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MODERN TECHNOLOGICAL SOLUTIONS IN THE TREATMENT OF OBSTRUCTIVE SLEEP APNEA: A REVIEW OF INNOVATIONS AND THEIR SOCIAL IMPACT

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ABSTRACT

Introduction: The aim of this review is to analyze technological advancements in the treatment of Obstructive Sleep Apnea (OSA) published between 2019 and 2025, with a specific focus on their impact on therapeutic adherence and public health.

Materials and methods: A comprehensive literature review was conducted utilizing key databases such as PubMed, Scopus, Web of Science, and Google Scholar. The selection process prioritized innovative technological solutions, telemedicine applications, and e-health concepts.

Results: The comprehensive review of the scientific literature revealed several technological advancements significantly impacting the treatment of Obstructive Sleep Apnea:

- **Hypoglossal Nerve Stimulation:** HNS serves as an effective alternative for moderate to severe OSA patients intolerant to CPAP [1]. This implantable treatment stimulates the hypoglossal nerve, activating muscles to maintain upper airway patency during sleep, resulting in significant reductions in Apnea-Hypopnea Index and improved sleep quality [2,3].
- **Advanced Algorithms in PAP Devices:** Integrating AI and machine learning into PAP devices optimizes treatment and boosts patient adherence [4]. These algorithms analyze CPAP data to predict adherence issues, enabling clinicians to tailor interventions and personalize strategies for better patient outcomes [5].
- **Telemedicine:** Telemedicine has advanced OSA management through remote patient interaction, monitoring, and follow-up [6]. This remote care often leads to comparable or improved treatment compliance, offering cost-effective solutions and increasing access to specialized care [7].
- **3D Printing in Oral Appliances:** 3D printing revolutionizes the fabrication of custom Mandibular Advancement Devices for OSA [8,9]. Utilizing digital workflows from intraoral scanning to CAD design, highly precise appliances are produced, improving patient comfort and adherence [9].

Conclusion: The introduction of new technologies in OSA treatment, such as hypoglossal nerve stimulation, improved algorithms in PAP devices, telemedicine, and 3D printing, holds significant potential for increasing patient therapeutic adherence [10]. These technologies favor therapy personalization, which is crucial given the diverse pathophysiology and phenotypes of OSA [2]. Improved compliance and the availability of personalized treatment methods directly translate into better public health outcomes, a reduction in the risk of cardiovascular and metabolic complications, and an overall improvement in the quality of life for OSA patients [11, 12]. However, attention must be paid to ensuring that the implementation of these innovations is conducted thoughtfully, so as not to exacerbate existing inequalities in access to healthcare [12].

KEYWORDS

Obstructive Sleep Apnea, Technological Innovations, E-Health, Hypoglossal Nerve Stimulation, Telemedicine

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1. Introduction

Obstructive Sleep Apnea (OSA) is a common disorder characterized by recurrent episodes of partial (hypopnea) or complete (apnea) cessation of airflow during sleep, resulting from the collapse of the upper airway [13]. It is estimated that the global prevalence of OSA in the adult population ranges from 9% to 38%, with higher rates observed in men and older adults [14]. This disease constitutes a serious global health and social problem, as untreated OSA is associated with significant consequences. The most severe include an increased risk of cardiovascular diseases, such as hypertension, coronary artery disease, heart failure, and stroke, as well as metabolic disorders. Furthermore, OSA contributes to reduced quality of life, decreased work productivity, and significantly increases the risk of traffic accidents [13,15]. The socio-economic burden resulting from untreated OSA, encompassing healthcare costs, productivity losses, and accident-related costs, is substantial, exceeding \$150 billion annually in the United States alone [12]. Despite its widespread prevalence, OSA remains largely undiagnosed and untreated, exacerbating the associated health risks [12,13].

Currently, Continuous Positive Airway Pressure (CPAP) therapy is recognized as the gold standard for treating moderate to severe OSA [13]. The CPAP device delivers pressurized air, maintaining airway patency during sleep, which effectively eliminates apneas and hypopneas [16]. Despite proven efficacy, the primary issue associated with CPAP therapy is the low level of long-term acceptance and adherence (non-adherence) by patients [11,13]. It is estimated that up to 50% of patients do not meet the criterion of using the device for at least 4 hours per night [16]. Factors influencing poor adherence are complex and include physical discomfort associated with the device, psychological problems, insufficient patient education regarding the disease and treatment benefits, as well as social and economic issues [7,16,11]. Despite advancements in mask technology, CPAP abandonment rates remain high, highlighting the need to explore alternative and supportive solutions [7].

Considering the challenges related to low CPAP therapy adherence, the aim of this paper is to analyze alternative and supportive technological innovations designed to improve the efficacy of obstructive sleep apnea treatment and enhance patient comfort and therapy acceptance.

2. Methodology

This review paper is based on a systematic search and analysis of scientific literature. The objective was to identify the latest technological achievements in obstructive sleep apnea therapy and their impact on patient therapeutic adherence and public health.

A literature search was conducted in major scientific databases: PubMed, Scopus, Web of Science, and Google Scholar. Key search terms included: *obstructive sleep apnea, smart sleep devices, hypoglossal nerve stimulation, AI in sleep medicine, telemedicine, mandibular advancement devices*.

The analysis focused primarily on publications from the years 2020–2025, with particular emphasis on clinical trials and systematic reviews.

3. Research results

3.1. Evolution of PAP Therapy

Positive Airway Pressure (PAP) therapy remains the established standard in the treatment of Obstructive Sleep Apnea; however, it has undergone significant evolution in recent years. Key development directions include algorithm enhancement, improvement of mask comfort, and integration with the Internet of Things (IoT), all aimed at increasing therapeutic adherence and overall treatment efficacy [7,13,16].

Modern APAP devices utilize advanced algorithms for precise and dynamic "breath-by-breath" air pressure adjustment. Intelligent algorithms, such as "intelligent" volume-assured pressure support (iVAPS), learn the patient's breathing pattern and provide targeted alveolar ventilation, compensating for anatomical dead space. Additionally, auto-EPAP functions, which automatically regulate expiratory pressure, may contribute to extending deep sleep phases and reducing nocturnal arousals, thereby improving comfort and therapy outcomes [17]. The integration of Artificial Intelligence into these algorithms allows for more personalized pressure adjustment, enhancing treatment efficacy [5,12]. Systems such as the Neurosync index and SyncSmart are examples of software algorithms that allow for automatic analysis and reduction of inter-scoring variability in sleep studies [17]. The capabilities of Machine Learning algorithms to estimate sleep stages from limited channels facilitate data collection in ambulatory settings, particularly given the ubiquity of photoplethysmography in consumer technologies. Analysis of ECG or PPG signals in isolation, or in combination with limited traditional respiratory parameters, is used to automate the assessment of respiratory events at home [5].

Low acceptance of CPAP masks is a key barrier to treatment adherence [7,16]. Progress in mask design has led to the creation of a wide range of interfaces aimed at maximizing comfort and fit [16]. Traditional masks, though often made of silicone or foam, are being supplemented by innovative solutions. An example is helmet interfaces, made of soft, transparent polyvinyl chloride with a seal around the neck. This design reduces pressure around the nose and nasolabial folds, minimizing pressure injuries and leaks common with standard masks [17]. Despite these improvements, CPAP abandonment rates remain high, highlighting the importance of other factors such as comorbidities, psychological factors, or access to care [7]. New materials and sensors aim not only to improve comfort but also to monitor physiological parameters. For instance, acoustic sensors embedded in wearable devices or smartphones can detect even subtle changes in breathing, which is valuable in remote monitoring and telemedicine. These can be discreetly integrated into various devices, minimizing patient discomfort [18].

Modern PAP devices are increasingly equipped with connectivity modules, such as Wi-Fi or GSM, enabling real-time data transmission to the cloud [7,19,20]. This IoT integration facilitates remote patient monitoring and therapy management, ensuring continuous medical care [7,20]. These systems allow for ongoing analysis of key parameters, such as usage time, AHI index, and mask leaks. In the event of abnormalities, automatic alerts can be sent to medical personnel, enabling rapid interventions [7,19,20]. Remote monitoring, often enriched with data visualization tools and AI-based analytics, has the potential for early detection of potential PAP therapy issues and facilitating timely actions [7]. Furthermore, IoT-based telemonitoring demonstrates positive results in increasing CPAP adherence [20]. Research indicates that CPAP devices with cloud connectivity and remote monitoring functions contribute to lowering healthcare costs by reducing the number of physician visits and improving adherence monitoring [5,12]. It is worth noting that in IoT-based systems, sensors collect data on various physical factors and transmit them to the cloud via Wi-Fi. Devices utilizing microcontrollers and selected sensors can monitor sleep apnea and may contribute to early disease detection [19].

3.2. Upper Airway Neurostimulation

Upper airway neurostimulation, specifically Hypoglossal Nerve Stimulation (HNS), represents one of the most significant breakthroughs in recent years for OSA patients who do not tolerate CPAP therapy or for whom it is ineffective [2,21]. This method offers an alternative approach to maintaining airway patency during sleep.

HNS systems operate via an implantable device, which can be described as a type of "tongue pacemaker." The primary goal is to stimulate the hypoglossal nerve (*nervus hypoglossus*), which innervates the tongue muscles, particularly the genioglossus muscle [2]. The implanted stimulator delivers electrical impulses to the hypoglossal nerve, leading to a controlled contraction of tongue muscles. Consequently, the tongue moves forward and/or stiffens, preventing its collapse and thereby maintaining upper airway patency during sleep [1,2].

There are various types of HNS systems. Early devices stimulated one of the hypoglossal nerves using a cuff electrode, leading to phasic or continuous contraction of the genioglossus muscle during sleep [2]. Newer generations of devices, such as bilateral systems, utilize paddle electrodes placed over the genioglossus muscles near their insertion to the mandible. Such a configuration allows for bilateral stimulation of the hypoglossal nerve. The device typically consists of a neurostimulator, a sensing lead (detecting respiratory effort), and a stimulation lead wrapped around the hypoglossal nerve [2,21]. Impulses are delivered transdermally from an external activation unit that the patient places under the chin before sleep. Programming and adjustment of stimulation parameters occur during both wakeful titration and PSG studies to ensure settings do not arouse the patient while maintaining upper airway patency and oxygen saturation [21]. These systems have proven effective in improving the AHI index as well as subjective measures of sleepiness and sleep-related quality of life, with a good safety profile [2].

In addition to implantable HNS systems, other stimulation techniques are being investigated. One of the most analyzed is transcutaneous electrical stimulation of submental muscles using electrodes attached to the skin in the chin area. Studies have shown that such stimulation, applied to OSA patients over a longer period (so-called "tongue muscle training"), may lead to post-treatment improvement in the AHI index. Electrical stimulation of tongue muscles also aims to strengthen and increase resistance to fatigue, contributing to snoring reduction. Another developing method is electrical stimulation of calf muscles during the day, aimed at reducing fluid accumulation in the legs and thus reducing fluid shift from the legs to the neck during sleep, which may affect airway narrowing reduction. Novel approaches also include neurostimulation of the *ansa cervicalis* branch innervating the sternothyroid muscle, which may increase inspiratory airflow by increasing tracheal traction and reducing pharyngeal collapsibility. However, further research is required to fully assess the feasibility and therapeutic efficacy of these new techniques [2].

3.3. Advanced Oral Appliances

Oral appliances, particularly Mandibular Advancement Devices (MADs), constitute an alternative treatment method for patients with mild to moderate OSA, as well as for those with severe OSA who do not tolerate or respond to CPAP therapy [3]. Technological advancements have significantly influenced their design and functionality.

The development of Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) technology and 3D printing has revolutionized the process of creating personalized MADs [9]. Traditional production methods required time-consuming plaster impressions, which were prone to dimensional errors [3,9]. Currently, thanks to digital intraoral scanning, it is possible to create a precise virtual model of the patient's maxilla and mandible. This data is then used in CAD software to design an individually fitted splint, which is subsequently manufactured using 3D printing, often with light-cured acrylic resins. Studies have shown that digitally made MADs (dMADs) are rated better by patients in terms of comfort and ease of use compared to conventionally made ones (cMADs), translating into better therapeutic adherence [9].

In response to the challenge of monitoring objective MAD wearing time, prototypes of "smart splints" are being developed. These devices are equipped with embedded sensors, such as thermosensitive microsensors, which monitor patient usage time (compliance). Although objective adherence monitoring is technically possible, it is not yet widely available in clinical practice. Collecting data on actual splint usage time is crucial for assessing treatment effectiveness and identifying patients who may need additional support or a change in therapy. Factors influencing higher objective compliance with MAD therapy include a marked reduction in snoring, whereas adverse effects, such as dry mouth, may demotivate patients from consistent use [3].

3.4. Next-Generation Positional Therapy

Positional therapy is a recognized treatment method for OSA patients whose symptoms are position-dependent, i.e., exacerbated in the supine position (positional OSA) [2,13]. Traditional techniques, such as sewing a tennis ball into pajamas, were often ineffective due to low tolerance and poor long-term compliance [3,22]. In response to these challenges, a new generation of positional therapy has developed, based on advanced wearable devices [2].

Modern positional therapy devices are lightweight and contain body position sensors that monitor posture during sleep. When the patient adopts a supine position, the device activates a subtle vibrational stimulus (biofeedback) intended to encourage a change to a lateral position without waking the patient [3,22]. These vibrations are generated by small haptic motors, similar to those used in smartphones [22]. These devices can be worn on various parts of the body, e.g., on the back, chest, neck, or forehead [3,22].

The aim of these devices is to prevent sleeping in the supine position, which reduces airway collapse and decreases the apnea-hypopnea index [13]. Studies have shown that vibrotactile positional therapy is effective in reducing time spent in the supine position and decreasing OSA severity. It may also contribute to improving daytime sleepiness, although this effect does not always reach clinically significant differences. Importantly, these devices are capable of objectively monitoring usage and adherence data, which is crucial for assessing therapy effectiveness [22].

Vibrotactile devices offer higher tolerance and better treatment compliance compared to archaic methods [2,3]. Despite concerns that vibrational stimuli might fragment sleep or lead to arousals, studies have shown that sleep efficiency and arousal index do not undergo significant changes when using this therapy [22].

Positional therapy is not suitable for all patients. It is most effective in individuals with mild to moderate positional OSA. For patients whose apneas are not related to sleep position or who present with severe OSA, positional therapy as a standalone treatment is often insufficient [13].

3.5. Telemedicine and Artificial Intelligence in the Treatment Process

Telemedicine and Artificial Intelligence (AI) are revolutionizing the management of Obstructive Sleep Apnea, offering new tools for predicting therapy issues, optimizing treatment, and increasing patient engagement [2,7,23].

Artificial Intelligence and Machine Learning play a key role in analyzing vast amounts of data generated by CPAP devices. AI algorithms can predict potential PAP therapy adherence issues (compliance) at an early stage [5,23]. Through big data analysis, AI can identify correlations between patient characteristics and treatment responses, enabling a personalized approach to therapy. ML models can also identify patient subgroups exhibiting diverse responses to CPAP therapy, allowing for the creation of more targeted treatment strategies [4]. Remote monitoring platforms, often enhanced by AI, allow for the detection of elevated or

unstable AHI under PAP therapy, enabling rapid interventions [7]. This integration of AI in the remote monitoring process can streamline the workflow for clinicians and caregivers, as well as empower patients to process their own data to improve health [2].

With the proliferation of remote monitoring platforms, access to online medical information is increasing, as is the popularity of health applications for mobile phones and wearable devices. Patients increasingly wish to be actively involved in managing their own health [7]. Mobile apps and web platforms, such as MiSAOS, provide patients with continuous monitoring and personalized feedback regarding their CPAP therapy, covering usage data, efficacy, mask leaks, and respiratory events [23]. They allow access to CPAP therapy data via the internet, as well as through other asynchronous telemedicine approaches that can increase patient engagement [7]. Although the term "gamification" is not explicitly mentioned in all sources, the concept of engaging patients through interactive platforms, personalized recommendations, and feedback (as in the MiSAOS project) [23] aims to improve treatment consistency by increasing awareness and motivation. Telemedicine, through access to objective adherence data and patient-reported outcomes, creates unique opportunities to improve treatment results by providing practical tips and reinforcing health education [2,7].

4. Discussion

4.1. Clinical Efficacy vs. Costs

The treatment of Obstructive Sleep Apnea involves various costs, both initial and long-term, which must be considered in the context of clinical efficacy and technology availability across different healthcare systems. Untreated OSA generates significant economic burdens, suggesting that effective treatment, even if initially more expensive, may yield overall savings [12].

CPAP therapy is the recognized gold standard for OSA treatment and often leads to better health outcomes. Its costs include the device and masks, as well as follow-up visits. Annual costs for CPAP equipment (purchase or rental, consumables, and maintenance) range from \$1,000 to \$3,500 [12]. The cost of CPAP masks alone in Spain can range from €16 to €75. Follow-up visits at sleep clinics cost approximately €41 (\$48.07) per contact, and visits to a CPAP provider are about €10 (\$11.73) per contact [23]. Economic studies indicate that the cost per Quality-Adjusted Life Year (QALY) gained in CPAP therapy in the UK was approximately \$15,915 for adults with moderate to severe OSA [12]. Intelligent CPAP monitoring systems and long-term telemedicine interventions have been deemed cost-effective [23].

Upper airway neurostimulation, such as implantable hypoglossal nerve stimulators, entails significantly higher initial costs. The estimated total cost, including the device and surgical implantation, ranges from \$30,000 to \$40,000 prior to insurance reimbursement. Additionally, the device battery requires surgical replacement after approximately 8-12 years, constituting a further cost. Despite high upfront costs, long-term economic benefits are anticipated from the prevention of complications associated with untreated OSA [13]. Patients optimally selected for neurostimulation may be at least as cost-effective as those treated with CPAP [12].

Oral appliances serve as an alternative for patients with mild to moderate OSA or those who do not tolerate CPAP [3]. Modern Mandibular Advancement Devices (MADs), produced using CAD/CAM technology and 3D printing, may offer more attractive economic profiles in the long term, with more durable devices and lower maintenance costs. Manufacturing advancements, including 3D printing, could yield 65% cost savings without compromising therapeutic effects [12]. CPAP is more effective in reducing the AHI index than oral appliances, with a mean difference of 6-7 events per hour. Nevertheless, oral appliances may offer comparable overall clinical effects due to superior patient adherence [8].

Next-generation positional therapy, utilizing wearable devices with vibrational biofeedback, is intended for patients with positional OSA. It is beneficial for individuals with mild to moderate positional OSA [13]. While CPAP was superior in AHI reduction, positional therapy proved more effective than passive control in improving subjective sleepiness and AHI. Short-term compliance with positional therapy is good, and patients often prefer it over CPAP [2]. There are reports of innovative wearables with advanced sensors and machine learning offering 89% diagnostic accuracy and potential cost reductions of 75%, although these early results require further research in larger populations [12].

Access to OSA management varies significantly by healthcare system and region:

- **CPAP:** Widely available and considered the standard globally. However, its efficiency is often limited by low patient compliance [12]. Telemedicine and smart monitoring aim to improve adherence, which is crucial for long-term efficacy and cost-effectiveness [23]. In high-income Western European countries, public healthcare covers 70% to 100% of OSA treatment costs. In Eastern Europe, availability is significantly poorer; only 23% of diagnosed patients receive appropriate treatment compared to 68% in Western Europe [12].
- **Neurostimulation:** Devices are approved by regulatory agencies (e.g., Inspire® FDA approved in 2014, Genio™ in 2025) [13]. Despite promising results, availability is limited due to high upfront costs and the need for specialized surgery. Reimbursement and insurance coverage are key to wider implementation [12].
- **Oral Appliances:** Availability is growing, driven by digital technologies like CAD/CAM and 3D printing, which lower production costs and improve personalization [12]. However, access may still depend on the availability of sleep dentistry specialists and reimbursement scope.
- **Wearable Devices:** Modern positional therapy devices are increasingly available, especially in consumer markets [2]. Their relatively lower costs compared to CPAP or neurostimulation may increase patient accessibility [12]. However, further research on long-term efficacy and adequate inclusion in OSA treatment algorithms are crucial for broader adoption in formal healthcare systems [2].

4.2. Social Aspect and Quality of Life

Modern technologies in OSA treatment have a significant impact not only on patient health but also on their quality of life and social relationships, including partnerships.

OSA symptoms, such as snoring, can significantly disrupt a partner's sleep, negatively affecting their quality of life [24]. Although effective, CPAP therapy has traditionally been associated with noise-generating devices, which could disturb the sleep of both the patient and the partner [13]. However, studies show that CPAP can positively influence the quality of life and sleep of not only the patient but also their partner, leading to greater relationship satisfaction. Improvement in the partner's sleep is noticeable, and increased device usage correlates with better sleep quality for both, translating into higher relationship satisfaction [24]. From the patients' perspective, an improvement in relationship dynamics is observed, attributable to the reduction of OSA symptoms like snoring and apneas, which previously negatively affected the couple's sleep quality, causing increased irritability and stress [14]. Oral appliances, being less bulky, more portable, and quieter than PAP devices, may lead to higher patient acceptance [13]. Miniaturization and silent operation are therefore crucial for improving comfort and maintaining harmony in partner relationships.

Telemedicine and remote monitoring play an increasingly significant role in optimizing care for OSA patients. Real-time monitoring and therapy adjustments via smart materials and biosensors can increase treatment efficiency and reduce costs [12]. Research has shown that telemonitoring is a cost-saving strategy, primarily by shifting from physical face-to-face visits to cheaper telephone contacts. Telemonitoring group participants conducted eight times more telephone visits and approximately 73% fewer physical visits to healthcare facilities, translating into significantly lower total costs compared to standard care [15]. Furthermore, virtual care solutions contribute to a 52% increase in access to specialized care, particularly in underserved populations, and annual savings of \$2,800 per patient related to lower travel costs and waiting times [12]. Telemedicine has the potential to lower healthcare costs and increase access to various care services for underserved populations [7].

4.3. Challenges and Limitations

Introducing modern technologies into OSA treatment involves a range of challenges and limitations that must be addressed to ensure equitable and effective access to care.

One of the main challenges is the "digital divide," which particularly affects the elderly, despite the fact that they could derive significant benefits from telemedicine services [7,25]. These barriers are technical, cultural, and financial in nature [7]. Older and less educated patients may find it difficult to learn how to operate app interfaces or install devices [12,25]. Limited digital literacy among patients and medical staff can impair the adoption of telehealth solutions [12]. Physical limitations, such as sensory impairments (vision or hearing problems), motor deficits, and cognitive disorders (e.g., poor memory, limited learning abilities), constitute significant challenges in using technology [25]. Furthermore, the lack of stable internet access and appropriate devices, especially in rural or low-income areas, is a serious obstacle, and telemedicine platforms may require bandwidth exceeding local access capabilities [12]. The reluctance of older adults to adapt to new technologies may stem from their habituation to alternative disease management methods and a lack of perceived need for

such devices [25]. It is crucial that digital development does not disadvantage patients, especially those most removed from these systems [7].

The expansion of the Internet of Things (IoT) in healthcare is associated with an elevated risk of new attacks and vulnerabilities in healthcare systems. Medical data is highly sensitive and contains personally identifiable information. Many medical devices collect and share critical and sensitive patient data on the Internet, creating security risks such as lack of availability, confidentiality, and integrity [19].

IoT solutions in healthcare are constantly exposed to high security threat risks, including breaches of authorization, privacy, and authentication. Cybersecurity in healthcare has become a major concern, as device flaws can be exploited by hackers, leading to IoT system disruption. Standard security criteria are often inadequate due to medical hardware limitations, such as scalability, energy consumption, and interoperability. Ethical challenges regarding privacy and security arise when medical records are digitized and stored in the cloud, creating a risk of hacker access in the event of a cloud server security breach [19]. Moreover, Artificial Intelligence algorithms, requiring sensitive data for training, raise immense privacy concerns, and any leaks or misuse of data can lead to massive harm for patients [26]. Existing regulations, such as GDPR, attempt to address these concerns; however, systemic gaps and technological shortcomings can weaken data privacy [19,27]. Stronger and more modern security standards and a resilient strategy for protecting key data are necessary [19].

5. Conclusions

Technological advancement is significantly transforming the paradigm of Obstructive Sleep Apnea treatment, shifting away from the universal "one-size-fits-all" approach (often equated with CPAP for everyone) towards precision and personalized medicine. Thanks to innovations, therapy is increasingly tailored to individual patient needs and preferences, taking into account various clinical profiles and treatment tolerance [13].

The key to success in modern OSA management is not merely advanced equipment, but primarily its integration with telemedicine systems and effective patient education. Artificial Intelligence and telemedicine play a central role in analyzing device data, predicting therapy issues, and providing personalized feedback, which increases treatment compliance and improves health outcomes [7,23]. Remote monitoring significantly reduces the need for in-person medical visits, translating into time and resource savings for both patients and the healthcare system, as well as increasing care accessibility [15]. Mobile applications and gamification of the treatment process are valuable tools for enhancing patient engagement and improving therapy consistency [23].

Given the growing role of modern treatment methods, such as neurostimulation, continuing research is essential. Although preliminary data regarding hypoglossal nerve stimulation demonstrate clinically significant reductions in AHI and ODI indices and improvement in patient quality of life over a 12-15 month period [1], further long-term research on neurostimulation is recommended. This will allow for a full understanding of the durable effects of this therapy, its impact on patients' long-term quality of life, and the optimal determination of this technology's place within the comprehensive OSA treatment algorithm.

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