OVERVIEW OF **ORTHOPEDIC MANAGEMENT** IN MARFAN SYNDROME

Skeletal manifestations in the Marfan patient may develop or become more pronounced with age. They can cause decreased mobility and chronic pain, thereby creating significant impact on the quality of life. This is becoming more and more evident as advances in cardiovascular surgery are extending life expectancy to nearly that of the general population. The progressive nature of the skeletal complications is an increased problem as people with Marfan syndrome now live longer.

DIAGNOSIS

A scoring system of skeletal manifestations has been designed and validated for use with the 2010 Ghent diagnostic criteria. For the full diagnostic criteria, please visit MarfanDX.org.

Skeletal features include:

- Scoliosis over 20° by upright radiographs
- Protrusio acetabulae by anteroposterior hip x-ray
- Severe hindfoot valgus, also noted as medial deviation of medial malleolus (by clinical finding, not imaging)
- Plain flat foot (pes planus)
- Increased extremity to trunk ratio (armspan to height >1.05)
- Arachnodactyly as diagnosed by positive thumb and wrist signs. The thumb sign is when the entire distal phalanx of the thumb protrudes beyond the ulnar border of the clenched fist. The wrist sign is when the thumb can cover the entire fifth fingernail when wrapped around the contralateral wrist
- Dural ectasia (MRI preferred for evaluation)
- Sternal deformities (pectus carinatum or severe excavatum)
- Elbow flexion contracture (by clinical diagnosis; at least 10 degrees from full extension of the elbow)
- Typical facial characteristics including dolichocephaly, downward slanting palpebral fissures, enophthalmos, retrognathia, and malar hypoplasia.

MANAGEMENT GUIDELINES

ONGOING SCREENING

All growing children with Marfan syndrome require annual screening for scoliosis, kyphosis, and spondylolisthesis by physical examination performed by the primary care physician. The examination should include:

- Standing examination for kyphosis
- Forward bend test to detect asymmetry of any portion of trunk
- Palpation for bony step-off

If abnormality is found, follow up with:

- Standing posteroanterior and lateral radiographs
- Lateral radiograph of the lumbosacral spine for spondylolisthesis
- Referral to orthopedic surgeon for further evaluation

All growing children with Marfan syndrome require screening at age 9–12 for leg length inequality.

- Palpate pelvis in standing position
- Note: false-positive may occur in cases of scoliosis
- Refer to orthopedic surgeon if significant difference is seen (1/2 inch or 1.2 cm)

SCOLIOSIS

MEDICAL MANAGEMENT

- Patients with scoliosis should be referred to a spine deformity expert for management
- Use of scoliosis bracing
    - No clear documentation of efficacy. Bracing may be appropriate for a subset of growing children, i.e., consider for curves of 15–30°
    - No role for bracing after skeletal maturity
    - Low-yield for curves over 35–40°
    - Curves greater than 40° are likely to progress over time. Bracing is of little or no value in these cases. Consider use on an individual basis.

SURGICAL MANAGEMENT

- Surgery is an appropriate option for curves greater than 45°
- Growing rods are a successful option for curves greater than 50°–60° in patients who are under the age of 9
- For older children, between 9 years and skeletal maturity, surgery may be deferred until ~60° to allow further growth
- Prior to surgery, obtain MRI or CT to assess dural ectasia and pedicle thinning
- Prior to surgery, obtain cardiology clearance (within past 6 months)
- Surgery should include all major curves; selective fusion is less successful than in idiopathic scoliosis
- Be aware of increased risk for blood loss, cerebrospinal fluid leak, and failure of fixation
- Posterior approach is currently the preferred approach for most scoliosis surgery.

KYPHOSIS

MEDICAL MANAGEMENT

- Patients with excessive kyphosis should be referred to a spine deformity expert for management.
- Physical therapy/exercises are appropriate for mild cases. (Note: there is no clinical research in Marfan syndrome patients.)
- No evidence of efficacy of kyphosis bracing, but it is an option if under 70°.

SURGICAL MANAGEMENT

- Spinal fusion is an option for curves greater than 70° in the thoracic spine and significant deformity of the thoracolumbar region.

BACK PAIN

- Back pain is more common in Marfan syndrome than in the general population.
- Causes include scoliosis, disc abnormalities, dural ectasia, and spondylolisthesis.
  - Consider MRI to evaluate for dural ectasia, a common feature of Marfan syndrome.
- Refer to orthopedic surgeon or rehabilitation specialist.
- Treatment options do not differ significantly from general population.
- Note that dural ectasia may also be asymptomatic.

CHIROPRACTIC MANAGEMENT

- There are no specific guidelines on chiropractic care for people with Marfan syndrome, and The Marfan Foundation does not have an official stance on chiropractic care.
- Every case should be assessed individually.
- Conduct a patient history and physical exam to exclude cervical instability or any other manual therapy contraindication in a Marfan patient prior to treatment.
- The use of spinal joint mobilization (in contrast to high-velocity, low-amplitude manipulation) should be considered as a “test” intervention. If no adverse events are observed, the amplitude of joint manipulation may be increased as deemed necessary by the clinician.
- Chiropractic manipulation is not recommended for those with certain of related disorders of connective tissue, such as Loeys Dietz syndrome, if the patient has cervical instability.
- Chiropractic care remains a concern primarily with cervical manipulation and the risk of vertebral and carotid dissections. Chiropractors should discuss these concerns with their patients because the evidential data is not clear.

MARFAN FEET

- Problems include severe flat feet, foot pain, weakness of foot/ankle mechanics, significant calluses, bunions, and toe deformities.
- Orthotic/brace treatment does not change growth of foot or create higher arches.
- Orthotics may be useful if pain is present. Custom-made soft orthotics may be needed to assure the proper fit essential for effective treatment.
- Ankle weakness may respond to use of ankle-foot orthoses. Evaluate for proper type to use.
- Surgery is indicated only if foot deformities and pain do not respond to conservative treatment.
- There is no proven success using artificial ankles or toe joints in the management of Marfan feet.

PROTRUSIO ACETABULAE/ HIP PAIN

- Protrusion is common in Marfan patients, but most people with Marfan syndrome are not at risk for hip arthritis.
- Protrusio accelerates degeneration only if extreme (center-edge angle >50° before age 11)
- Consider triradiate epiphyseodesis only if this degree of protrusion is seen before age 11

PECTUS EXCAVATUM

- May displace heart to left and limit exercise tolerance
- Considered significant if depression exceeds 2.5 cm or if the ratio of chest width to sterno-vertebral distance (Haller index) exceeds 3.2
- Surgery may be done via open or minimally-invasive approaches
    - Open approach (Ravitch procedure) consists of detaching rib cartilages and osteotomizing sternum, elevating it over a bar
    - Minimally invasive approach (Nuss procedure) consists of elevating sternum with a curved bar attached to ribs on each side. Bar is left in place for 2–3 years to promote remodeling of chest wall
- Optimal time for pectus excavatum surgery is in the early teen years
- Nuss procedure may be combined with cardiac surgical procedure in carefully selected situations
- Pectus excavatum may be corrected after prior median sternotomy

PECTUS CARINATUM

- May cause symptoms from pressure or impact
- Some patients may benefit from treatment for self-image concerns/personal preference
- Brace treatment in juvenile age is investigational
- Surgical treatment for severe cases may be offered at or near skeletal maturity. It involves rib cartilage detachment and osteotomy.

REFERENCES:

Ahn NU, Ahn UM, Nallamshetty L, Rose PS, Buchowski JM, Garrett ES, Kebaish KM., Sponseller PD: The lumbar interpediculate distance is widened in adults with Marfan Syndrome. *Acta Orthop. Scand* 2001 72(6): 67–71.

Ahn NU, Sponseller PD, Ahn UM, Kusczyk B, Zinreich SJ, Nallamshetty LK. Dural ectasia is associated with back pain in the Marfan syndrome. *Spine* 2000 25(12): 1562–1569.

Ahn, NU, Sponseller PD, Kusczyk B, Ahn UM, Zinreich SJ, Fishman EK. Dural ectasia: MR and CT diagnosis and criteria. *Genetics in Medicine* 2000; 2(3):173–179.

DiSilvestre M, Greggi T: Surgical treatment for scoliosis in Marfan syndrome. *Spine* 2005 Oct 15;30 (20):E597–604.

Do T, Giampietro P, Raggio C: The incidence of protrusio acetabuli in Marfan's syndrome and its relationship to bone mineral density. *J Pediatr Orthop.* 2000; Nov-Dec. 20(6):718–21.

Erkula G, Jones KB, Sponseller PD, Dietz HC, Pyeritz RE. Growth and Maturation in Marfan syndrome. *Am J Med Genet.* 2002 Apr 22;109(2):100–15.

Erkula G, Sponseller PD, Paulsen LC, Oswald GL, Loeys BL, Dietz HC. Musculoskeletal findings of Loeys-Dietz syndrome. *J Bone Joint Surg Am.* 2010 Aug 4;92(9):1876–83.

Foran JRH, Pyeritz RE, Dietz HCIII, Sponseller PD: Characterization of the symptoms associated with dural ectasia in the Marfan patient. *Am J Med Genet A.* 2005 Apr 1;134(1):58–65.

Gjolaj JP, Sponseller PD, Shah SA, Newton PO, Flynn JM, Neubauer PR, Marks MC, Bastrom TP. Spinal deformity correction in Marfan syndrome versus adolescent idiopathic scoliosis: learning from the differences. *Spine* 2012 Aug 15;37(18):1558–65.

Haller JA Jr, Loughlin GM. Cardiorespiratory function is significanty improved following correction of severe pectus excavatum. Proposed treatment guidelines. *J Cardiovasc Surg* (Torino). 2000 Feb;41(1):125–30.

Herzka A, Sponseller PD, Pyeritz RE: Atlantoaxial Subluxation in Patients with the Marfan Syndrome. *Spine* 2000; 25(4): 524–526.

Hobbs, W., Sponseller, P.D., Weiss, A.P., Pyeritz, R.E: Cervical Spine Problems in Marfan Syndrome. Spine 22(9):983-989, 1997. *J Orthop Research* 2007; 25(3): 413–422.

Jones KB, Erkula G, Sponseller PD, Dormans JP: Spinal Deformity Correction in Marfan Syndrome. *Spine* 2002 27 (18):2003–2012

Jones KB, Myers L, Judge DP, Kirby PA, Dietz HC, Sponseller PD. Toward an understanding of dural ectasia: a light microscopy study in a murine model of Marfan syndrome. *Spine* 2005 Feb 1;30(3):291–3.

Jones KB, Sponseller PD, Erkula G, Sakai LY, Ramirez F, Dietz HC III, Kost-Byerly S, Bridwell KH, Sandell L: Symposium on the Musculoskeletal Aspects of Marfan Syndrome: Meeting Report and State of Science *J Orthop Res.* 2007 Mar;25(3):413–22.

Jones KB, Sponseller PD, Hobbs W, Pyeritz RE: Leg-length discrepancy and scoliosis in marfan syndrome. *J Pediatr Orthop.* 2002 Nov–Dec. 22(6):807–12.

Joseph KN, Bowen JR: Orthopedic aspects of the Marfan phenotype. *Clin Orthop Relat Res.* 1992 Apr (277):251–61.

Kelly RE Jr, Cash TF, Shamberger RC, Mitchell KK, Mellins RB, Lawson ML, Oldham K, Azizkhan RG, Hebra AV, Nuss D, Goretsky MJ, Sharp RJ, Holcomb GW 3rd, Shim WK, Megison SM, Moss RL, Fecteau AH, Colombani PM, Bagley T, Quinn A, Moskowitz AB. Surgical repair of pectus excavatum markedly iproves body image and perceived ability for physical activity. A multi-center study. *Pediatrics* 2008 Dec 122(6): 1218–22.

Kohlmeier L, Gasner C: Bone mineral status of women with Marfan syndrome. *Am J Med.* 1993 Dec 95(6):568–72.

LeParc JM: Bone mineral density in sixty adult patients with Marfan syndrome. *Osteoporos Int.* 1999 10(6):475–9.

Lipton GE, Guille J, Kumar SJ: , Surgical treatment of scoliosis in Marfan syndrome: guidelines for a successful outcome. *J Pediatr Orthop* 2002 May–Jun 22(3):302-7.

Loeys BL, Dietz HC, Braverman AC, Callewaert BL, De Backer J, Devereux RB, Hilhorst-Hofstee Y, Jondeau G, Faivre L, Milewicz DM, Pyeritz RE, Sponseller PD, Wordsworth P, De Paepe AM. *J Med Genet.* 2010 Jul;47(7):476–85.

Mesfin A, Ahn NU, Carrino JA, Sponseller PD. Ten-year clinical and imaging follow-up of dural ectasia in adults with Marfan syndrome. *Spine J.* 2013 Jan;13(1):62–7.

Nallamshetty L, Ahn NU, Ahn UM, Nallamshetty HS, Rose PS, Buchowski JM, Sponseller PD.Dural ectasia and back pain: review of the literature and case report. *J Spinal Disord Tech.* 2002 Aug 15(4):326-9.

Nuss D, Kelly RE Jr. Minimally-invasive correction of chest wall deformities. *Adv Pediatr.* 2008 55:395–410

Rose PS, Levy HP, Ahn NU, Sponseller PD, Magyri T, Davis J, Francomano CA: A comparison of the Berlin and Ghent Nosologies and the influence of dural ectasia in the diagnosis of Marfan Syndrome. *Genetics in Medicine* 2000 2(5): 278–28

Shirley ED, Sponseller PD. Marfan syndrome. *J Am Acad Orthop Surg.* 2009 Sep;17(9):572–81

Sponseller PD, Ahn, NU, Ahn UM, Kusczyk B, Fishman EK, Zinreich SJ. Osseous anatomy of the lumbosacral spine in Marfan syndrome. *Spine* 2000 25(21):2797–2802.

Sponseller PD, Bhimani M: Result of Brace Treatment for Scoliosis in Marfan Syndrome. *Spine* 2000; 25(18): 2350–2354.

Sponseller PD, Erkula G, Skolasky RL, Venuti KD, Dietz HC. Improving clinical recognition of Marfan syndrome. *J Bone Joint Surg Am.* 2010 Aug 4;92(9):1868–75.

Sponseller PD, Jones KB, Ahn NU, Erkula G, Dietz HC III: Protrusio Acetabuli in Marfan Syndrome: Age-Related Prevalence and Associated Hip Function. *J. Bone Joint Surg.* 2006; 88-A. p. 486-495.

Sponseller, P.D., Hobbs, W., Riley, L.H. III, Pyeritz, R.E.: Thoracolumbar Spine in Marfan Syndrome. *J. Bone Joint Surgery* 1995 77-A(6): 867–876.

Sponseller, P.D., Sethi, N., Pyeritz, R.E.: Infantile Scoliosis in Marfan Syndrome. *Spine* 1997 20(5):509–516.

Sponseller, P.D., Tomek, I., Pyeritz, R.E.: Developmental Dysplasia of the Hip in Marfan Syndrome. *J. Ped. Orthop* 1997 (B) 6(4):255–259.

Sponseller PD, Thompson GH, Akbarnia BA, Glait SA, Asher MA, Emans JB, Dietz HC. Growing rods for infantile scoliosis in Marfan syndrome. *Spine* 2009 Jul 15;34(16):1711–5.

Ting BL, Mathur D, Loeys BL, Dietz HC 3rd, Sponseller PD. The diagnostic value of the facial features of Marfan syndrome. *J Child Orthop.* 2010 Dec;4(6):545–51.

Thakkar SC, Foran JR, Mears SC, Sponseller PD. Protrusio acetabuli and total hip arthroplasty in patients with Marfan syndrome. *J Arthroplasty.* 2012 May;27(5):776–82.

Vande Velde S, Yandow S: Protrusio acetabuli in Marfan syndrome. History, diagnosis, and treatment. *J Bone Joint Surg Am* 2006 Mar;88(3):639–46. Review

Yang JS, Sponseller PD. Severe cervical kyphosis complicating halo traction in a patient with Marfan syndrome. *Spine* 2009 Jan 1;34(1):E66–9.