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Review article

Klinefelter Syndrome (47, XXY) and Turner Syndrome (45, X): A Narrative Overview with a Focus on Dental Considerations

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Abstract
Klinefelter syndrome (KS) and Turner syndrome (TS) are sex chromosome disorders with distinct genetic mechanisms and clinical consequences. KS, characterized by a 47, XXY karyotype, leads to primary hypogonadism and infertility in males, while TS, resulting from monosomy X (45, X) or X chromosome abnormalities, causes ovarian dysgenesis and infertility in females. Both conditions exhibit wide phenotypic variability, often leading to delayed or obscured diagnosis. Early craniofacial and dental features, such as taurodontism in KS and a high-arched palate in TS, can serve as crucial diagnostic indicators, guiding timely genetic evaluation and management. Dentists play a vital role in identifying these manifestations, facilitating early genetic diagnosis and multidisciplinary care. Timely recognition enables healthcare providers to offer individualized support, including hormone therapy, speech therapy, and orthodontic treatment, ultimately improving long-term outcomes and quality of life. This presentation highlights the importance of early detection and collaborative care in optimizing outcomes for individuals with KS and TS. This review synthesizes current evidence on dental and orthodontic considerations, providing strategies to enhance oral health and overall quality of life for individuals affected by these conditions.
Keywords. *Oral Health, Klinefelter Syndrome, Turner Syndrome, Orthodontic Considerations, Sex Chromosome Alterations.*

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Introduction

Klinefelter syndrome (KS) and Turner syndrome (TS) are the most common sex chromosome aneuploidy disorders. KS affects males with one or more extra X chromosomes (most commonly 47, XXY), whereas TS occurs in females with a complete or partial loss of the second X chromosome (e.g., 45, X). Both syndromes involve gonadal dysgenesis and chromosomal abnormalities—numerical or structural that influence diagnosis, clinical expression, and long-term management [1].

Klinefelter syndrome encompasses a group of chromosomal variants characterized by at least one supernumerary X chromosome, affecting approximately 1 in 500 males. Clinically, KS presents with tall stature, narrow shoulders, broad hips, gynecomastia, and primary hypogonadism [2].

In addition to their primary role in gonadal differentiation and development, sex chromosomes are important in controlling craniofacial morphology and dental development [3,4]. Males with KS demonstrate elongated but shallow hard palate [5], enlarged alveolar arch dimensions [6,7], and increased tooth size [8]. Root morphology is also affected, with increased final tooth root length reported in individuals with a 47, XXY karyotype [9]. Dental anomalies frequently associated with KS include taurodontism [10], multiple impacted teeth [11], high prevalence of palatally displaced canines [12], and increased maxillary canine eruption angles [13]. Compared to the dominant 46, XY, men with Klinefelter syndrome have more orthodontic-aesthetic problems and severe malocclusion [14-17].

Turner syndrome is the most common chromosomal disorder caused by the complete or partial loss of the second sex chromosome. It affects approximately 1 in 2,000 liveborn females, with approximately 40-50% exhibiting full monosomy X (45, X) [18]. TS typically arises from nondisjunction, and approximately 75–80% of cases result from loss of the paternal X chromosome. Unlike other chromosomal abnormalities, TS is not clearly associated with maternal age or other known risk factors [19].

Common clinical features of TS include short stature (85%), cubitus valgus (77%), a low posterior hairline (70%), and a broad thoracic configuration (“shield chest”) [20]. Deficiency of the X chromosome genes had a direct influence on all three anatomic parts – cranial base, maxilla, and mandible – causing irregular growth [21]. Distinctive craniofacial development contributes to a characteristic facial profile with features such as palpebral ptosis, strabismus, downturned palpebral fissures, a thin upper lip, long philtrum, epicanthal folds, and posteriorly rotated ears, which collectively increase susceptibility to otitis media and associated hearing and perceptual problems [22,23]. Orofacial characteristics include a narrow maxilla (53%), high-arched palate micrognathia (63%), and reduced alveolar arch dimensions [24]. Frequent and Severe

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orthodontic anomalies [25], and altered eruption timing were reported in TS [26]. Table 1 summarizes the key orofacial and dental manifestations of KS and TS.

These conditions present unique craniofacial, dental, and functional challenges, underscoring the dentist's essential role in early recognition, individualized care, and prevention of complications. Coordinated medical-dental collaboration is especially important in regions such as Libya, where diagnostic delays, limited genetic services, and low awareness contribute to underdiagnosis and suboptimal management [27]. This review provides dental practitioners with current evidence to support early detection, tailored treatment planning, and comprehensive long-term dental care for individuals with KS and TS.

Table 1. Craniofacial and Dento-Occlusion Characteristics of Klinefelter and Turner Syndromes*

Domain	Klinefelter Syndrome (47, XXY)	Turner Syndrome (45, X)
Cranial base	Shortened anterior cranial fossa and a decreased angle of the cranial base.	Shorter posterior part, which can lead to a more flattened overall cranial base angle. This Underdevelopment led to midface hypoplasia.
Head shape	Dolichocephalic (long and narrow) skull shape. Low nuchal hairline, and minor ear defects.	Brachycephalic tendency, but it's not a universal character. Low hairline at the nape of the neck, low-set and prominent, and unusually shaped ears.
Facial characteristics	Long, narrow face and other distinct features. Hypertelorism, flat nasal bridge, subtle facial asymmetries.	Reduction in the midface and maxilla. Facial asymmetry, heart-shaped face, short neck, convex facial profile.
Maxilla Palatal features	The maxilla is smaller in overall size and is positioned slightly forward relative to the cranial base.	The maxilla is positioned backward relative to the cranial base and posteriorly inclined. A high-arched palate is a common physical feature, contributing to crowded teeth and potentially leading to other oral health issues.
Mandible	Longer mandibular base, and more prognathic, mesial molar occlusion tendencies.	It usually shows a decrease in growth. A smaller lower jaw can affect facial aesthetics and the relationship of tooth arches to each other.
Tooth anomalies	Taurodontism affects both primary and permanent teeth. The presence of other dental anomalies may lead to orthodontic and aesthetic problems.	Reduced tooth size, thin enamel, and short roots. Disrupted tooth eruption patterns. Increased risk of dental complications such as cavities, gum disease, and root resorption.
Occlusion traits	Skeletal class III malocclusion is a relatively common feature. Incisal open bite and mesial molar relationship are also frequently observed.	Class II skeletal malocclusion is a common finding. A narrow maxillary alveolar arch and a shorter and broader mandibular arch also contribute to other common malocclusions, such as a deep bite or an open bite.

**Klinefelter (47, XXY) and Turner (45, X) syndromes exhibit variable phenotypic expression of craniofacial and dento-occlusal features, spanning from mild to severe manifestations.*

Clinical Presentations and Implications

Klinefelter syndrome (47, XXY) and Turner syndrome (45, X) exhibit variable clinical presentations, influenced by X chromosome dosage, gene expression patterns, and individual genetic and demographic factors [1]. Klinefelter syndrome presents with a broad spectrum of physical, cognitive, craniofacial, and dental manifestations [28]. Turner syndrome is characterized by significant systemic and craniofacial implications, including increased cardiovascular morbidity, reproductive abnormalities, and metabolic and endocrine dysfunction. Additional complications may include conductive hearing loss, visual impairments, learning difficulties, and a heightened risk of dental caries, periodontal disease, and traumatic dental occlusion, which can impact overall health and oral function [29].

Neuropsychiatric Profiles of Klinefelter and Turner Syndromes

Klinefelter Syndrome and Turner Syndrome exhibit contrasting profiles in cognitive function but share common challenges in social and emotional processing. Although individual presentations vary widely, sex-chromosome variations contribute to distinct neuropsychiatric profiles in KS and TS. Characteristic patterns

of cognitive, emotional, and social functioning are commonly reported [30]. Individuals with Klinefelter syndrome typically exhibit average to below-average IQ, with an elevated prevalence of language-based learning disabilities, reduced executive functioning, and social-emotional challenges. Neuropsychiatric comorbidities are common; depressive symptoms occur in up to 69% of affected individuals, and anxiety disorders are reported in 12–18% of cases [31]. Females with Turner syndrome typically exhibit average global intelligence but often experience specific learning difficulties, particularly in visuospatial reasoning, mathematical skills, and executive functioning [32]. Social cognition may also be affected, contributing to challenges in peer interactions and emotional regulation. Anxiety, depression, attention problems, and mood instability are frequently reported, further impacting psychosocial development [18,33].

Diagnosis of Klinefelter and Turner Syndromes

Klinefelter syndrome (KS) and Turner syndrome (TS) can be difficult to recognize clinically, particularly in early life, and diagnosis therefore relies on a combination of physical assessment, endocrine evaluation, and chromosomal analysis [34,35]. Fewer than 10% of KS cases are identified before puberty, with only 26–37% diagnosed during a patient's lifetime [36,37]. The mean age at diagnosis is approximately 30 years, and affected males experience a 5–6-year reduction in life expectancy compared with the general population [38]. In contrast, TS is typically recognized between 8–12 years of age, although many cases are detected prenatally or in infancy [39]. Despite its prevalence, TS remains significantly underdiagnosed; fewer than one-third of patients are identified before puberty. In European cohorts, the average age at diagnosis is roughly 15 years [40,41], with delays expected to be even greater in resource-limited settings such as Libya [42]. These diagnostic delays can postpone essential interventions such as growth hormone therapy and timely initiation of estrogen replacement [43]. Cytogenetic testing is the definitive method of diagnosis for both KS and TS. Standard karyotyping (typically 20–30 metaphases) remains the gold standard, capable of detecting numerical abnormalities and structural variants such as mosaicism. Fluorescence in situ hybridization (FISH) and chromosomal microarray analysis (CMA) may be used when mosaicism is suspected or when rapid confirmation is required [44].

Treatment Options for Klinefelter and Turner Syndromes

Klinefelter syndrome and Turner syndrome occur sporadically and are not inherited; no preventive or curative treatments are currently available. Management, therefore, focuses on alleviating symptoms, improving functional outcomes, and minimizing associated medical risks [45]. In KS, therapeutic strategies commonly include testosterone replacement therapy to restore androgen levels and support the development of secondary sexual characteristics. Fertility interventions, particularly testicular sperm extraction combined with intracytoplasmic sperm injection (ICSI), may enable biological paternity in some affected men [46]. Psychosocial support, including mental health care, speech and language therapy, and occupational or physical therapy, is often required to address developmental, behavioral, and neuromotor challenges. Surgical management, such as a reduction mastectomy, may be indicated for significant gynecomastia [47]. In TS, standard management typically includes growth hormone therapy to promote linear growth and increase adult height, along with estrogen replacement therapy to induce puberty and maintain secondary sexual characteristics, bone health, and uterine development [48]. Routine cardiovascular surveillance is essential because of the high prevalence of congenital and acquired heart disease, including bicuspid aortic valve, coarctation of the aorta, and aortic dilatation. Comprehensive care also includes regular hearing and vision assessments, screening for thyroid and metabolic disorders, and individualized educational support for specific learning difficulties [49].

Cognitive and Behavioral Challenges in Dental Management

Cognitive and behavioral differences may complicate dental management in individuals with Klinefelter syndrome and Turner syndrome. Awareness of these patterns is essential for delivering patient-centered and effective care. Both conditions are associated with neurodevelopmental characteristics that may influence how patients respond to the dental environment, clinical communication, and procedural demands [18,19].

Individuals with KS may present with the following behavior patterns during dental visits:

Heightened anxiety and stress are frequently observed and may present as reduced cooperation or difficulty adhering to instructions [50]. Communication challenges, including limitations in speech, language, or expressive–receptive abilities, can further impede the patient's capacity to comprehend explanations or respond appropriately [51]. Additionally, sensory hypersensitivities—whether auditory, olfactory, or tactile—may be exacerbated in the dental environment, potentially provoking discomfort or intensified stress reactions [52].

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Patients with TS may likewise demonstrate behavioral characteristics with implications for dental care

Elevated anxiety, especially in unfamiliar or clinical environments, may hinder a patient's ability to maintain cooperation throughout procedures [53]. Additionally, difficulties in social cognition, nonverbal communication, and broader interpersonal interactions can impede rapport-building, limit effective communication, and reduce overall engagement during clinical encounters [54].

Barriers to Optimal Management of Klinefelter and Turner Syndromes

Individuals with Klinefelter syndrome and Turner syndrome frequently face substantial medical, dental, and psychosocial challenges, despite neither condition being formally classified as a disability [55]. Underdiagnosis remains a persistent concern, driven by highly variable phenotypic expression, limited clinician awareness, and inconsistent diagnostic pathways across healthcare systems [56]. Although interest in early identification of genetic conditions is gradually increasing in Libya and comparable developing regions, comprehensive newborn screening for sex chromosome aneuploidies is not yet established, and societal acceptance of genetic testing remains limited [57]. The limited availability of genetic counseling services, coupled with a shortage of trained clinical geneticists, remains a major contributor to delayed diagnosis and long-term fragmented care for individuals with chromosomal disorders. Financial constraints —including high individual costs of karyotyping, advanced diagnostic imaging, and prolonged hormone replacement therapy— place significant economic pressures on affected families and often limit timely access to essential public dental health care services [58]. The social stigma associated with genetic conditions can discourage patients from seeking early evaluation or disclosing relevant medical information, hindering timely diagnosis and management [59,60]. These barriers are intensified by unequal access to specialized healthcare facilities, limited cytogenetic laboratory capacity, and the absence of structured national registries for rare genetic conditions. To address these challenges, strengthening public health infrastructure, establishing standardized national guidelines, expanding medical genetics training programs, and integrating genetic counseling into primary healthcare systems are critical steps toward improving diagnostic equity and outcomes for individuals with KS and TS [61-63].

The Role of Dentists in Early Diagnosis

Dentists may be among the first healthcare professionals to suspect underlying chromosomal disorders such as Klinefelter syndrome or Turner syndrome, particularly when distinctive orodental features are present. The relationship between an extra chromosome and taurodontism has been widely described. Taurodontism is an isolated anomaly, and it can be associated with KS and can be detectable before puberty. Taurodontism, for instance, is reported in approximately 40% of individuals with KS compared with about 12% of males with a typical 46, XY karyotype [2,64]. Taurodontic teeth could be a clinical sign of this syndrome, and the pediatric dentist should refer for chromosome analysis [65-67]. Severe malocclusion, including specific types of crossbite, is a common finding in males with KS, constitutes 43%**,** often stemming from characteristic craniofacial growth patterns, making it a clinically valuable diagnostic marker [15,17,68]. In Turner syndrome**,** characteristic findings such as reduced dental crown dimensions, a high-arched palate, and maxillary constriction can signal the need for further evaluation, prompting timely referral for genetic testing and karyotype analysis. Severe malocclusion, including crossbite**,** is a common feature in individuals with TS. This is a result of an imbalance in the growth of the jaw bones and a narrowed upper dental arch, often stemming from an imbalance in craniofacial growth patterns [15,69,70]. Thorough dental examination combined with targeted medical and developmental history-taking allows clinicians to identify broader phenotypic patterns indicative of sex chromosome anomalies. Tall stature with disproportionately long legs is observed in over 90% of individuals with KS, often resulting in an adult height exceeding familial expectations by approximately 10 cm [1,2]. In contrast, girls with TS commonly present with pronounced short stature—affecting more than 90% of patients—with final height typically 20–22 cm below population norms [70]. Additional musculoskeletal abnormalities may provide further diagnostic clues. Madelung deformity, characterized by a progressive dorsal "bayonet" deformity of the radioulnar joint, occurs in roughly 10% of individuals with TS and is frequently bilateral [39,71].

Ortho-Dental Management and Considerations

Early mixed-dentition screening is essential for assessing tooth eruption patterns, arch morphology, oral habits, and occlusal development. Interceptive orthodontic measures—including habit correction, space maintenance, and maxillary expansion—can help lessen future malocclusion severity and support functional orofacial development [24,67,72,73]. Accurate diagnosis requires comprehensive records such as study models, panoramic radiographs, and lateral cephalograms, while cone-beam computed tomography (CBCT) is recommended when root anomalies, impactions, or taurodontism are suspected [74,75]. KS and TS require coordinated, multidisciplinary dental care due to genetically mediated craniofacial deviations that

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impact jaw growth, dental development, occlusal alignment, and overall treatment prognosis. In individuals with 47, XXY or 45, X karyotypes, craniofacial morphology is strongly genetically determined, particularly in deep skeletal structures such as the chondrocranial and chondrofacial complexes, including the cranial base and mandibular border [3,76]. Given this strong genetic influence, environmental or mechanical modification alone has limited capacity to counteract growth disturbances [15]. Accordingly, treatment planning must be carefully synchronized with each patient's individual growth trajectory, often necessitating early or strategically timed adolescent-phase interventions to address specific occlusal discrepancies [29,31]. Orthodontic procedures involving skeletal expansion may provide greater benefit for patients with TS than for those with KS, as the pronounced growth patterns in KS can limit the degree of achievable skeletal change through orthodontic appliances [77,78]. In KS, mandibular prognathism and transverse discrepancies may necessitate dental decompensation strategies or, in severe cases, orthognathic surgery [79-81]. Orthodontic treatment in KS often focuses on dental compensation, functional improvement, and aesthetic enhancement within the anatomical limits imposed by the underlying skeletal pattern. Continuous monitoring of craniofacial development is essential, with treatment timing individually tailored based on growth assessments [82]. Some individuals with KS require prosthodontic rehabilitation due to premature tooth loss, severe occlusal wear, or significant discrepancies in occlusal relationships [17]. In such cases, accurate reconstruction of the original occlusal plane is crucial to ensure stable functional outcomes and to optimize orthodontic and prosthodontic planning [83]. Dental implants may be an appropriate option for individuals with KS or TS; however, both syndromes are associated with hormonal imbalances and genetic factors contributing to diminished bone mineral density, osteoporosis, and increased fracture risk [44,49]. Zirconia implants may confer advantages in such cases by enhancing osseointegration and supporting bone regeneration in low-density bone environments [84]. A multidisciplinary approach emphasizing prevention, early intervention, and continuous monitoring of occlusal development and orofacial function is essential for managing the orthodontic and dental needs of individuals with KS and TS. (Table 2) summarizes key management strategies and challenges for both conditions, underscoring the importance of coordinated, prevention-focused care.

Table 2. Oral care strategies for Klinefelter and Turner syndromes*

Domain	Klinefelter Syndrome (47, XXY)	Turner Syndrome (45, X)	Dental Considerations
X-ray for early detection and screening	Orthopantomography (OPG) can reveal a range of characteristic craniofacial and dental anomalies.	Orthopantomography can reveal a range of characteristic craniofacial and dental anomalies.	OPG often aids in early diagnosis. Regular dental exams. Orthodontic referral by age 7–8 years.
Preventive care	Maintain rigorous oral hygiene with consistent, comprehensive dental visits. Address caries risk and periodontitis through fluoride and hygiene education.	Early, consistent dental visits and personalized hygiene plans are crucial. Some individuals may experience fine motor skill difficulties, hindering effective brushing and flossing.	Emphasize fluoride, sealants, oral hygiene education, and frequent recall appointments. Promote preventive dentistry and hygiene support, focusing on the narrow palate areas.
Restorative Endodontic care	Address specific dental morphology issues influenced by genetic and hormonal profiles.	Address distinctive dental characteristics like enamel defects, small/malformed teeth, and bleeding disorders.	Manage tooth decay, compensate for weak bone, and adapt to atypical tooth anatomy. Treatment plans are individualized and often multidisciplinary.
Orthodontic management	Consider individual needs, including cooperation level and specific oral health issues. A multidisciplinary approach is required due to complex craniofacial and dental anomalies.	Start earlier if the eruption is accelerated; palate expansion is often needed. A comprehensive, multidisciplinary approach is required due to effects on skeletal growth, dental development, and root health.	Timing is personalized and coordinated with endocrinology. Potential malocclusions (Class II) may require two-phase treatment. Heightened risk of root resorption necessitates careful monitoring with frequent X-rays. Consider skeletal anchorage.

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Prosthetic reconstruction	Dental implants face challenges with bone atrophy, poor mineralization, osteoporosis, and hormonal deficiencies.	Dental implants require careful planning considering craniofacial differences, underlying oral issues, medical conditions, and growth hormone therapy.	Treatment is complex, addressing craniofacial, dental, and systemic issues. Customized care is needed due to hormonal imbalances and bone mineralization problems.

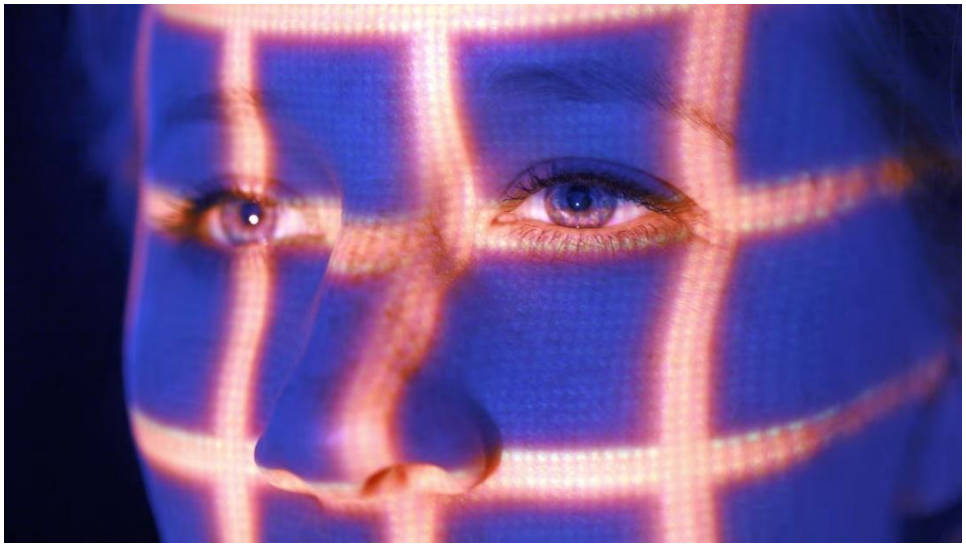
** Individuals with Klinefelter syndrome and Turner syndrome present uniquely, with varying symptom severity. Clinicians must manage behavioral and cooperative challenges, adapting their approach to meet the unique needs of each patient.*

Discussion

In this review, we prioritized Klinefelter syndrome over Turner syndrome because of its higher prevalence. Disrupted gene expression and perturbations in developmental pathways contribute to the marked clinical variability observed in both syndromes. Although KS and TS share some genes, their differential expression underscores a complex genotype–phenotype relationship. Alterations in X chromosome dosage significantly impact somatic proportions, craniofacial architecture, and dental development [85].

Globally, underdiagnosis of both KS and TS remains well documented. Klinefelter syndrome, most commonly the 47, XXY karyotype, comprises approximately 80–90% of KS cases, yet a majority remain undiagnosed. Only an estimated 25% of males with 47, XXY receive a clinical diagnosis in their lifetime [1,86]. The timing of diagnosis varies significantly between KS and TS. KS is often diagnosed in adulthood, typically between the ages of 27-30, unless earlier signs prompt evaluation [35,44-46]. In contrast, TS is frequently identified in adolescence, with around 40% of cases exhibiting the classic 45, X karyotype. However, diagnosis can be challenging, and only 10-20% of TS cases are recognized in early childhood [19,29,87]. Notably, TS is often diagnosed later than expected, with a median age of diagnosis at 15 years, and some individuals never receive a diagnosis. This delay has significant implications for research interpretation and intervention planning. Early diagnosis, facilitated through neonatal screening programs, can improve outcomes [88].

In Libya, limitations in public health infrastructure and genetic services contribute to delayed or missed diagnoses [89,90]. The country's cytogenetic testing capacity is minimal or under-resourced if non-existent, karyotyping services are often private and centralized, and reliant on foreign laboratories, forcing individuals to rely on referral abroad for karyotyping, which hinders timely diagnosis [91]. The financial burden of chromosomal testing further compounds these issues. Although precise current data from Libya are sparse, in some comparable settings, the cost of karyotyping can range from the equivalent of USD 250. These economic barriers contribute to persistently delayed or missed diagnoses, especially when public funding and insurance support are limited [92,93]. Expanding affordable cytogenetic services and integrating them within pediatric and endocrine screening frameworks may help to reduce these disparities [94-96].



New AI technology could identify rare genetic diseases from patients' facial images. Jochen Tack/imagebroker/REX/Shutterstock. https://www.cnn.com/2019/01/08/health/ai-technology-to-identify-geneticdisorder-from-facial-image-intl

The social impact and quality of life of individuals with KS and TS are heavily influenced by their orofacial dysfunction and psychosocial well-being [97-99]. Clinicians should remain sensitive to the behavioral and sensory phenotypes often seen in KS and TS. Strategies such as calm, patient-centered communication,

accommodation of sensory sensitivity, and caregiver involvement can enhance cooperation [100,101]. For those with mobility, coordination, or balance challenges, modifying the clinical environment and employing behavior-guidance techniques may improve procedural outcomes [102].
Advances in diagnostic technologies and rising clinical awareness are promising. Artificial intelligence (AI) — including facial recognition tools and predictive modeling — may support earlier detection and personalized management pathways for individuals with KS and TS [103,104].
Coordinated management enhances self-esteem, social functioning, and overall quality of life [86,105]. Achieving these outcomes will require strengthened public and professional awareness, increased access to specialized services, stigma reduction, and financial support. Enhancing patient and family education and optimizing care transition from pediatric to adult services will further support long-term health. Ultimately, integrated, individualized management strategies can help individuals with KS and TS reach their full potential [46,77,106,107].

Conclusion

Dentists play a crucial role in the early detection of Klinefelter syndrome and Turner syndrome, as distinctive craniofacial and/or orodental features may be among the earliest clinical indicators of underlying chromosomal abnormalities. Early recognition enables prompt referral, targeted intervention, and improved long-term outcomes. Preventive strategies and interceptive orthodontic care are essential components of management. Clinicians should be vigilant for syndrome-specific findings, such as taurodontism and altered tooth morphology in KS, and a high-arched palate, short tooth roots, and malocclusion in TS. To address persistent underdiagnosis, especially in low-resource settings, we advocate implementing newborn screening programs, expanding access to low-cost cytogenetic testing, and incorporating routine karyotyping into pediatric and endocrine screening pathways. Developing evidence-based guidelines, increasing access to multidisciplinary care, and leveraging emerging technologies will support equitable care. Future research should focus on genotype-phenotype relationships, hormonal modulation of craniofacial development, and incorporating teledentistry to advance personalized management and optimize care for individuals with KS and TS.

Recommendations for Managing the Dental and Craniofacial Aspects of Klinefelter and Turner Syndromes

1. Develop individualized, precision-based dental treatment plans that thoughtfully integrate each patient's medical history, hormonal profile, and systemic health considerations, ensuring safe and tailored clinical care.
2. Initiate early and ongoing oral health surveillance in childhood to identify emerging dental or maxillofacial abnormalities, enabling proactive management during critical developmental periods.
3. Implement early intervention strategies and patient-centered education programs to reduce long-term complications and develop lifelong habits that support optimal oral and systemic health.
4. Recognize the strong genetic influences on dental development and eruption patterns, including the increased risk of ankylosis in individuals with KS and ectopic eruption in those with TS, to inform timely interventions and optimize dental management.
5. Consider hormonal influences on craniofacial growth, bone turnover, and skeletal maturation when planning orthodontic treatment, as these factors can impact treatment timing and response, and vary between KS and TS, to optimize outcomes and minimize complications.
6. Adopt a collaborative, multidisciplinary approach that harmonizes dental, medical, genetic, and psychosocial care, ensuring comprehensive support for patients and their families throughout the lifespan.
7. Empower patients and caregivers through clear communication, education, and counseling, promote adherence to preventive protocols, enhance self-efficacy, and support informed decision-making.

References

1. Zhang X, Hong D, Ma S, Ward T, Ho M, Pattni R, et al. Integrated functional genomic analyses of Klinefelter and Turner syndromes reveal global network effects of altered X chromosome dosage. Proc Natl Acad Sci U S A. 2020 Mar 3;117(9):4864–73.
2. Los E, Leslie SW, Kadam SJ. Klinefelter Syndrome. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan–. [Updated 2025 May 5].
3. Brkic H, Kaic Z, Poje Z, Singer Z. Shape of the craniofacial complex in patients with Klinefelter syndrome. Angle Orthod. 1994 Oct;64(5):371–6.
4. Alvesalo L. Sex chromosomes and human growth: a dental approach. Hum Genet. 1997 Oct;101(1):1–5.
5. Kaić Z, Brkić H, Poje Z, Njemirovski V, Dorn V. Hard palatal size and shape in 47, XXY males. J Coll Antropol. 1996;20:87–91.

6. Laine T, Alvesalo L. Palatal and alveolar arch dimensions in 47,XXY (Klinefelter syndrome) men. Hum Biol. 1993 Feb;65(1):131–8.
7. Šćepan I, Babić M, Glišić B. Mesiodistal dimension of permanent teeth in men with Klinefelter's syndrome. Eur J Orthod. 1993 Jun;15(3):195–7.
8. Hunter ML, Collard MM, Razavi T, Hunter B. Increased primary tooth size in a 47, XXY male: a first case report. Int J Paediatr Dent. 2003 Jul;13(4):271–3.
9. Lahdesmaki R, Alvesalo L. Root lengths in 47,XXY males' permanent teeth. J Dent Res. 2004 Oct;83(10):771–5.
10. Giambersio E, Barile V, Giambersio AM. Klinefelter's syndrome and taurodontism. Arch Ital Urol Androl. 2019 Jul 2;91(2).
11. Parhiz A. A rare case of multiple impacted teeth in a Klinefelter patient. J Craniomax Res. 2014;1:66–8.
12. Kaić Z, Abulwefa A, Štefanac-Papić J, Brkić H. Prevalence of the palatally displaced canine in 47, XXY males. J Dent Res. 1998;77:3057.
13. Abulwefa A, Brkić H, Kaić Z. Differences in the eruption angle of palatally displaced canines in Klinefelter syndrome: A retrospective study on panoramic radiographs. Acta Stomatol Croat. 2017 Dec;51(4):300.
14. Kaić Z, Abulwefa A, Poje Z, Štefanec-Papić J, Brkić H. Dentofacial anomalies in XXY males (Klinefelter syndrome). J Dent Res. 2001;80:1224.
15. Poje Z, Skrinjaric I, Kaic Z, Stefanac-Papic J. Prevalence of malocclusions in patients with gonadal dysgenesis. Coll Antropol. 1996 Jun;20:201–6.
16. Capasso F, Panetta F, Ierardo G, Parisella V, Polimeni A. Klinefelter syndrome: Case report. Oral Implantol (Rome). 2010 Apr;2(3):27.
17. Abulwefa A, Štefanac-Papić J, Kaić Z. Assessment of dentofacial aesthetics in 47, XXY men. Lib J Med Res. 2013;8:62–9.
18. Breehl L, Caban O. Genetics, Gonadal Dysgenesis. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023. [Updated 2023 Aug 14].
19. Sharma L, Shankar Kikkeri N. Turner Syndrome. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan–. [Updated 2025 Jun 22].
20. Zhong Q, Layman LC. Genetic considerations in the patient with Turner syndrome—45, X with or without mosaicism. Fertil Steril. 2012 Oct;98(4):775–9.
21. Dumancic J, Kaic Z, Varga ML, Lauc T, Dumic M, Milosevic SA, et al. Characteristics of the craniofacial complex in Turner syndrome. Arch Oral Biol. 2010 Jan;55(1):81–8.
22. Ibarra-Ramírez M, Martínez-de-Villarreal LE. Clinical and genetic aspects of Turner's syndrome. Med Univ. 2016 Jan;18(70):42–8.
23. Frelich J, Lepska K, Jeż W, Irzyniec TJ. Select clinical features in the craniofacial region in women with Turner syndrome. Ann Acad Med Siles. 2019;73:255–65.
24. Rizell S, Barrenäs ML, Andlin-Sobocki A, Stecksén-Blicks C, Kjellberg H. Palatal height and dental arch dimensions in Turner syndrome karyotypes. Eur J Orthod. 2013 Dec;35(6):841–7.
25. Szilágyi A, Keszthelyi G, Nagy G, Madléna M. Oral manifestations of patients with Turner syndrome. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2000 May;89(5):577–84.
26. Tallón-Walton V, Sánchez-Molins M, Hu W, Martínez-Abadías N, Casado A, Manzanares-Céspedes MC. Comprehensive oral diagnosis and management for women with Turner syndrome. Diagnostics (Basel). 2024 Apr 5;14(7):769.
27. Elkalmi RM. Transforming healthcare in Libya–the need for clinical practice guidelines in disease management. J Pharm Policy Pract. 2025 Dec 31;18(1):2565419.
28. Scheidt L, Sanabe ME, Diniz MB. Oral, physical, and behavioral aspects of patient with chromosome 47, XYY syndrome. J Indian Soc Pedod Prev Dent. 2015 Oct-Dec;33(4):347–50.
29. Turner HE, Johannsen EB, Smyth A, Orchard E, Gravholt CH. Approach to the Patient with Turner Syndrome. J Clin Endocrinol Metab. 2025 Sep 13:dgaf517.
30. Hong DS, Reiss AL. Cognitive and neurological aspects of sex chromosome aneuploidies. Lancet Neurol. 2014 Mar;13(3):306–18.
31. Arnold A, Bojesen A. 2nd International Workshop on Klinefelter Syndrome.
32. Hong D, Scaletta Kent J, Kesler S. Cognitive profile of Turner syndrome. Dev Disabil Res Rev. 2009;15(4):270–8.
33. Stoynova H, Staynova R, Kafalova D. How Does Turner Syndrome Affect Quality of Life? A Systematic Review. Medicina (Kaunas). 2025 Sep 10;61(9):1643.
34. Groth KA, Skakkebæk A, Høst C, Gravholt CH, Bojesen A. Klinefelter syndrome—a clinical update. Clin Endocrinol (Oxf). 2013 Jul;79(1):20–30.
35. Pinsker JE. Turner syndrome: updating the paradigm of clinical care. J Clin Endocrinol Metab. 2012 Jun;97(6):E994–1003.
36. Abramsky L, Chapple J. 47,XXY (Klinefelter syndrome) and 47,XYY: estimated rates and indications for postnatal diagnosis. J Med Genet. 1997 Sep;34(9):632–6.
37. Bojesen A, Juul S, Gravholt CH. Prenatal and postnatal prevalence of Klinefelter syndrome: a national registry study. J Clin Endocrinol Metab. 2003 Feb;88(2):622–6.
38. Bojesen A, Kristensen K, Birkebaek NH, Fedder J, Mosekilde L, Bennett P, et al. Increased mortality in Klinefelter syndrome is associated with comorbidity. J Clin Endocrinol Metab. 2004 Aug;89(8):3830–4.
39. Gravholt CH, Andersen NH, Conway GS, Dekkers OM, Geffner ME, Klein KO, et al. Clinical practice guidelines for Turner syndrome. Eur J Endocrinol. 2017 Sep;177(3):G1–70.

40. Sävendahl L, Davenport ML. Delayed diagnoses of Turner's syndrome: proposed guidelines for change. J Pediatr. 2000 Oct;137(4):455–9.
41. Berglund A, Viuff MH, Skakkebæk A, Chang S, Stochholm K, Gravholt CH. Changes in the cohort composition of turner syndrome and severe non-diagnosis of Klinefelter, 47, XXX and 47, XYY syndrome: a nationwide cohort study. Orphanet J Rare Dis. 2019 Jan 14;14(1):16.
42. Ibrahim MA, Abusrewel FA, Elshrek YM. Challenges in diagnosing genetic disorders in low-resource settings: experiences from Libya. Libyan J Med Sci. 2021;5(2):45–51.
43. Fathalla O, Alghazir N, Hadid I, Ghawil M, Mattar S, Abdulgader M, et al. Final Height Outcome in Girls with Turner Syndrome Treated with Growth Hormone and Low Dose Estrogen. Khalij-Libya J Dent Med Res. 2022:53–8.
44. Groth KA, Skakkebæk A, Høst C, Gravholt CH. Clinical review: Klinefelter syndrome—A clinical update. J Clin Endocrinol Metab. 2013 Jan;98(1):20–30.
45. Corona G, Pizzocaro A, Lanfranco F, Garolla A, Pelliccione F, Vignozzi L, et al. Sperm retrieval and assisted reproduction outcomes in Klinefelter syndrome: A systematic review. Hum Reprod Update. 2017 May;23(3):265–75.
46. Mehta A, Paduch DA. Klinefelter syndrome: Diagnosis and management. Curr Opin Endocrinol Diabetes Obes. 2012 Dec;19(6):505–12.
47. Narula HS, Carlson HE. Gynecomastia—pathophysiology, diagnosis, and treatment. Nat Rev Endocrinol. 2014 Nov;10(11):684–98.
48. Gravholt CH, Andersen NH, Conway GS, Dekkers OM, Geffner ME, Klein KO, et al. Clinical practice guidelines for the care of girls and women with Turner syndrome: proceedings from the 2016 Cincinnati International Turner Syndrome Meeting. Eur J Endocrinol. 2017 Sep;177(3):G1-70.
49. Szybiak W, Kujawa B, Miedziaszczyk M, Lacka K. Effect of growth hormone and estrogen replacement therapy on bone mineral density in women with Turner syndrome: a meta-analysis and systematic review. Pharmaceuticals (Basel). 2023 Sep 19;16(9):1320.
50. van Rijn S, Swaab H. Emotion regulation in adults with Klinefelter syndrome (47, XXY): Neurocognitive underpinnings and associations with mental health problems. J Clin Psychol. 2020 Jan;76(1):228–38.
51. Panvino F, Paparella R, Gambuti L, Cerrito A, Menghi M, Micangeli G, et al. Klinefelter Syndrome: A Genetic Disorder Leading to Neuroendocrine Modifications and Psychopathological Vulnerabilities in Children—A Literature Review and Case Report Children. 2024 Apr 24;11(5):509.
52. Bryant DM, Hoeft F, Lai S, Lackey J, Roeltgen D, Ross J, et al. Neurodevelopmental profiles in Klinefelter syndrome. Dev Med Child Neurol. 2020 Jan;62(1):91–9.
53. Culen C, Ertl DA, Schubert K, Bartha-Doering L, Haeusler G. Psychological functioning and anxiety in Turner syndrome. Horm Res Paediatr. 2017;87(3):184–91.
54. Hong DS, Dunkin B, Reiss AL. Psychosocial functioning and social cognition in Turner syndrome. J Dev Behav Pediatr. 2011 Sep;32(7):512–20.
55. World Health Organization. International Classification of Functioning, Disability, and Health: Children & Youth Version: ICF-CY. Geneva: World Health Organization; 2007.
56. Hussein A, El-Hassi A, Ben Amer S. Parental attitudes toward genetic testing in North African populations: a cross-sectional survey. Libyan J Med. 2021 Dec;16(1):1893427.
57. Waked M, Amr K, El-Gammal M. Barriers to the implementation of genetic screening programs in developing countries. J Community Genet. 2020 Oct;11(4):345–53.
58. Abdulqader R, Gashut H, Shihata S. Awareness and acceptance of chromosomal disorder screening among families in Libya. Pan Afr Med J. 2022;41:102–9.
59. Boussoura A, Chaouch L, Kefi R. Public perceptions and ethical concerns regarding genetic testing in Arab societies. Ethics Med Public Health. 2020 Jul;14:100480.
60. Albar MA. Ethical, social and cultural issues in genetic disorders in the Arab world. Saudi Med J. 2020 Sep;41(9):971–9.
61. World Health Organization (WHO). Strengthening genetic services in developing countries: policy recommendations. Geneva: WHO; 2019.
62. Elmahdi E, Almansori M, Tarhuni A. Diagnostic challenges of rare diseases in Libya: a call for national registries and improved laboratory capacity. East Mediterr Health J. 2021 Nov;27(11):1087–95.
63. Abdalla M, El-Hawat A, El-Khazen S. Improving access to diagnostic and therapeutic services for chromosomal disorders in North Africa: recommendations for policy development. Afr Health Sci. 2022 Jun;22(2):491–9.
64. Chetty M, Roomaney IA, Beighton P. Taurodontism in dental genetics. BDJ Open. 2021 Jul 9;7(1):25.
65. Hata S, Maruyama Y, Fujita Y, Mayanagi H. The dentofacial manifestations of XXXXY syndrome: a case report. Int J Paediatr Dent. 2001 Mar;11(2):138–42.
66. Varrela J, Alvesalo L. Taurodontism in 47,XXY males: a controlled cephalometric study. J Craniofac Genet Dev Biol. 1988;8(3):245–51.
67. Öznurhan F. Taurodontism and Klinefelter syndrome: case report and review of the literature. Cumhuriyet Dent J. 2014 Dec 5;1(1):21-5.
68. Alvesalo L, Laine T. Occlusion in 47, XXY (Klinefelter syndrome) men. Am J Phys Anthropol. 1992 Feb;87(2):161–5.
69. Bajraktarova Miševska C, Kočova M, Kanurkova L, Curcieva Cuckova G, Bajkratarova B, Maneva M, et al. Craniofacial morphology in Turner syndrome karyotypes. South Eur J Orthod Dentofac Res. 2015;2(1):7–13.
70. Ratcliffe S. Long-term outcome in children of sex chromosome abnormalities. Arch Dis Child. 1999 Feb;80(2):192–5.

71. Clementz BT, Breen TF. Madelung deformity in Turner syndrome. J Pediatr Orthop. 1997 Jan-Feb;17(1):110–4.
72. Marçal FF, Costa AC, Magalhães IA, Guerra LM, Lopes LL, Alves e Silva FC, et al. Orthodontic treatment and aesthetic rehabilitation in a patient with Turner syndrome: A case report. Spec Care Dentist. 2020 Sep;40(5):498–505.
73. Zervou-Valvi F, Konstantopoulou K, Giannopoulou A, Giannikakis D, Dimitriou A, Fandridis I, et al. Oral Manifestations and Dental Treatment of Patients with Klinefelter Syndrome: Report of Two Cases. J Integr Health. 2022;1(1):1–5.
74. Kaur M, Yang J. CBCT applications in orthodontic diagnosis of dental anomalies. Int J Dent Imaging. 2021;8(1):33–41.
75. Larsen P, Fink C. Deep skeletal pattern alterations in 47,XXY and 45,X: a morphometric study. J Craniofac Genet Dev Biol. 2017;37(3):145–52.
76. Gruszczyński D, Nijakowski K, Wolska-Bułach A, Lacka K. Skeletal and dental abnormalities in patients with sex chromosome aberrations: a systematic case-based review. Pediatr Pol. 2022;97(1):29–38.
77. Aristizábal JF, Smit RM. Two-phase orthodontic treatment in a patient with Turner syndrome: an unusual case of deep bite. Cleft Palate Craniofac J. 2015 May;52(3):56–64.
78. Steinberger Z, Al-Qadi M. Maxillary expansion outcomes in Turner syndrome. J Orthod Sci. 2019 Apr-Jun;8(2):72–8.
79. Samango-Sprouse CA, Counts DR, Tran SL, Lasutschinkow PC, Porter GF, Gropman AL. Update on the clinical perspectives and care of the child with 47, XXY (Klinefelter Syndrome). Appl Clin Genet. 2019 Oct 23;12:191–202.
80. Ramos P, da Silva R. Orthognathic surgery considerations in Klinefelter syndrome. J Maxillofac Surg. 2017 Dec;45(4):511–7.
81. Grubb J, Evans C. Orthodontic management of dentofacial skeletal deformities. Clin Plast Surg. 2007 Jul;34(3):403–15.
82. Lucas-Herald AK, Aksglaede L, Caspersen ID, Ahmed SF, Carlomagno F, Isidori AM. New Horizons in Klinefelter Syndrome: Current Evidence, Gaps, and Research Priorities. Endocr Rev. 2025 Feb 11:bnaf005.
83. Čelebić A, Brkić H, Kaić Z, Vojvodić D, Poje Z, Singer Z. Occlusal plane orientation in Klinefelter syndrome (47, XXY males). J Oral Rehabil. 1997 Dec;24(12):942–6.
84. Kouser MS, Prathibha M, Mohammed OB, Elhammali NA, Jameel AS, Chauhan M, et al. A Finite Element Analysis of Peri-implant Stresses Surrounding Zirconium and Titanium Dental Implants. J Pharm Bioallied Sci. 2024 Dec;16(Suppl 4):S3377–9.
85. Viuff M, Skakkebæk A, Johannsen EB, Chang S, Pedersen SB, Lauritsen KM, et al. X chromosome dosage and the genetic impact across human tissues. Genome Med. 2023 Mar 28;15(1):21.
86. Zitzmann M, Aksglaede L, Corona G, Isidori AM, Juul A, T'Sjoen G, et al. European academy of andrology guidelines on Klinefelter syndrome endorsing organization: European Society of Endocrinology. Andrology. 2021 Jan;9(1):145–67.
87. Ding F, Xu J, Xiong J, Li Q, Cheng Z, Deng L. Epidemiological analysis of turner syndrome in children aged 0–14 years: global, regional, and national perspectives (1990-2021). Front Endocrinol (Lausanne). 2025 Apr 30;16:1552300.
88. Gravholt CH, Viuff M, Just J, Sandahl K, Brun S, van der Velden J, et al. The changing face of Turner syndrome. Endocr Rev. 2023 Feb 1;44(1):33–69.
89. World Health Organization (WHO). Public health situation analysis-Libya. 2025 Jun 30. Available from: https://www.who.int › Publications › m › item
90. Othman T, El-Mahdi S. Genetic services in Libya: challenges and perspectives. Libyan Med J. 2018;13(1):22–9.
91. Ameigaal SD, Eljabu N, Mohammed AI, Mohammed RA, Mohammed BM. Genetic Diseases and Associated Risk Factors in Some Libyan Districts: A Cross Sectional Study. Libyan J Med Res. 2023;17(1):19–25.
92. Suleiman A, Khouli R. Referral pathways for cytogenetic testing in resource-limited countries. Middle East Genet J. 2021;12(2):66–73.
93. Al-Hashmi A, Idris W. Barriers to genetic testing and care in North Africa: A review. Afr J Med Sci. 2017;46(2):77–84.
94. Elghuol MM, Algbbasi OS, Mohammed SS, Alfaitory SN, Salh KM, Jumaa W, et al. Chromosomal Mapping Technique for Early Diagnosis of Human Genetic Diseases in Libyan populations, is it needed?. J Med Sci. 2022 Oct 3;17(2):1–6.
95. Bader L, Soufi A. Infrastructure gaps in cytogenetics in developing nations. J Pediatr Genomics. 2020;4(1):55–62.
96. Abou Tayoun AN, DiStefano MT, Iskander N, et al. Genomic medicine in the Middle East: current state, challenges, and opportunities. Genome Med. 2021 Dec;13:184.
97. Goldenberg A, Bonham VL. Predictive modeling and personalized health pathways for patients with sex chromosome disorders. Trends Endocrinol Metab. 2023 Apr;34(4):271–84.
98. Franik S, Fleischer K, Kortmann B, Stikkelbroeck NM, D'hauwers K, Bouvattier C, et al. The impact of Klinefelter syndrome on socioeconomic status: a multicenter study. Endocr Connect. 2022 Jul 1;11(7).
99. Mehmet B, Dwyer AA, Jayasena CN, Gillard S, Llahana S. Update on Physical, Psychological and Quality of Life Management in Klinefelter Syndrome. J Clin Endocrinol Metab. 2025 May 2:dgaf261.
100. van Rijn S, Mason M, van Buggenhout G, Swaab H, Boot AM, van Ravenswaaij-Arts CMA. Social behavior and autism traits in children with 47,XXY Klinefelter syndrome. Genes (Basel). 2018 Jul;9(7):309.
101. Ross JL, Kushner H, Zinn AR. Behavioral phenotype of sex chromosome aneuploidies: clinical and research perspectives. Horm Res. 2006;65 Suppl 3:93–101.

102. Leggett V, Jacobs P. Left-right coordination and balance in individuals with Turner Syndrome. Dev Med Child Neurol. 2008 Aug;50(8):595–600.
103. Aurellia S, Rahman SF. Face recognition in identifying genetic diseases: a progress review. IAES Int J Artif Intell. 2023 Sep;12(3):1019–25.
104. Avramova N. AI technology can identify genetic diseases by looking at your face, study says. CNN. 2019 Jan 8.
105. Gravholt CH, Andersen NH, Christin-Maitre S, Davis SM, Duijnhouwer A, Gawlik A, et al. Clinical practice guidelines for the care of girls and women with Turner syndrome: Proceedings from the 2023 Aarhus International Turner Syndrome Meeting. Eur J Endocrinol. 2024 Jun;190(6):G53–151.
106. Espehana A, Tomlinson C. Klinefelter syndrome and the need for a multi-disciplinary approach. Front Reprod Health. 2021 Apr 22;3:622144.
107. Bondy CA. Care of girls and women with Turner syndrome: A guideline of the Turner Syndrome Study Group. J Clin Endocrinol Metab. 2007 Jan;92(1):10–25