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Review Article: Genu Valgum in the Developing Child: Etiology, Evaluation, and Evidence-Based Management

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Abstract: ***Genu valgum is a condition where an individual's knees bend inward, touching each other and creating a "knock-kneed" look, which may lead to discomfort and difficulties with walking. Commonly known as knock knees, genu valgum is a coronal plane deformity of the lower limb that is often seen in pediatric orthopedic settings. This review focuses on distinguishing between physiological and pathological genu valgum, highlighting the significance of a thorough clinical history, physical examination, and radiographic assessment for accurate diagnosis. Although it is usually a normal variation of growth that appears between ages 2 and 5 and typically resolves on its own by age 7, it is essential to differentiate between physiological and pathological genu valgum to ensure proper treatment. Physiological genu valgum is usually symmetrical, associated with typical height, and seldom leads to functional issues. Conversely, pathological genu valgum can arise from injuries, metabolic conditions (like rickets), skeletal abnormalities, tumors, or systemic illnesses, and is marked by asymmetry, progress that exceeds the anticipated age for correction, or notable functional limitations. The evaluation starts with a thorough clinical history that emphasizes growth, development, family patterns, and dietary habits. A comprehensive physical assessment involves measuring the tibiofemoral angle or the intermalleolar distance, analyzing limb alignment and gait, and checking for rotational deformities or ligament laxity. Imaging is generally utilized only for cases with unusual characteristics, such as asymmetry, abnormal height, or suspected underlying conditions. X-rays, especially long-leg standing images, are useful for determining mechanical axis deviations and assist in planning for surgery.***

Management typically follows a conservative approach in physiological cases, where observation is the key strategy. Bracing and orthotic devices are generally discouraged due to their limited effectiveness and low adherence rates. For growing children, guided growth techniques like hemi-epiphysiodesis using staples, plates, or screws are preferred, while osteotomy is typically reserved for patients with fully developed skeletons or when rapid correction is essential. In certain cases that necessitate concurrent limb lengthening, external fixators may be used. This review emphasizes the clinical presentation, evaluation, and treatment alternatives for genu valgum in children, with the goal of assisting clinicians in distinguishing benign growth variations from significant underlying problemsand guiding appropriate care to prevent long-term consequences.

Keywords: Genu valgum, Deformity, Pediatric, knee , Lower Extremity.

I. INTRODUCTION

Many parents bring their children in for concerns about bow legs or knock knees, which are typically variations of normal growth and development that resolve on their own as the child matures[3]. Common normal variations of lower extremities in children include rotational issues like intoeing and out-toeing, angular issues such as genu varum (bowleg) and genu valgum (knock knee), and pes planus (flatfoot)[13] . Genu valgum, or 'knock knees,' is a deformity of the lower limb that manifests in the coronal plane.. Although most individuals experience no symptoms and function normally, these conditions may sometimes present with flat feet and pain in the inner sides of the foot and knee[6]. Genu valgum can result from several metabolic disorders, such as rickets, vitamin deficiencies, and damage to the epiphyseal region due to trauma, infection, or tumors[9].

Being overweight in childhood raises the likelihood of becoming obese in adulthood and can contribute to musculoskeletal issues, one being genu valgum[1]. A significant portion of this diagnostic research has been conducted on human skeletal remains from the 18th and 19th centuries in northern Europe, where rickets and osteomalacia were prevalent., commonly known as “knock-knees,” which has been linked to vitamin D deficiency during adolescence.[7]. Genu valgum deformities are common anomalies of the lower limbs, associated with various anatomical alterations in the knee joint and surrounding areas, placing individuals at risk for both acute and chronic injuries[2]. As a result, children who have genu valgum often experience discomfort and face functional challenges such as postural instability, difficulties with walking or gait patterns, and challenges when standing, walking, running, or navigating stairs[1]. The development of genu valgum typically begins around age 2 and becomes most noticeable between ages 3 and 4[17].

There is a lack of sufficient data regarding the anatomical changes that occur in the affected joint and its neighboring joints and segments as a result of this condition. For instance, Sahrmann et al. (2010) observed internal rotation of the hip, external rotation of the tibia, and an increased likelihood of foot supination or pronation in individuals with genu valgum[2]. Abnormalities in the lower limbs among children can generally be classified into three categories: rotational, angular, and foot variations[13].

II. TYPES OF GENU VALGUM

A. *Physiologic genu valgum :*

Physiologic genu valgum is a common and expected phase in the normal growth and development of children. It follows a distinct pattern in the alignment of the lower limbs, starting with genu varum (bow-legs) during infancy, advancing to a neutral alignment by 18–24 months of age, and then shifting into a valgus alignment that peaks between ages 3 to 4 years. This physiologic genu valgum gradually corrects itself, aligning into the normal adult configuration by around 7 to 8 years of age (Ramagopal, 2016; White & Mencio, 1995)[3]. Throughout this stage, the valgus angle is usually symmetrical and does not coincide with pain, instability, or functional limitations, setting it apart from pathological deformities that might require intervention. The clinical significance of physiologic genu valgum lies in its self-resolving nature. As noted by White and Mencio (1995), most instances only necessitate clinical monitoring and reassurance for parents, since spontaneous resolution occurs with growth. However, variations in this natural progression can be affected by factors such as body weight. In a study conducted by Putri et al. (2020)[1], It was found that children aged 10 to 12 years who were overweight or obese in Denpasar, Indonesia, had a higher incidence of genu valgum. This finding implies that excess body weight might impose additional biomechanical stress on the growth plates and joints, which could delay the resolution of physiologic genu valgum or promote the development of a persistent, exaggerated deformity.

For clinicians, comprehending normal anatomical alignment is essential to distinguish between physiologic and pathologic genu valgum. Mozafaripour et al. (2018)[2] performed an analysis of lower limb alignment and observed that mild forms of genu valgum may still fall within normal anatomical parameters. They stressed the importance of using an evidence-based approach for diagnosis, taking into account factors like age, symmetry, severity, and functional impact. Radiographic assessment is seldom necessary unless the deformity is severe, asymmetrical, progressive, or persists beyond the age when resolution is expected.

B. *Pathologic genu valgum*

Genu valgum, commonly known as knock-knees, is a condition characterized by the inward angling of the knees while the legs remain straight. Although mild instances are frequently observed in young children and typically resolve as they grow, pathologic genu valgum persists and can lead to considerable discomfort, gait issues, and long-term complications if left untreated. The underlying causes of pathologic genu valgum may include genetic disorders, obesity, injuries, and metabolic conditions such as rickets. Genetic factors, including osteogenesis imperfecta or achondroplasia, can interfere with normal bone development, resulting in angular deformities. Injuries, especially those involving proximal tibial fractures, can disrupt normal bone growth, leading to misalignment of the knees. Obesity, as noted by Vidya Rahmayunissa Swandi Putri et al. (2020)[1], exerts excessive pressure on the knees, exacerbating the deformity in children who are overweight. Furthermore, metabolic disorders like rickets, which arise from deficiencies in vitamin D, calcium, or phosphate, weaken the bones and increase their susceptibility to deformities.

In contrast to physiological genu valgum, which usually resolves by ages 4 to 6, pathologic genu valgum continues and can often worsen. Children with significant deformities may exhibit a waddling gait or limp, which can result in functional limitations and joint pain. This condition can also impact other joints, such as the hips and back, due to compensatory movements. Ferguson & Fernandes (2016)[15] stress that this altered gait can hinder mobility and negatively affect quality of life.

Diagnosis involves a clinical evaluation to examine leg alignment, with X-rays or CT scans utilized to assess the severity and exclude other deformities like genu varum or tibial torsion. Imaging studies aid in designing the appropriate treatment plan. For less severe cases, conservative approaches like physical therapy and the use of orthotics may prove beneficial. Managing weight, particularly in obese children, is crucial in preventing the condition from worsening.

In more severe instances, surgical intervention may be necessary. Hemiepiphysiodesis, which employs eight-plates, is a prevalent technique for children who are still growing. This method gradually corrects knee alignment by adjusting growth on one side of the growth plate, as demonstrated by Zajonz et al. (2017)[5]. For older children, surgical options such as the implantless femoral “V” osteotomy described by Goyal et al. (2021)[9] may be required to realign the bones. In advanced cases, external fixation might be employed for gradual correction.

III. ETIOLOGY

A. Unilateral Genu valgum

Unilateral genu valgum is a valgus deformity that affects one limb only, leading to angular misalignment in the coronal plane. This asymmetrical condition is less frequently observed compared to the bilateral type and often indicates a pathological issue. Typical causes include trauma to the physis or metaphysis, infections such as osteomyelitis, injuries to the physis, or bone tumors. Unlike physiological genu valgum, which is usually bilateral and self-resolving in children, the unilateral variant requires further examination. Radiographic assessment is vital, focusing on indicators like narrowing or premature closure of the physis and the presence and configuration of growth recovery lines (Park-Harris lines), which may suggest prior physeal injury. Timely detection and appropriate treatment are critical to prevent the deformity from worsening and to maintain limb functionality. [9,16,17]

B. Bilateral genu valgum

Bilateral genu valgum, also known as "knock-knees," is a condition characterized by the inward angling of both knees, resulting in a space between the ankles when standing with the knees together. This condition is frequently observed in young children and is typically a normal part of their development, beginning around the ages of 2 to 3 and usually resolving by ages 7 or 8. However, if the condition persists or worsens, it may signal underlying issues such as skeletal dysplasias (e.g., spondyloepiphyseal dysplasia, Ellis van Creveld syndrome), metabolic bone disorders (e.g., rickets, renal osteodystrophy, hypophosphatemic rickets), or lysosomal storage diseases like Morquio syndrome. A radiographic evaluation, including X-rays, is crucial for diagnosing and determining the severity of the condition. When genu valgum leads to functional difficulties or fails to resolve, treatment options such as bracing, physiotherapy, or surgery may be necessary [4,16,18].

C. Intoeing

where the toes direct inward. This is the most prevalent rotational condition observed in children. It is primarily caused by metatarsus adductus, internal tibial torsion, and femoral anteversion, with the origin often associated with the age at which symptoms arise. Metatarsus adductus, recognized as the most common congenital foot deformity, usually resolves naturally by the age of one. It appears as an inward curve of the forefoot, resembling a C-shaped outline of the foot. The flexibility of the foot helps assess the severity; rigid cases will necessitate treatment. Mild and flexible cases do not require any intervention, whereas severe or rigid deformities might be treated through serial casting or with adjustable shoes in infants [13].

D. Tibial Torsion

Tibial torsion refers to the angular variation between the upper and lower axes of the tibia, which indicates the bone's rotational positioning. It is an important factor in the biomechanics of the lower limb and plays a significant role in overall limb alignment and movement.

Research by Mullaji et al. (2008)[20], involving 100 limbs from non-arthritic Indian adults analyzed via computed tomography, found that the average external tibial torsion in this group is lower than what has been recorded in Western populations but aligns closely with Japanese standards. These differences among ethnic groups highlight the necessity for population-specific reference values when clinically assessing tibial torsion. Tibial torsion gradually develops throughout growth, shifting from internal rotation during infancy to external torsion in the teenage years. Any deviations from this normal development can lead to abnormalities in gait and may affect the presentation of coronal plane deformities, such as genu valgum.

In cases where pathological torsion persists or leads to functional difficulties, surgical intervention may be warranted. Dodgin et al. (1998)[21] studied 63 pediatric patients who underwent distal tibial-fibular derotation osteotomy, finding positive results with improved alignment and low complication rates. This surgical method remains a dependable choice for correcting notable torsional deformities. A thorough evaluation of tibial torsion is vital in assessing lower limb deformities in children. Ignoring abnormal torsion could lead to inadequate treatment or a recurrence of issues after the correction of angular deformities. [2,7,19-21].

E. Knee Malalignment

Overweight individuals often experience knee malalignment. A study by Vidya Rahmayunissa Swandi Putri et al. (2020)[1] identified a significant occurrence of genu valgum among overweight children aged 10-12 years. Obesity raises mechanical stress on the knee, worsening alignment problems and increasing the likelihood of degenerative changes and early-onset osteoarthritis.

Various anatomical variations and conditions also play a role in malalignment. Mozafaripour et al. (2018)[2] highlighted differences in joint mechanics and alignment between genu valgum and genu varum. These deformities often arise from abnormal bone growth or changes in the growth plate, impacting gait and mobility.

Injuries, particularly fractures around the knee joint, can cause misalignment. For instance, fractures of the proximal tibia in children may lead to conditions like genu valgum. Currarino & Pinckney (1981)[10] explained how such fractures can result in growth abnormalities and misalignment. Addressing pathologic genu valgum may require conservative options like the use of orthotics and physical therapy, or surgical procedures. Zajonz et al. (2017)[5] showed that hemiepiphysiodesis using eight-plates can gradually align the knee, providing a less invasive solution than osteotomy. In more severe instances, surgical techniques like femoral "V" osteotomy, as mentioned by Goyal et al. (2021)[9], may be necessary to restore proper alignment and diminish the chance of degenerative joint conditions.

Vitamin D deficiency, especially in cases of rickets, has also been associated with genu valgum, according to Khrystyne Tschinkel & Rebecca Gowland (2020)[7]. Inadequate vitamin D weakens bones, leading to deformities, particularly in children who have insufficient dietary intake or limited exposure to sunlight. Comprehending these causes is crucial for accurate diagnosis and effective treatment. [7,8].

F. Angular Variations

A research study by Putri et al. (2020)[1] conducted in Sanur Kaja Village, Denpasar, focused on children aged 10 to 12 years old and discovered a significant prevalence of genu valgum among those classified as overweight or obese—46.7% for overweight children and 53.3% for those who are obese. The research indicates that excess body weight exerts mechanical strain on the knees, particularly affecting the lateral distal femoral physis, which may result in angular deformities due to microtrauma and changes in growth patterns.

Mozafaripour et al. (2018)[2] explored anatomical alignment in individuals with genu valgum and found that those affected exhibited increased femoral anteversion, a larger quadriceps (Q) angle, greater internal rotation of the hip, knee hyperextension, and flatter foot arches. These anatomical traits contribute to the altered alignment of the lower limbs observed in genu valgum and may influence gait and overall biomechanical function. Together, these studies emphasize that both mechanical stress from obesity and specific anatomical abnormalities play a role in the angular variations associated with genu valgum, particularly in developing children..

IV. TREATMENT PROTOCOL FOR GENU VALGUM

The approach to managing genu valgum in children depends on the extent of the deformity, the child's age, and any underlying factors. Generally, physiologic genu valgum, seen in children between the ages of 2 and 7, typically resolves on its own without the need for treatment. For children under six with a tibiofemoral angle of less than 15 degrees, simple observation is usually adequate as natural correction is anticipated. In these cases, braces or orthotic devices do not prove beneficial. However, if the deformity is more significant or persists beyond the expected age frame, especially in those under 10 with a tibiofemoral angle greater than 15-20 degrees or an intermalleolar distance exceeding 8 cm, a more thorough assessment and intervention may be required. Surgical options might be necessary if the condition persists past age 10, or if there are contributing factors like obesity or rickets. In these situations, the main strategy is to continue monitoring while also addressing any metabolic concerns, such as through weight control or vitamin D supplementation. For more pronounced or worsening deformities, surgical procedures might become essential.

Common techniques such as temporary hemiepiphysiodesis, which utilizes screws, plates, or staples, are frequently used to correct angular deformities, particularly in children under 10 who still have growth potential. In instances where the deformity remains despite attempts at growth modulation, or in older children who have reached skeletal maturity, an osteotomy may be required to align the bones correctly. In more intricate or serious cases, specifically when limb lengthening is necessary, external fixation systems can be applied to gradually adjust the deformity. Usually, femoral osteotomy, along with external fixation, serves as the surgical method for older children or those with more severe deformities. Post-surgery rehabilitation and ongoing monitoring are vital to ensure proper alignment is sustained and to avoid over-correction. Timely intervention is essential for preventing long-term issues like joint degeneration and reduced mobility, with the selection of treatment guided by the child's age, skeletal maturity, and severity of the deformity.[1 -20].

V. ASSESSMENT AND EVALUATION OF GENU VALGUM

Assessment begins with a comprehensive history that encompasses birth, growth milestones, family dynamics, and dietary habits. Physiologic genu valgum generally impacts children younger than 7, characterized by symmetrical alignment and typical height. In contrast, pathologic cases may be associated with progressive deformities, trauma, infections, or systemic illnesses. Physical examinations include measuring the tibiofemoral angle or intermalleolar distance, evaluating rotational alignment, and checking for ligamentous laxity. Analyzing gait and rotational profiles assists in differentiating between true and apparent valgus deformities. True valgus is often accompanied by a valgus thrust during walking, which is associated with metabolic or structural disorders. Apparent valgus may result from rotational factors such as femoral anteversion. Radiographs are only warranted in non-physiologic conditions, particularly in instances of asymmetry, short stature, or a history of trauma or infection. Weight-bearing X-rays assess alignment through mechanical axis deviation and tibiofemoral angle measurements [4,6,16].

VI. CONCLUSION

Genu valgum, commonly known as knock knees, is a frequent pediatric issue that often raises concerns among parents, mainly due to its visible deformity in early childhood. However, in many instances, genu valgum is merely a benign, physiological variant of growth and development that usually resolves on its own without any intervention. It tends to be most prominent between the ages of 3 and 5, and typically diminishes as the child matures, particularly by around 7 years old. It is crucial for healthcare providers to reassure parents about this normal developmental trend while also being alert to unusual presentations. Lower limb deformities in children, including genu valgum, can be classified into physiological and pathological types. Physiological genu valgum is symmetrical and non-progressive, generally not affecting functionality. It often appears alongside other normal variations such as flatfoot and ligament laxity. On the other hand, pathological genu valgum is marked by asymmetry, a progressive nature, short stature, or additional systemic symptoms. The causes of these pathological cases can include metabolic bone disorders like rickets, trauma, infections, genetic syndromes, and skeletal dysplasias. These situations often necessitate an in-depth evaluation, which may involve radiographic imaging and, at times, laboratory tests to ascertain the root cause.

Assessing genu valgum involves a thorough clinical evaluation that includes developmental history, family medical history, nutritional status, and analysis of the child's gait. Measuring the tibiofemoral angle and intermalleolar distance assists in quantifying the deformity, while evaluations of rotational profile and ligamentous laxity help distinguish between true valgus deformities and those caused by rotational issues. Radiologic imaging is typically reserved for children exhibiting warning signs such as asymmetry, significant deformity, or lack of improvement as they age.

Management approaches greatly depend on the severity and the underlying cause. Physiological genu valgum usually requires just observation and reassurance. The use of braces or orthotic devices has not consistently proven beneficial and is generally not advised. Conversely, pathological or persistent genu valgum, especially when linked to considerable functional impairments, aesthetic issues, or abnormal mechanical alignment, may call for surgical intervention. Growth modulation methods like guided growth through hemi-epiphysiodesis are preferred for skeletally immature children, whereas osteotomy is an option for older children or those with severe or rigid deformities. Care following surgery, which includes physiotherapy and monitoring for complications like overcorrection or recurrence, is vital for ensuring positive outcomes.

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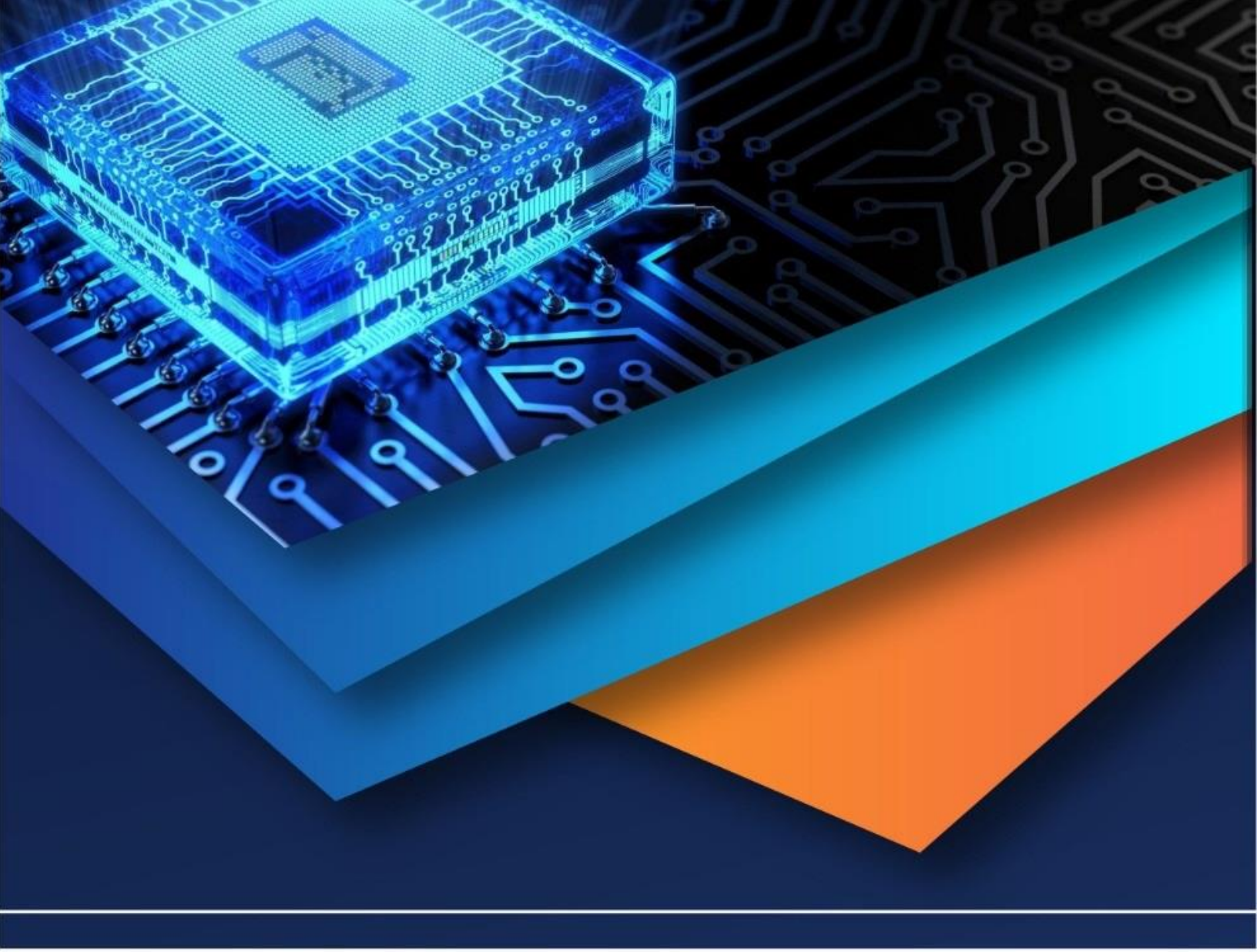

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