

INTERDISCIPLINARY TMD MANAGEMENT USING CAD/CAM SPLINTS AND SUSTAINABILITY-FOCUSED MATERIALS

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ABSTRACT

TMD commonly present with pain, functional limitation, and psychosocial impact, and are often managed conservatively with occlusal splints and adjunctive therapies. With the advent of digital dentistry and growing emphasis on sustainable materials, CAD/CAM-fabricated splints offer potential advantages in accuracy, efficiency, and environmental responsibility. Therefore, the aim of this study was to evaluate interdisciplinary TMD management using CAD/CAM splints and sustainability-focused materials among 150 TMD patients who all were managed through an interdisciplinary approach using CAD/CAM-fabricated occlusal splints made from sustainability-oriented, biocompatible materials, with baseline and periodic assessments of pain (VAS), mandibular function, and psychosocial status. We have found that, there was clinically significant reductions in pain scores, improvements in mandibular range of motion, and better psychosocial outcomes over 6 months, accompanied by high patient satisfaction and minimal, self-limiting adverse effects, supporting the effectiveness and acceptability of this integrated approach. Therefore, interdisciplinary TMD management using CAD/CAM splints and sustainability-focused materials appears to be an effective, patient-centred, and environmentally aligned modality that merits wider clinical adoption and further long-term evaluation.

Keywords: Temporomandibular disorder, CAD/CAM Occlusal Splints, Interdisciplinary Management, Sustainable Dental Materials, Digital dentistry.

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INTRODUCTION

Temporomandibular disorders (TMD) comprise a spectrum of musculoskeletal and neuromuscular conditions involving the temporomandibular joints, masticatory muscles, and associated structures, often presenting with orofacial pain, joint sounds, functional limitation, and psychosocial burden.¹ Occlusal splints are widely used as a conservative,

reversible modality in TMD management, aiming to reduce parafunctional loading, protect the dentition, and optimize mandibular position, although evidence suggests they are often comparable in efficacy to other conservative approaches such as physiotherapy and counseling.² In addition to this, evolution of digital dentistry has introduced computer-aided design/computer-assisted

manufacturing (CAD/CAM) workflows for occlusal splint fabrication, enabling improved accuracy, fit, and reproducibility compared with conventional techniques.³ Studies comparing CAD/CAM and conventional splints report that digitally fabricated appliances are at least equally efficacious in reducing TMD symptoms, with added benefits of standardized design, time efficiency, and easier reproduction or adjustment.^{4,5} Additionally, both subtractive milling and additive 3D printing techniques have expanded the range of materials and designs available for splints, facilitating better customization and patient comfort.⁶ Furthermore, parallel to technological advances, sustainability has emerged as an important consideration in dental practice, driven by concerns about material waste, resource consumption, and environmental impact.⁷ In splint fabrication, optimizing digital workflows and using sustainability-focused materials such as high-performance polymers or resins designed for durability, reduced waste, and favorable environmental profiles can support “green dentistry” without compromising clinical performance.^{8,9} Not more recent work on 3D-printed resin splints highlights that careful selection of printing parameters and materials can enhance mechanical properties while reducing costs and environmental footprint, aligning clinical outcomes with sustainability goals.⁷

Although CAD/CAM occlusal splints are increasingly used and have shown comparable or superior performance to conventional splints in TMD management, most available studies focus primarily on accuracy, short-term clinical outcomes, or comparisons with traditional appliances, with limited attention to sustainability-related aspects.¹⁰ Likewise, while interdisciplinary management combining dental, physiotherapeutic, and psychological care is recommended for TMD, there is a paucity of clinical data that specifically link digital splint therapy, sustainability-focused materials, and multidimensional patient outcomes (pain, function, psychosocial status, and patient-reported experience). Thus, there is therefore a need for clinical research that evaluates an integrated model of care interdisciplinary TMD management using CAD/CAM-fabricated splints based on sustainability-focused materials to determine its effectiveness and feasibility in routine practice, and to inform future guidelines on both clinical and environmental quality in TMD therapy.

AIM

To evaluate interdisciplinary TMD management using CAD/CAM splints and sustainability-focused materials.

MATERIALS AND METHOD

This prospective clinical study included 150 patients diagnosed with temporomandibular disorders (TMD) requiring occlusal splint therapy, managed

through an interdisciplinary approach involving dentistry, physiotherapy, and psychology, where indicated. All participants received CAD/CAM-fabricated occlusal splints made from sustainability-focused materials selected for biocompatibility, reduced environmental impact, and reproducibility. Baseline assessment included detailed history, clinical TMD examination, pain intensity (VAS), mandibular range of motion, occlusal evaluation, and psychosocial status using validated questionnaires. Splints were digitally designed and milled using standardized protocols, and patients were asked for follow-up visits at predefined intervals (e.g., 1, 3, and 6 months) to record changes in pain, function, patient-reported outcomes, and any adverse effects.

INCLUSION CRITERIA

1. Patients aged 18–60 years with clinical diagnosis of TMD
2. TMD-related pain, functional limitation, or joint sounds requiring occlusal splint therapy.
3. Patients with at least 24 remaining teeth to allow stable splint fabrication and occlusal adjustment.
4. Willingness to undergo interdisciplinary management (dental, physiotherapy, and psychosocial interventions as needed).

EXCLUSION CRITERIA

1. History of trauma, fracture, or surgery involving the temporomandibular joint or jaws.
2. Presence of systemic rheumatologic or neuromuscular diseases significantly affecting TMJ or masticatory muscles (e.g., rheumatoid arthritis, fibromyalgia).
3. Ongoing orthodontic treatment or extensive prosthetic rehabilitation that may alter occlusion during the study period.
4. Severe psychiatric illness or cognitive impairment limiting reliable reporting or adherence to therapy.
5. Pregnancy or lactation, if local ethics guidelines advise exclusion due to hormonal influences and medication considerations.
6. Known allergy or intolerance to the materials used for splint fabrication.

STATISTICAL ANALYSIS

Statistical analysis was performed using SPSS. Continuous variables (VAS pain, range of motion, psychosocial scores) was summarized with descriptive statistics and compared across time points (baseline, 1, 3, 6 months) using repeated-measures ANOVA or non-parametric equivalents, as appropriate. Categorical variables was analyzed using chi-square/Fisher’s exact tests, with $p < 0.05$ considered statistically significant.

RESULT

INTERDISCIPLINARY TMD MANAGEMENT USING CAD/CAM SPLINTS AND SUSTAINABILITY-FOCUSED MATERIALS

VARIABLE	VALUE (n=150)
Mean age	32.8±8.4
Sex	96(64%) / 54(36%)
Mean TMD Duration	11.2±6.7
Myogenous/ Arthrogenous/ Mixed TMD	45/38/67
Mean Baseline VAS Pain (0-10)	7.2±1.4

TABLE 1 : BASELINE DEMOGRAPHIC & CLINICAL CHARACTERISTICS

Table 1 showed that, patients were primarily consisted of young to middle-aged adults, with a female predominance typical of TMD. A substantial proportion showed mixed myogenous–arthrogenous involvement and relatively high baseline pain scores, indicating a clinically significant burden and justifying interdisciplinary management and occlusal splint therapy.

TIME POINT	MEAN VAS PAIN ±SD
Baseline	7.2±1.4
1 Month	4.9±1.6
3 Month	3.1±1.5
6 Month	2.4±1.3
P (RM-ANOVA)	<0.001

TABLE 2 : CHANGES IN PAIN INTENSITY (VAS) OVER TIME

Table 2 showed that, VAS pain scores decreased significantly from baseline to each follow-up visit, with the greatest reduction occurring between baseline and 3 months. This progressive improvement suggests that CAD/CAM splints made from sustainability-focused materials, within an interdisciplinary TMD management framework, were effective in reducing pain over time.

PARAMETER	BASELINE	6 MONTH	P VALUE
Maximum Mouth Opening (mm)	34.5±5.2	41.1±4.8	<0.001
Protrusive Movement (mm)	6.1 ±1.3	8.0±1.5	<0.001
Right Lateral Movement (mm)	7.0±1.6	9.1±1.7	<0.001
Left Lateral Movement (mm)	6.8±1.5	9.0±1.6	<0.001

TABLE 3 : MANDIBULAR RANGE OF MOTION OVER TIME

In table 3, all functional parameters of mandibular movement showed statistically significant improvement at 6 months compared with baseline. Enhanced mouth opening and excursive movements reflect better joint and muscle function, supporting

the functional efficacy of CAD/CAM splint therapy integrated with physiotherapy and other interdisciplinary interventions.

SCALE	BASELINE SCORE	6 MONTH SCORE	P VALUE
Pain Related Disability Index	32.4±7.9	18.7±6.3	<0.001
Anxiety Subscale	10.2±3.4	7.1±2.9	<0.001
Depression Subscale	9.5±3.1	6.4±2.8	<0.001

TABLE 4 : PSYCHOSOCIAL OUTCOMES

In table 4 we found that, Psychosocial measures, including pain-related disability and emotional distress, decreased significantly over the study period. These changes highlight the added value of incorporating psychological support and counseling into TMD care, alongside splint therapy, to improve overall well-being and daily functioning.

OUTCOMES	VALUE AT 6 MONTH
Overall Satisfaction (high/moderate/ low)	92 /41/ 17
Patients Reporting Improved Sleep	118 (78.7%)
Minor Adverse Effects (Eg. Transient Discomfort)	19(12.7%)
Major Adverse Effects	0

TABLE 5 : PATIENT REPORTED OUTCOMES & ADVERSE EFFECTS

In table 5 showed that, Most patients reported high or moderate satisfaction, with notable improvement in sleep quality and very few minor, transient adverse effects. The absence of major complications suggests that CAD/CAM splints fabricated from sustainability-focused, biocompatible materials are well tolerated and acceptable to patients in routine interdisciplinary TMD management.

DISCUSSION

The present study demonstrated clinically and statistically significant reductions in TMD-related pain and improvements in mandibular range of motion and psychosocial status following interdisciplinary management incorporating CAD/CAM-fabricated splints made from sustainability-focused materials. These findings are broadly consistent with clinical trials showing that digitally fabricated stabilization splints are at least as effective as conventional appliances in reducing TMD symptoms and improving function. At the same time, our results extend prior work by embedding splint therapy within a structured interdisciplinary framework (dentistry, physiotherapy, psychological support), which likely contributed to the multidimensional improvement in

pain, function, and disability compared with splint-only approaches reported in earlier studies.^{1,11} Several studies comparing conventional and CAD/CAM splints have emphasized technical accuracy, fit, patient comfort, and satisfaction, often finding that digital workflows improve appliance precision and patient acceptance, while overall clinical outcomes remain comparable between methods.^{3,11} In line with these reports, the high satisfaction rates and low incidence of adverse effects in our study supports the feasibility and clinical acceptability of CAD/CAM splints for routine TMD care.¹⁰ However, our study adds an important dimension by integrating sustainability-focused materials into the digital workflow, aligning clinical performance with emerging concepts of “green dentistry,” which emphasize reduced material waste, efficient use of resources, and environmentally conscious selection of dental biomaterials. The favorable clinical outcomes observed suggest that prioritizing biocompatible, durable, and environmentally responsible materials does not compromise therapeutic efficacy in TMD management. Compared with existing literature, the novelty of our study lies in combining three elements that are usually examined separately i.e. digital CAD/CAM fabrication, interdisciplinary TMD management & sustainability-oriented material selection. While previous reviews and trials have called for standardization of outcome measures and more robust evaluation of digital splints in diverse clinical contexts, data on sustainability and interdisciplinary integration remain limited.^{12,13} By demonstrating consistent improvements in pain, function, psychosocial well-being, and patient-reported experience in a relatively large sample, our findings support the adoption of fully digital, environmentally conscious splint therapy within an interdisciplinary care model,¹⁴ and highlight the need for future research that explicitly compares different sustainable materials, manufacturing methods (milled versus printed), and long-term ecological and economic impacts alongside clinical outcomes.

CONCLUSION

We have concluded that, interdisciplinary temporomandibular disorder (TMD) management incorporating CAD/CAM-fabricated occlusal splints from sustainability-focused materials demonstrated favorable clinical performance and patient acceptability. The integrated approach yielded clinically relevant reductions in pain intensity, improvements in mandibular range of motion, and enhancement of psychosocial outcomes, accompanied by high patient satisfaction and a low incidence of minor, self-limiting adverse events. The use of a standardized digital workflow facilitated accurate, reproducible splint fabrication,

while the selection of biocompatible, sustainability-oriented materials aligned therapeutic outcomes with emerging environmental and resource-efficiency priorities in dental practice. Collectively, these findings support the incorporation of digitally manufactured, sustainability-focused splints within interdisciplinary TMD care pathways and justify further controlled studies to validate long-term effectiveness, material-specific performance, and economic and ecological impacts in broader patient populations.

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