	BOPA; segmental (anterior-first) rehabilitation	Satisfactory function and esthetics
Balavadivel 2020 (India)[40]	Deranged plane needing equilibration	Full-mouth fixed rehabilitation	BOPA correction transferred with customised acrylic template	Controlled, conservative reduction
Chen 2022 (China)[41]	Severe dental erosion	Functional and esthetic fixed rehabilitation	BOPA for occlusal plane design	Rehabilitation completed (Chinese-language report)
Kumar A 2024 (India)[42]	Dentinogenesis imperfecta type II, lost VDO	PFM crowns (PMS philosophy)	Anterior first; posterior plane by Broadrick flag	Restored esthetics, VDO and function

3 Accuracy of the Broadrick curve in intact dentitions

Only one study tested the fundamental premise of the device — that the Broadrick curve approximates the natural cusp line — in an adequately sized sample. In 100 patients with intact arches, deviations measured on scanned casts averaged 0.13 mm with good intra-examiner reliability, leading the authors to conclude that the method is a reasonable approximation of the original curve for patients whose planes later become deranged. [24] Jagadeesh and colleagues reached a compatible conclusion in an Indian sample across skeletal relationships: when the radius was varied in half-inch steps, most subjects still fitted the radii proposed in the Lynch–McConnell technique, with only minor variation. [9,29]

4 Accuracy in deranged and partially edentulous arches

Four studies found that deviation from the Broadrick curve was much greater when posterior teeth were missing. [25–28] Craddock et al. showed that teeth left unopposed for five years or more can drift and erupt to positions far from the curve, while moderate tipping of the tooth forming the posterior determinant had little effect on the radius. [25] These findings have two main implications. First, they support the analyzer as a diagnostic tool because the curve can distinguish deranged from intact arches. Second, they highlight a key problem: the device is most needed when its reference points are least reliable, so choosing the posterior survey point becomes very important.

5 Validity of the 4-inch radius and the centre of the curve

The idea of a constant radius is the weakest part of the theory. In a Moroccan cephalometric study of 31 dentate normo-occlusions, the 104 mm value could not be considered a standard mean. Anatomical and geometric radii did not match, and the gaps between the constructed curve and the actual plane were 3 mm and 3.5 mm. [30] Kumar TK et al. tried to find the centre of the anteroposterior curve in the cranium using cephalometric landmarks and the condyle, giving anatomical context for where the analyzer centre should be.31 In practice, López-Pulido and colleagues changed the centre of the curve to fit anatomical differences in the anteroposterior reference points. This is outside the FPD scope of this review, but it shows that operators already adjust the standard geometry. [22] Small also described Monson's radius as just a starting point for analysis. [11]

6 Operator dependence and educational value

The only randomized study had 37 third-year students draw occlusal planes on Class II models with edentulous spaces, with or without a new 3D-printed flag support, compared to a prosthodontist's reference. [33] A significant benefit was observed only for the right second molar in one model, and the students' second-molar curves were usually above the expert's. The device helped beginners a little in a complex situation, but did not replace judgement. The technique is known to be operator-sensitive: the compass fulcrum can move while drawing arcs, and the choice of anterior or posterior survey points varies between authors (cusp tip versus disto-incisal angle of the canine; disto-buccal cusp of the last molar versus the condylar element). [8,9]

7 Comparison with alternative devices

One in vitro study on eight casts mounted on a Hanau articulator compared BOPA with the Yurkstas metal occlusal template for over-erupted mandibular teeth. [32] The results were generally similar, but the template showed a much smaller reduction, which the authors attributed to its acting as both an analytical and a corrective device. Muley et al. later described a clear thermoformed template to address the opacity problem of the Yurkstas plate [23], and Balavadivel et al. used a custom acrylic template to transfer a BOPA-based correction into the mouth. [40] This suggests that the two methods can be used together rather than as competitors.

8 Functional correlates

Three Japanese studies used the Broadrick method to fit an occlusal sphere to the mandibular arches of young adults and linked its radius to chewing function. [34–36] Flatter curves (larger radii) were linked to better food breakdown and mixing, as well as more efficient jaw movement. These studies did not directly test the analyzer, but they indirectly support the idea that the shape of the curve is important and warn against making the curve too deep in posterior FPDs.

9 Clinical application in FPD and fixed rehabilitation

Nine clinical reports described the use of BOPA in fixed prosthodontics (Table 4). Indications included the classic deranged plane with extruded and tipped teeth [9,11,14], generalized wear [39], erosion [41], dentinogenesis imperfecta [42], and ectodermal dysplasia requiring a long-span FPD. [37] Common methods included (i) restoring the anterior segment and incisal plane first, following PMS sequencing; [39,42] (ii) using the preparation line and a wax or acrylic occlusal cutting guide to transfer planned reduction to the mouth; [8,40] and (iii) combining with other procedures like crown lengthening. [38] Outcomes were described qualitatively; none of the reports included a comparator, objective occlusal measurement, or long-term follow-up to assess prosthesis survival, complications, or temporomandibular outcomes.

10 Evidence on SOPA

No primary study — cast-based, cephalometric or clinical — evaluated SOPA. Its description in the literature derives from Dawson's texts [5,7] the manufacturer's instructions [15], and a narrative review.8 According to these sources, SOPA is preset at 4 inches from the condylar axis and is designed for Dénar articulators; setting the caliper scribe at 4 inches and aligning it with the canine tip scribes, in one step, an arc that passes through the condylar axis. The scribe can be lengthened to the preparation height, and a wax index trimmed to the line guides occlusal reduction. [8] Dawson explicitly cautions that the resulting plane is arbitrary and should be used only once restoration of the posterior teeth has been decided, never to decide whether teeth must be prepared. [5,8]

11 Risk of bias

Table 5. Risk-of-bias appraisal of included studies.

Study / group	Tool	Main concerns	Overall
Craddock 2005	JBI analytical cross-sectional	Convenience sample; single examiner; outcome method validated	Moderate
Craddock 2006	JBI case–control	Exposure duration self-reported/estimated; small subgroups	Moderate
Manvi 2012; Jaiswal 2015; Kumar V 2025	JBI case–control	Small samples; no examiner calibration or blinding reported; ideal plane operator-drawn	High
Jagadeesh 2012	JBI analytical cross-sectional	Sampling unclear; caliper measurement; confounding by skeletal class partly addressed	Moderate

Study / group	Tool	Main concerns	Overall
Ousehal 2012; Kumar TK 2013	JBI analytical cross-sectional	Cephalometric landmark error; indirect to clinical device use	Moderate
Alsaileek 2019	JBI (quasi-experimental, in vitro)	Eight casts; no sample-size justification; operator not blinded	High
Gerard 2025	RoB 2	Randomisation adequate; outcome assessment by photographic superimposition; single centre; multiple comparisons	Some concerns
Okano 2011; Fueki 2013a, 2013b	JBI analytical cross-sectional	Homogeneous young samples; validated outcome instruments; analyzer used only as a measurement method	Low–Moderate
Clinical reports (n = 9)	JBI case report	Adequate description of technique; no comparator; outcomes qualitative; follow-up short or unstated	High (inherent to design)

Judgements are based on full texts where accessible and on abstracts and published summaries otherwise; they should be confirmed by a second independent reviewer.

Discussion

Principal findings

This review found that BOPA has a modest but coherent evidence base, whereas SOPA has essentially no evidence. The Broadrick curve closely mirrors the natural cusp line in intact arches and consistently flags deviations once posterior teeth are lost, supporting its role as a diagnostic aid in planning multi-unit posterior FPDs. [24–26] However, the certainty of evidence is low to very low, the fixed 4-inch radius is not universally valid [30], and no study links analyzer use to objective prosthodontic outcomes. The device is best understood as a structured way to make an informed first estimate of the plane, which must then be validated by anterior guidance, esthetic requirements and intraoral excursive testing.

Geometric equivalence of BOPA and SOPA

Figures 2 and 3 show that the two analyzers are really just different versions of the same method, not separate approaches. In BOPA, the center of the curve is found where a long arc from the front survey point (mandibular canine) meets a short arc from the back survey point (disto-buccal cusp of the last molar or the condylar element). [8,9] From that center, a 4-inch arc is drawn across the buccal surfaces of the mandibular cast. In SOPA, the back point is always set at the condylar axis, so the center is fixed in advance and only the canine alignment needs to be adjusted. [8,15] SOPA is mathematically equivalent to BOPA when the condyle is used as the back reference. SOPA is faster and reduces the chance of compass slip, but it does not allow for a dental posterior reference, relies on Dénar equipment, and lacks validation.

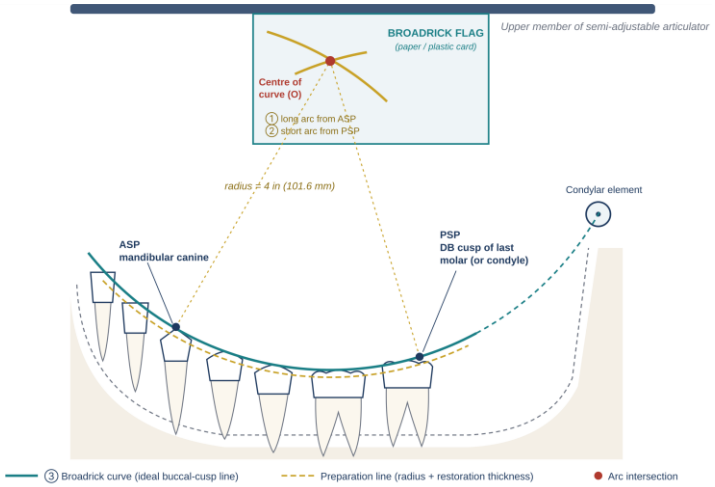


Figure 2. Geometry of the Broadrick occlusal plane analyzer. ① A long 4-inch arc is struck on the flag from the anterior survey point (ASP, mandibular canine); ② a short arc from the posterior survey point (PSP, disto-buccal cusp of the last molar or the condylar element) intersects it at the centre of the

curve (O); ③ a 4-inch arc from O is drawn across the buccal surfaces of the mandibular cast. Opening the compass by the planned restoration thickness yields the preparation line used to fabricate the occlusal cutting guide. Schematic, not to scale.

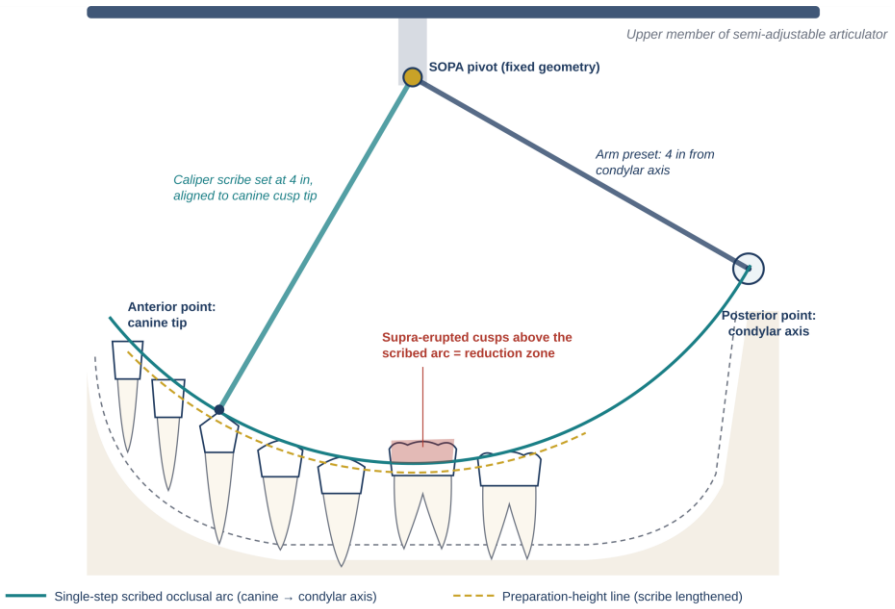


Figure 3. Geometry of the Simplified Occlusal Plane Analyzer. The pivot is preset 4 inches from the condylar axis; the caliper scribe, also set at 4 inches, is aligned to the canine tip so that a single sweep scribes an arc from canine to condylar axis. Cusps lying above the arc (shaded) indicate the reduction zone. The construction is equivalent to BOPA with the condyle as posterior survey point. Schematic, not to scale.

Table 7. Comparative features of BOPA and SOPA.

Feature	Broadrick occlusal plane analyzer (BOPA)	Simplified occlusal plane analyzer (SOPA)
Lineage	PMS philosophy; simplification of the Pankey–Mann instrument	Dénar instrumentation; Dawson's occlusal-plane protocol
Theoretical basis	Monson's sphere, 4-in (101.6 mm) radius	Same
Anterior reference	Mandibular canine (cusp tip or disto-incisal angle)	Canine cusp tip
Posterior reference	Disto-buccal cusp of last molar or condylar element (operator choice)	Condylar axis (fixed by design)
Locating the centre	Intersection of two arcs drawn on a card/flag	Preset geometry; no construction arcs
Number of steps	Three (two locating arcs, one occlusal arc)	One scribe
Individualisation	Radius and survey points can be modified	Limited; posterior end judged clinically
Articulator compatibility	Hanau, Dénar, Artex, Protar; custom versions for others	Dénar articulators
Outputs	Occlusal curve, preparation line, wax/acrylic cutting guide	Occlusal arc, preparation-height line, wax index
Main error sources	Survey-point selection; compass slip; deranged posterior determinant	Mounting/condylar-axis accuracy; canine position

Feature	Broadrick occlusal plane analyzer (BOPA)	Simplified occlusal plane analyzer (SOPA)
Evidence base	10 quantitative studies, 3 functional studies, 9 clinical reports	No primary studies
Shared limitations	Sagittal (2D) only; ignores curve of Wilson; assumes 4-in radius; cannot indicate whether teeth need restoring	Same

Role in the FPD workflow

Across the clinical reports and textbook protocols, the analyzer occupies a defined position in the planning sequence (Figure 4). Its legitimate uses are to make a preliminary determination of an acceptable plane on the diagnostic cast, to predict the reduction required for each abutment, to predetermine the preparation height to ensure adequate material thickness, to guide cusp heights during wax-up, and to transfer this plan intraorally through a cutting guide. [8,43] Two caveats are consistently emphasised. The anterior segment and incisal plane must be organised first, because the plane is acceptable only insofar as the anterior guidance can disclude it; and the analyzer must never be used to justify preparing teeth that would not otherwise need restoration. [5,7]

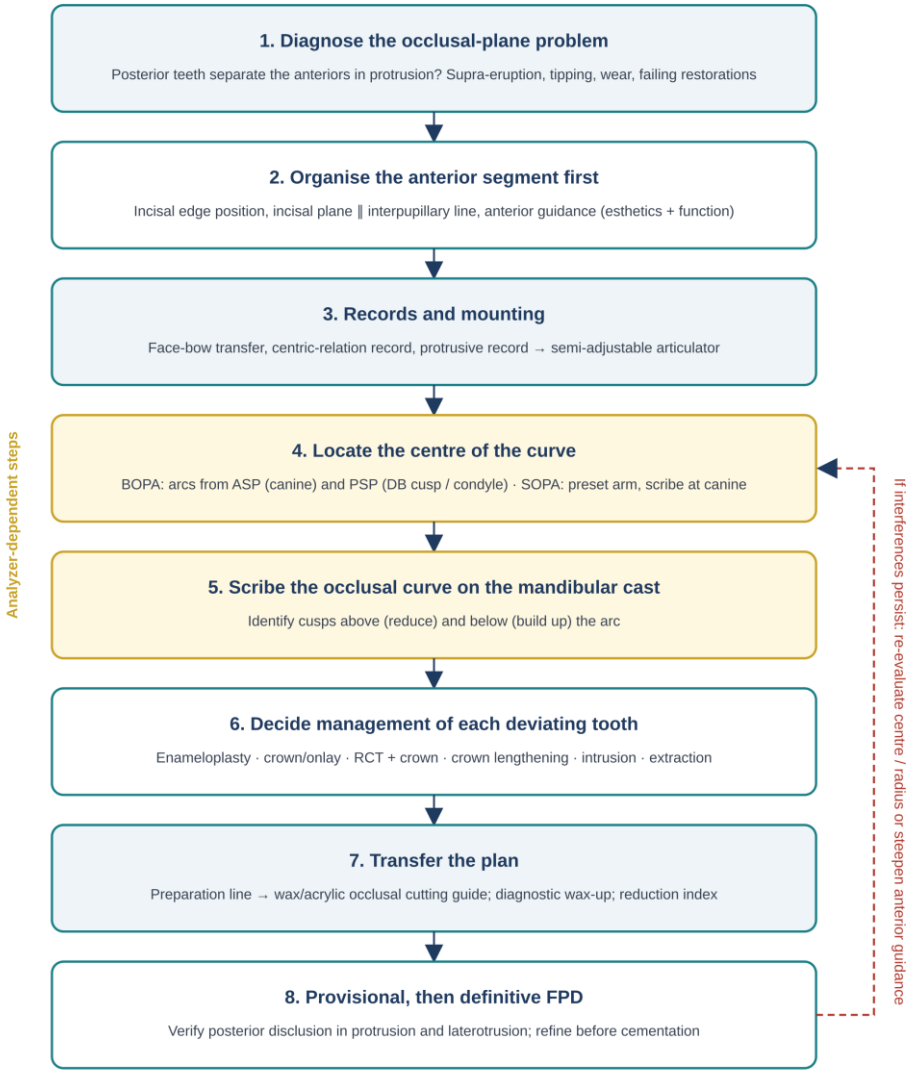


Figure 4. Clinical workflow for occlusal plane management in multi-unit posterior FPD, showing the analyzer-dependent steps (shaded gold) and the verification loop. Synthesised from included reports and standard occlusion texts.

If the curve shows supra-erupted abutments or opposing teeth, treatment options include enameloplasty, crowns, elective endodontics with crown lengthening, orthodontic intrusion, or extraction. If too much reduction would be needed, it may be better to steepen the anterior guidance, depending on the envelope of function, arch relationship, esthetics, and periodontal support of the anterior teeth.[5,8] The analyzer does not provide information about these trade-offs; it only defines the target.

The digital transition

Digital measurement of the curve of Spee on scanned models has been shown to be more accurate than conventional measurement [21], and Craddock et al. already analysed deviation from the Broadrick curve on scanned casts in 2005. [24] Gerard et al. demonstrated that an analyzer support can be produced via additive manufacturing and distributed as an open-design file. [33] The logical next step — a parametric "virtual flag" in CAD software that fits a patient-specific sphere to selected cusp tips and condylar points from a virtual articulator and exports a reduction guide — would eliminate compass error and allow the radius to be quantitatively individualised. No study evaluating such a tool was identified.

Strengths and limitations of this review

To our knowledge, this is the first systematic synthesis to address BOPA and SOPA together and the first to highlight the lack of primary evidence for SOPA. We deliberately included regional journals outside MEDLINE. However, there are limitations: only one bibliographic database was searched, with additional non-systematic sources (Embase, Scopus, Web of Science and the Cochrane Library were not searched); screening and appraisal were done by a single reviewer; some reports relied only on abstracts or summaries, including non-English publications; and there was no prospective registration. The small and varied evidence base made meta-analysis and assessment of publication bias impossible, and the predominance of favourable case reports suggests publication bias is likely.

Implications for research

* Prospective clinical studies comparing analyzer-guided and conventionally planned multi-unit posterior FPDs, with objective outcomes (excursive contacts on T-Scan or digital analysis, chair-side adjustment time, survival, complications).

* Head-to-head comparison of BOPA and SOPA, and of dental versus condylar posterior survey points, on the same mounted casts.

* Population-specific studies of occlusal sphere radius, including Indian cohorts across skeletal classes, using 3D digital fitting.

* Development and validation of a CAD-based virtual analyzer and its agreement with physical BOPA.

Conclusion

BOPA closely reproduces the Spee curve in intact dentitions and reliably discriminates arches deranged by posterior tooth loss, supporting its use as a diagnostic and planning aid for multi-unit posterior FPDs (low certainty).

1. The fixed 4-inch radius is just a convention, not a biological rule. Analyzer results should be tailored to each patient and checked against anterior guidance and excursive testing (very low certainty).

2. SOPA works the same way as BOPA but uses the condyle as the back reference and is easier to use. However, no main studies have tested its accuracy or clinical results.

3. Neither device has been proven to improve long-term FPD results. Both should be seen as helpful starting points that support, but do not replace, clinical judgement.

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