Adv Ther
https://doi.org/10.1007/s12325-024-02880-3

COMMENTARY

European Achondroplasia Forum Practical Considerations for Following Adults with Achondroplasia

Svein Fredwall · Moeenaldeen AlSayed · Tawfeg Ben-Omran · Silvio Boero · Valérie Cormier-Daire · Brigitte Fauroux · Encarna Guillén-Navarro · Florian Innig · Philip Kunkel · Christian Lampe · Mohamad Maghnie · Klaus Mohnike · Geert Mortier · Zagorka Pejin · Marco Sessa · Sérgio B. Sousa · Melita Irving

Received: March 22, 2024 / Accepted: April 19, 2024

ABSTRACT

Achondroplasia is a lifelong condition requiring lifelong management. There is consensus that infants and children with achondroplasia should be managed by a multidisciplinary team experienced in the condition. However, many people are lost to follow-up after the transition from paediatric to adult care, and there is no standardised approach for management in adults, despite the recent availability of international consensus guidelines. To address this, the European Achondroplasia Forum has developed a patient-held checklist to support adults with achondroplasia in managing their health. The checklist highlights key symptoms of spinal stenosis and obstructive sleep apnoea, both among the most frequent and potentially severe

Prior Presentation: An abstract based on this publication has been submitted to the International Skeletal Dysplasia Society meeting in Madrid, Spain 18–21 September 2024.

S. Fredwall (✉)
Sunnaas Rehabilitation Hospital, TRS National Resource Centre for Rare Disorders, Nesodden, Norway
e-mail: svfred@sunnaas.no

M. AlSayed
Department of Medical Genomics, King Faisal Specialist Hospital and Research Centre, Riyadh, Kingdom of Saudi Arabia
e-mail: moeen@kfshrc.edu.sa

M. AlSayed
Faculty of Medicine, Alfaisal University, Riyadh, Kingdom of Saudi Arabia

T. Ben-Omran
Division of Genetics and Genomic Medicine, Sidra Medicine and Hamad Medical Corporation, Doha, Qatar
e-mail: tawben11@hotmail.com

S. Boero
Istituto Giannina Gaslini, Genoa, Italy
e-mail: s.boero56@gmail.com

V. Cormier-Daire
Paris Descartes University, Paris, France
e-mail: valerie.cormier-daire@inserm.fr

B. Fauroux
Necker University Hospital and Paris Cité University, Paris, France
e-mail: brigitte.fauroux@aphp.fr

E. Guillén-Navarro
Medical Genetics Division and Pediatrics Department, Virgen de la Arrixaca University Hospital, IMIB-Pascual Parrilla, University of Murcia, Murcia, Spain
e-mail: guillen.encarna@gmail.com

E. Guillén-Navarro
CIBERER-ISCIII, Madrid, Spain

F. Innig
BKMF e.V., Leinestraße 2, 28199 Bremen, Germany
e-mail: florian.innig@bkmf.de

Published online: 15 May 2024

medical complications in adults with achondroplasia. The checklist acts as a framework to support individuals and their primary care provider in completing a routine review. General advice on issues such as blood pressure, pain, hearing, weight, adaptive aids, and psychosocial aspects are also included. The checklist provides key symptoms to be aware of, in addition to action points so that people can approach their primary care provider and be directed to the appropriate specialist, if needed. Additionally, the European Achondroplasia Forum offers some ideas on implementing the checklist during the transition from paediatric to adult care, thus ensuring the existing multidisciplinary team model in place during childhood can support in engaging individuals and empowering them to take responsibility for their own care as they move into adulthood.

Keywords: Achondroplasia; Adult; Assessment; Checklist; EAF; Follow-up; Sleep apnoea; Spinal stenosis; Transition

Key Summary Points

Achondroplasia is a lifelong condition requiring lifelong management.

Many people are lost to follow-up after the transition from paediatric to adult care, and there is no standardised approach for management in adults.

The European Achondroplasia Forum (EAF) (www.achondroplasiaforum.com) has developed a patient-held checklist to support adults with achondroplasia in managing their health.

The EAF checklist provides key symptoms to be aware of, including action points, and is intended to guide consultations and discussions and to support and empower people with achondroplasia to manage their own health.

The EAF propose that the checklist be delivered to young people with achondroplasia during the transition from paediatric to adult care.

P. Kunkel
University Medical Centre Mannheim, Mannheim, Germany
e-mail: philip.kunkel@umm.de

C. Lampe
Clinic of Child and Youth Medicine, University Hospital Mannheim, Mannheim, Germany
e-mail: christian.lampe@dolichol.de

M. Maghnie
Paediatric Endocrinology Unit, IRCCS Istituto Giannina Gaslini, 16147 Genoa, Italy
e-mail: MohamadMaghnie@gaslini.org

M. Maghnie
Department of Neuroscience, Rehabilitation, Ophthalmology, Genetics, Maternal and Child Health, University of Genoa, 16147 Genoa, Italy

K. Mohnike
Children's Hospital, Otto-von-Guericke-University, Magdeburg, Germany
e-mail: Klaus.Mohnike@med.ovgu.de

G. Mortier
Centre for Human Genetics, University Hospitals Leuven, Leuven, Belgium
e-mail: geert.mortier@uzleuven.be

Z. Pejin
Hôpital Necker, Paris, France
e-mail: zagorka.pejin@aphp.fr

M. Sessa
Italian Association on Achondroplasia, Milan, Italy
e-mail: msessa@aisac.it

S. B. Sousa
Medical Genetics Department, Hospital Pediátrico de Coimbra, Unidade Local de Saúde de Coimbra, Coimbra, Portugal
e-mail: sbsousa@ulscoimbra.min-saude.pt

S. B. Sousa
Clinical Academic Center of Coimbra, Hospital Pediátrico de Coimbra, Unidade Local de Saúde de Coimbra, Coimbra, Portugal

S. B. Sousa
University Clinic of Genetics, Faculty of Medicine, University of Coimbra, Coimbra, Portugal

S. B. Sousa
ERN-BOND, Bologna, Italy

M. Irving
Guy's and St Thomas' NHS Foundation Trust, London, UK
e-mail: Melita.Irving@gstt.nhs.uk

INTRODUCTION

Achondroplasia is a lifelong condition requiring lifelong management [1, 2]. In many countries, care is fairly well organised for infants and children with this condition, with international consensus recommendations emphasising the benefits of multidisciplinary management in expert centres [1–3]. Close monitoring during the first 2–3 years of life is critical [1–4]. Follow-up after transition from paediatric services can be more complicated, but remains essential, since adults with achondroplasia are at risk of medical complications impacting physical functioning and daily activities [5]. Until recently, understanding of complications of achondroplasia in adulthood has been relatively lacking, but data from natural history studies such as CLARITY, LIAISE, and The Norwegian Adult Achondroplasia study, as well as recently published review papers, have improved our understanding of the key issues affecting people with achondroplasia as they age [5–14].

Although some recommendations for care of adults with achondroplasia do exist [1–3], they are not as extensive and specific as those for children. Both the International Consensus Statement and The European Achondroplasia Forum (EAF) Guiding Principles acknowledge that the condition requires lifelong management by an experienced multidisciplinary team, with regular monitoring after transition to adult care—including counselling on genetics, pregnancy, and psychosocial well-being [1, 2].

However, an online survey conducted by the EAF identified that barriers to effective care in adults exist. These include that there is often no multidisciplinary service available for adults with achondroplasia, those services that do exist are not as experienced as their paediatric counterparts, and there could be a lack of interest or resistance from individuals with achondroplasia to seek ongoing care [15]. Often, people with achondroplasia are relatively healthy at the point of transition from paediatric to adult care; they may therefore feel there is no need to continue accessing regular medical care as a young adult [15]. Therefore, many people are lost to follow-up at the point of transitioning to adult services [15].

Transfer from paediatric to adult healthcare is a particularly vulnerable period for people with chronic conditions [16]. Many factors are associated with being lost to follow-up—some patient- or disease-related, others linked to the healthcare system [17]. In more common conditions, such as type 1 diabetes and inflammatory bowel disease, the experience is that the period of transition is challenging, and people are lost to follow-up [18–20]. Despite the importance of long-term care and monitoring, many people with a chronic condition fail to adhere to follow-up [17, 21, 22].

Taken together, the healthcare risks and lack of a standardised approach suggest there is a clear need for proactive adult care in achondroplasia. The key issue remains how to implement this.

FROM PAEDIATRIC MULTIDISCIPLINARY TEAM TO PRIMARY CARE SERVICES

The well-established paediatric multidisciplinary care model is not replicated for adults with achondroplasia, who often find themselves under the management of their primary care provider. This is also the case for many other chronic conditions being managed in primary care, with specialist referrals as needed. Relying on the partnership between the patient and their primary care provider requires that both

Consultation Guide

EAF
European Achondroplasia Forum

	ASSESSMENT	ACTION	REFERRAL
	Do you have any symptoms/signs relating to **SPINAL STENOSIS**? • Ongoing back pain in combination with pain or discomfort radiating into the buttocks or legs, worsened by prolonged walking or standing • Reduced sensation, tingling or numbness in arms or legs • Symptoms typically relieved by rest, lumbar flexion, or squatting • Reduced walking distance/ increased need for walking aids • Bladder and/or bowel dysfunction	• Neurological assessment • Referral to MRI of the total spine (spinal stenosis can occur at multiple spine levels)	**TO:** Neurologist (experienced in achondroplasia) Spine centre/specialist experienced in achondroplasia **IF:** Ongoing back pain in combination with neurological symptoms **WHEN:** As soon as possible to avoid spinal cord injury
	Do you have any symptoms/signs relating to obstructive **SLEEP APNOEA**? • Excessive daytime sleepiness • Not feeling rested after sleep • Loud, disruptive snoring • Breathing stops, choking, or gasping during sleep (observed) • Hypertension	• Overnight sleep study (ambulant or polysomnography)	**TO:** Respiratory/sleep specialist (experienced in achondroplasia) **IF:** Excessive daytime sleepiness in combination with at least one of the other symptoms/signs **WHEN:** As soon as possible
	**BLOOD PRESSURE MONITORING**	• Treatment as for the general population	
	**SYMPTOMS OF HEARING LOSS**	• Referral for a formal hearing assessment if hearing loss is suspected	**TO:** ENT specialist
	**WEIGHT MANAGEMENT**	• Discuss the importance of an active and healthy lifestyle to prevent excessive weight gain • Advice as for the general population	
	**PAIN**	• If symptoms of pain, perform a formal pain assessment	
	**NEED FOR ADAPTATIONS/AIDS**	• Referral if needs identified	**TO:** Occupational therapist
	**GENETIC NATURE OF ACH**	• Discuss heritability and pregnancy (if needed) • Referral if needed	**TO:** Clinical geneticist or genetic counsellor
	**PSYCHOSOCIAL HEALTH**	• Evaluate psychosocial health. Refer if indicated	**TO:** Psychologist or psychosocial health worker

This checklist has been developed by the EAF as a working template. ENT, ear, nose, and throat; MRI, magnetic resonance imaging.

◂**Fig. 1** The EAF patient-held checklist

parties are well educated and informed about achondroplasia, including the range of potential complications through the lifespan, and that they have a directory of specialists available should red-flag symptoms arise. With over 7000 rare disorders identified, it is impossible for every primary care provider to be an expert across even a small fraction. It is estimated that the average primary care provider sees only one case of an individual rare disease in their career [23]. Naturally, it is not realistic to expect the primary care provider to be up to date on international guidelines and recommendations on rare conditions [23]. There is a need for a mechanism to disseminate core information to those in primary care who encounter an individual with a rare condition, and often the individuals themselves are the best people to do this. Some people with achondroplasia are experts on their condition by experience, but at the other end of the spectrum some may struggle with the confidence and health literacy to access the healthcare they need as adults.

PATIENT-HELD CHECKLIST

Adults with achondroplasia may not need routine clinic appointments when they are well, but individuals must be clear on red flag symptoms of potentially severe complications of the condition and on what steps to take should these symptoms present. The idea of a standardised, patient-held checklist empowers individuals to take control of their own healthcare requirements. Patient-held tools have been shown to increase adherence to guideline-based care [24], to facilitate communication [25], and to assist in enhancing handover and patient-centred practices for people with chronic conditions such as cardiovascular disease, chronic respiratory disease, diabetes [26], and cancer [27].

To test the idea of a patient-held checklist in achondroplasia, the EAF developed a checklist that was presented and discussed during a workshop held in Frankfurt, Germany, in April 2023. The meeting was attended by 112 healthcare professionals, patient advocacy representatives, and individuals with achondroplasia from 19 countries.

The checklist is intended to raise awareness of red flag symptoms of potentially severe complications and to provide a framework for discussion during a routine appointment in the primary care setting. This document has been drafted by the EAF based on the most up-to-date guidelines and natural history information. This article is based on previously conducted studies and does not contain any new studies with human participants or animals performed by any of the authors.

The first two sections of the checklist are structured around two key complications: symptomatic spinal stenosis and obstructive sleep apnoea, both among the most frequent and potentially severe complications in adults with achondroplasia (Box 1 and Box 2). For each, a number of symptoms are detailed, with a suggested course of immediate action for both the patient and primary care provider (Fig. 1). By providing information on key symptoms, people with achondroplasia can be aware of when there is a need to see a healthcare professional.

Box 1. Symptomatic spinal stenosis

In achondroplasia, a congenital narrow spinal canal, in addition to degenerative changes progressing by age, results in a high lifetime risk of developing symptomatic spinal stenosis.[5,28,29] While symptomatic spinal stenosis affects around 10–20% of children with achondroplasia, the prevalence increases up to 60–70% in adults.[5,29–32]

Symptomatic spinal stenosis is a potentially severe complication for people with achondroplasia, causing not only neurological symptoms and pain but also impacting physical functioning and ability to perform daily activities. In some cases, it may result in partial or complete leg paralysis or even paraplegia.[5,33]

First symptom onset shows a great variability from early childhood to late adulthood, but the majority of people will develop symptoms in their mid-30s and early 40s.[5]

Characteristic symptoms include:[34–37]

- Back pain – which may radiate into the buttocks or legs – exacerbated by prolonged walking, standing, or lumbar extension
- Decreased walking distance
- Symptoms are typically relieved by squatting or rest
- Bladder and bowel symptoms, such as urinary urgency

Since the entire spinal canal is narrow, it is important to understand that the location of stenosis in people with achondroplasia can occur at any level of the spinal canal, although the upper lumbar region is most commonly affected.[5] Magnetic resonance imaging (MRI) of the spine should therefore always include the total spine when spine surgery is considered.[2,29]

Progressive symptoms of spinal stenosis are in most cases a good indication for decompression surgery, and there is evidence to support that an early surgery is beneficial.[38] In the majority of milder cases a microsurgical posterior decompression of one or two upper lumbar or thoraco-lumbar segments in a stability preserving fashion is sufficient and safe. However, the reported complication rate of spinal surgery is much higher in achondroplasia than in the general population.[39,40] This is most likely attributable to more extensive surgeries needed in cases where the spinal stenosis is combined with thoraco-lumbar kyphosis and where decompression of a posterior spinal fusion is also necessary. In patients with thoracic levels affected by symptomatic canal stenosis, it is of utmost importance to undertake timely decompressive surgery for the therapeutic window. This can preserve neurological function in cases where spinal cord compression is much less than in lumbar segments in which only spinal nerves are affected. Spinal surgery in people with achondroplasia should therefore be undertaken only by a surgical team with extensive experience in the condition.

Box 2. Obstructive sleep apnoea

Obstructive sleep apnoea is also highly prevalent in achondroplasia and may affect around 50–60% of adults with this condition.[7,13] If left untreated, obstructive sleep apnoea may have severe consequences, including hypertension, cardiovascular disease, metabolic disorders, stroke, and an increased risk of traffic or workplace accidents.[41,42]

Obstructive sleep apnoea should be considered in the presence of:[7,43,44]

- Excessive daytime sleepiness in combination with other symptoms such as
  - Loud snoring
  - Unrested sleep
  - Breaks in nocturnal breathing with associated choking or gasping
  - Hypertension

In adults presenting with symptoms suggestive of sleep apnoea, an overnight sleep study (full polysomnography or, if possible, home sleep study) should be performed.[2]

Treatment with a Continuous Positive Airway Pressure (CPAP) mask is considered first-line treatment for obstructive sleep apnoea in adults with achondroplasia.[45] In some cases, weight loss might help improve apnoea symptoms. Comprehensive orthodontic and maxillofacial surgery evaluation, if not done before, should be performed.

The checklist also includes information for routine follow-up in primary care on achondroplasia-specific considerations for blood pressure, pain, hearing, weight, discussing the need for aids and adaptations, as well as psychosocial aspects of care [2].

Blood Pressure

Hypertension appears to be more common in adults with achondroplasia and has been reported in approximately 50% of men and 35% of women compared to 22% in the general population [8, 46]. It is therefore essential to check blood pressure regularly, as untreated hypertension can lead to cardiovascular disease and increased mortality. Blood pressure measurement should be undertaken using a cuff that fits appropriately; measurement on the forearm is an option if elbow contractures or rhizomelia prevent measurement at the upper arm [2, 46].

Hearing Loss

Ear infections and hearing loss are common in children with achondroplasia, but recent evidence suggests the risks extend into adulthood [9]. Hearing loss affects around one in five people in the general population and has been ranked as the third largest cause of disability worldwide [47]. In a population-based study on adults with achondroplasia, 43% of people aged 16–44 had mild loss

in at least one ear, with no real difference between men and women [9]. This more than doubled prevalence emphasises the need for regular hearing assessments, even in younger patients.

Lifestyle and Weight

Many adults with achondroplasia find it difficult to prevent weight gain [6, 48, 49]. Although the risk of developing type 2 diabetes or metabolic complications does not seem to be increased in achondroplasia, obesity predisposes to sleep apnoea and hypertension, may worsen leg and back pain and spinal stenosis, and may cause reduced mobility and physical functioning [2, 5, 10, 29]. As for the general population, it is important to maintain a healthy diet and regular physical activity [6, 8, 46, 48, 50]. However, there is minimal evidence to guide nutritional management in this population, including how to classify obesity [51].

Pain and Function

Pain becomes more prevalent into adulthood [14]. In several studies, approximately 65–70% of adults with achondroplasia reported chronic pain [5, 14, 33, 52]. Pain can impact mood, self-care, education, employment, and leisure activities, and as such it is recommended that it is examined and monitored using patient-reported outcome scales such as the Brief Pain Inventory [2, 5, 33, 52, 53]. It is particularly important to identify pain related to early symptoms of spinal stenosis [2, 5]. The need for adaptations or aids to support everyday activities may change throughout the lifespan and should be discussed at every medical check-up [2]. This includes specific requirements or modifications at home, school, work, or in the community to promote independence and participation and ease everyday activities. For many people with short stature, a car is crucial to maintain independence.

Genetic Aspects

Achondroplasia is a genetic condition, caused by pathogenic missense variants in the gene coding for the fibroblast growth factor receptor 3 (*FGFR3*) [2]. The condition is transmitted in an autosomal dominant manner [2]. When one parent has achondroplasia, there is a 50% probability of each child receiving the *FGFR3* variant and therefore having achondroplasia [2]. If both parents are affected, the probability for "classic" achondroplasia (heterozygous carrier) in each child is 50% and the probability for severe (perinatally lethal) achondroplasia (homozygous carrier) is 25%; there is still a 25% chance of having an unaffected child [2]. Many adults with achondroplasia seek information to understand their available reproductive options and possibilities for preimplantation and/or prenatal diagnosis. As noted in the recommendations, several different agencies can provide this support, but they differ from country to country [2]. Including this item in the routine follow-up checklist should help people to identify the most appropriate source of support in their location, to access prenatal advice and counselling.

Psychosocial Health

Achondroplasia presents psychosocial challenges across the lifespan [2]. Several studies demonstrate that adults with achondroplasia tend to have lower quality of life than the general population for both physical and mental domains [2, 33, 52–55]. Appropriate support, including through patient advocacy groups, should be made available and provided in a culturally sensitive way [2].

Each country or region should have well identified centres of expertise with experience in dealing with the above-mentioned complications, in particular spinal stenosis.

IMPLEMENTATION OF PATIENT-HELD CHECKLIST IN CLINICAL PRACTICE

When considering whether a patient-held checklist could work in practice, a key advantage of this model is that there is no need for a fixed multidisciplinary team—only one lead healthcare

provider in primary care, who is responsible for appropriate referrals to specialists with expertise in achondroplasia. This model is a good starting point and should be feasible to implement across different countries and healthcare systems. The checklist will support a systematic and structured way of monitoring people with achondroplasia without stigma or unnecessary medical burden. It is intended to guide consultations and discussions and to support and empower people to manage their own health. Primary care providers can ask for symptoms of spinal stenosis and sleep apnoea, including performing a formal pain assessment, to identify early symptoms or signs and initiate appropriate action and referrals as indicated in the checklist. Local healthcare providers are also well positioned to manage blood pressure, hearing issues and weight, and for these issues people with achondroplasia can be treated as for the general population.

Generally, there is no consensus on the need for a regular assessment in adults with achondroplasia. Some argue for starting routine assessments at a particular age, with more frequent annual or biannual assessments as people get older. Others believe healthcare should be on demand and accessed only as and when an individual has a concern, as for people in the general population. One thing that is clear is that any assessment model or checklist implementation should be on an opt-in basis rather than something perceived as mandatory. As in any condition or population of people, there is a spectrum of behaviour, beliefs, and desires. In this regard, patient choice will be important.

PROCESS FOR TRANSITION FROM PAEDIATRIC TO ADULT CARE

The existing paediatric care model is based on the different complications that may occur in children with achondroplasia, with dedicated multidisciplinary clinics set up around key affected systems and supported by specialists in areas such as neurosurgery, orthopaedic and spine surgery, ear, nose, and throat (ENT) and sleep-disordered breathing, physical functioning and daily activities, and psychosocial well-being. Transition out of paediatric care should therefore prepare young people for the adult setting, where the multidisciplinary team might not exist and the primary care physician provides the management and follow-up. This is the case in other chronic conditions. For example, in the UK, transfer from paediatric to adult care in patients with diabetes takes place at 17–18 years of age, but the preparation for transition begins from the age of 14 years, with increasingly autonomous care more focused on the individual than the family [56]. Similarly, in paediatric inflammatory bowel disease, there is an iterative process that starts at the age of 11 years, with regular health maintenance visits every 1–2 years that prepares children for the transition to adult gastroenterology [20]. Other suggested models include a handover clinic with a one-off direct transfer, parallel adult and paediatric clinics that allow for communication between physicians, or transition clinics where adolescent patients are seen by both teams [57]. Ultimately, a good transition should result in a handover of power from parents to the individual, with increasing levels of engagement and delegation that support them to own and manage their condition in early adulthood. In achondroplasia, transition should happen in mid to late childhood, with specific considerations and emphasis placed on spinal stenosis and sleep-disordered breathing, as well as pain management, weight, and mental health. There may be a place for some baseline investigations at the point of transition, including MRI of the spine and a sleep study, which can both be used for comparison in later years, if needed. This approach has been trialled in clinics in the US, where it has proven useful to support clinical decision-making for people who are lost to follow-up after paediatric care but present many years later with a symptom.

DISCUSSION

Achondroplasia is a lifelong condition with associated lifelong medical complications that can have significant impact on physical functioning, daily activities, pain, and psychosocial health. Adults with achondroplasia have been found to have lower physical and psychosocial health

than people without, alongside higher rates of anxiety, depression, and low self-esteem [5, 12, 54, 55]. This demonstrates the need for lifelong care [1, 2], but how that care is delivered is vital. Achondroplasia does not necessarily require regular, routine check-ups if people are feeling well. However, empowering people with achondroplasia to understand their condition and recognise key symptoms and red flags can help to direct resources and ensure timely referrals to specialists. International consensus guidelines already exist [2], but a need remains to implement these in clinical practice. It has previously been suggested that the unique characteristics of people with a rare condition demand evolution beyond the multidisciplinary model to a more nuanced one of networked care, based on the experience and expertise of the relevant community [23].

Alongside development of the EAF checklist, we have made some suggestions for how to move people from paediatric to adult care to help avoid the common pitfall of being lost to follow-up, a common occurrence for people with chronic conditions in this period of their life [16, 18, 19]. This will become a key consideration in supporting people with achondroplasia to optimise their health and make the most of the healthcare support available, should they need or desire it. Transition could also represent the optimal moment at which to deliver the proposed checklist—when individuals are learning to engage with their condition and taking more responsibility from their parents and carers about how to manage it.

The checklist is available on the EAF website (achondroplasiaforum.com). Where appropriate, the checklist could be made available on an app, both making it accessible to younger people and enabling easy updates to account for evolving data, literature, and recommendations. However, a key point to consider in planning for transition from paediatric services is that adolescence and early adulthood is the point in the lifespan when people have the fewest achondroplasia complications [12] and therefore feel comparatively well. With this in mind, any initiative to implement follow-up for adults with achondroplasia needs to be meaningful; otherwise, it will be susceptible to the poor adherence seen in other chronic conditions.

CONCLUSION

The EAF advocates the development of a patient-held checklist to support adult follow-up through the lifespan. The checklist should be delivered to young people with achondroplasia during the transition from paediatric to adult care as part of an endeavour to empower them to understand their condition, recognise key symptoms and red flags, and direct resources and ensure timely referrals to specialists. Each country or region should have well-identified centres of expertise with experience in dealing with the mentioned complications, in particular spinal stenosis. It is important to communicate the benefits of proactive management of any symptoms that may arise and that individuals are confident about working with their primary care provider for their ongoing health and well-being into adulthood.

Medical Writing/Editorial Assistance. Medical writing assistance in the preparation of this manuscript was provided by CESAS Medical Ltd and was funded by unrestricted educational grants from BioMarin, Sanofi, Ascendis Pharma, and QED Therapeutics.

Author Contributions. Svein Fredwall conceptualised and developed the checklist, gave a presentation at a meeting of the European Achondroplasia Forum, on 22 April 2023, developed the first draft, read and provided comments on all drafts of the manuscript. Moenaldeen AlSayed, Tawfeg Ben-Omran, Silvio Boero, Valérie Cormier-Daire, Brigitte Fauroux, Encarna Guillén-Navarro, Christian Lampe, Mohamad Maghnie, Klaus Mohnike, Geert Mortier, Zagorka Pejin, Marco Sessa, and Sérgio B. Sousa read and provided comments on the first draft manuscript. Florian Innig, Philip Kunkel, and Melita Irving developed the checklist, gave a presentation at a meeting of the European Achondroplasia Forum, on 22 April 2023, read and provided comments on the first draft manuscript. All authors read and approved the final manuscript.

Funding. The EAF workshop was funded by unrestricted educational grants from BioMarin,

Sanofi, Ascendis Pharma and QED Therapeutics. The journal's Rapid Service and Open Access Fee was funded by unrestricted educational grants from BioMarin, Sanofi, Ascendis Pharma and QED Therapeutics.

Declarations

Conflict of Interest. Svein Fredwall, Moenaldeen AlSayed, Tawfeg Ben Omran, Brigitte Fauroux and Christian Lampe have nothing to disclose. Silvio Boero has received payment or honoraria, support for attending meetings and/or travel from BioMarin. Valerie Cormier-Daire has received payment or honoraria, support for attending meetings and/or travel from BioMarin. Sérgio B Sousa has received payment or honoraria, support for attending meetings and/or travel and has participated in Advisory Boards for BioMarin. Encarna Guillen-Navarro has received payment or honoraria, support for attending meetings and/or travel from BioMarin. Florian Innig has received grants or contracts paid to BKMF e.V from BioMarin. Melita Irving has received grants or contracts and consulting fees from BioMarin, QED/Bridge Bio, Ascendis, Sanofi, Tyra, NovoNordisk; and payment or honoraria from BioMarin; and has participated in Advisory Boards for BioMarin and QED/BridgeBio. Philip Kunkel has received payment or honoraria, support for attending meetings and/or travel from BioMarin. Mohamad Maghnie has received consulting fees, payment or honoraria, support for attending meetings and/or travel and has participated in Advisory Boards for BioMarin. Klaus Mohnike has received consulting fees from BioMarin and NovoNordisk, payment or honoraria from Kyowa-Kirin, support for attending meetings and/or travel from BioMarin, has participated in Advisory Boards for QED and is Vice-Chair of BKMJ. Geert Mortier has received payment or honoraria and support for attending meetings and/or travel from BioMarin, and has participated in Advisory Boards for Sanofi. Zagorka Pejin has received consulting fees and payment or honoraria from Orthofix Italy and Newclip France; support for attending meetings and/or travel from Orthofix Italy, and patents planned, issued or pending with Orthofix Italy. Marco Sessa has received grants or contracts paid to AISAC OdV from BioMarin and QED.

Ethical Approval. This article is based on previously conducted studies and does not contain any new studies with human participants or animals performed by any of the authors.

REFERENCES

1. Cormier-Daire V, AlSayed M, Ben-Omran T, et al. The first European consensus on principles of management for achondroplasia. Orphanet J Rare Dis. 2021;16(1):333.

2. Savarirayan R, Ireland P, Irving M, et al. International Consensus Statement on the diagnosis, multidisciplinary management and lifelong care of individuals with achondroplasia. Nat Rev Endocrinol. 2022;18(3):173–89.

3. Hoover-Fong J, Scott CI, Jones MC. Health supervision for people with achondroplasia. Pediatrics. 2020;145: e20201010.

4. Irving M, AlSayed M, Arundel P, et al. European Achondroplasia Forum guiding principles for the detection and management of foramen magnum stenosis. Orphanet J Rare Dis. 2023;18:219.

5. Fredwall S, Steen U, de Vries O, et al. High prevalence of symptomatic spinal stenosis in Norwegian adults with achondroplasia: a population-based study. Orphanet J Rare Dis. 2020;15(1):123.

6. Madsen A, Fredwall SO, Maanum G, Henriksen C, Slettahjell HB. Anthropometrics, diet, and resting energy expenditure in Norwegian adults with achondroplasia. Am J Med Genet A. 2019;179(9):1745–55.

7. Fredwall SO, Øverland B, Berdal H, et al. Obstructive sleep apnoea in Norwegian adults with achondroplasia: a population-based study. Orphanet J Rare Dis. 2021;16(1):156.

8. Fredwall SO, Linge J, Dahlqvist Leinhard O, et al. Cardiovascular risk factors and body composition in adults with achondroplasia. Genet Med. 2021;23(4):732–9.

9. Fredwall SO, Åberg B, Berdal H, Savarirayan R, Solheim J. Hearing loss in Norwegian adults with achondroplasia. Orphanet J Rare Dis. 2021;16(1):468.

10. de Vries OM, Johansen H, Fredwall SO. Physical fitness and activity level in Norwegian adults with achondroplasia. Am J Med Genet A. 2021;185(4):1023–32.

11. Hoover-Fong JE, Alade AY, Hashmi SS, et al. Achondroplasia Natural History Study (CLARITY): a multicenter retrospective cohort study of achondroplasia in the United States. Genet Med. 2021;23(8):1498–505.

12. Maghnie M, Semler O, Guillen-Navarro E, et al. Lifetime impact of achondroplasia study in Europe (LIAISE): findings from a multinational observational study. Orphanet J Rare Dis. 2023;18(1):56.

13. Okenfuss E, Moghaddam B, Avins AL. Natural history of achondroplasia: A retrospective review of longitudinal clinical data. Am J Med Genet A. 2020;182(11):2540–51.

14. Stender M, Pimenta JM, Cheung M, Irving M, Swati MS. Comprehensive literature review on the prevalence of comorbid conditions in patients with achondroplasia. Bone. 2022;162: 116472.

15. Fredwall S, Allum Y, AlSayed M, et al. Optimising care and follow-up of adults with achondroplasia. Orphanet J Rare Dis. 2022;17(1):318.

16. Skogby S, Bratt E-L, Johansson B, Moons P, Eva GE. Discontinuation of follow-up care for young people with complex chronic conditions: conceptual definitions and operational components. BMC Health Serv Res. 2021;21(1):1343.

17. Tong CYM, Koh RYV, Lee ES. A scoping review on the factors associated with the lost to follow-up (LTFU) amongst patients with chronic disease in ambulatory care of high-income countries (HIC). BMC Health Serv Res. 2023;23(1):883.

18. Bowen ME, Henske JA, Potter A. Health care transition in adolescents and young adults with diabetes. Clin Diab. 2010;28(3):99–106.

19. Gleeson H, Davis J, Jones J, O'Shea E, Clayton PE. The challenge of delivering endocrine care and successful transition to adult services in adolescents with congenital adrenal hyperplasia: experience in a single centre over 18 years. Clin Endocrinol. 2013;78(1):23–8.

20. Fu N, Bollegala N, Jacobsen K, et al. Canadian consensus statements on the transition of adolescents and young adults with inflammatory bowel disease from pediatric to adult care: a collaborative initiative between the Canadian IBD Transition Network and Crohn's and Colitis Canada. JCAG. 2022;5:105–15.

21. Tien Y-C, Chiu Y-M, Liu M-P. Frequency of lost to follow-up and associated factors for patients with rheumatic diseases. PLoS ONE. 2016;11(3): e0150816.

22. Davis A, Baldwin A, Hingorani M, Dwyer A, Flanagan D. A review of 145 234 ophthalmic patient episodes lost to follow-up. Eye (London). 2017;31(3):422–9.

23. Bolz-Johnson M, Kenny T, Le Cam Y, Hernando I. Our greatest untapped resource: our patients. J Community Genet. 2021;12(2):241–6.

24. McCarthy S, Fitzgerald C, Sahm L, Bradley C, Walsh EK. Patient-held health IT adoption across the primary-secondary care interface: a Normalisation Process Theory perspective. Health Syst (Basingstoke). 2022;11(1):17–29.

25. Licqurish SM, Cook OY, Pattuwage LP, et al. Tools to facilitate communication during physician-patient consultations in cancer care: an overview of systematic reviews. CA Cancer J Clin. 2019;69(6):497–520.

26. Humphries C, Jaganathan S, Panniyammakal J, et al. Patient and healthcare provider knowledge, attitudes and barriers to handover and healthcare communication during chronic disease inpatient care in India: a qualitative exploratory study. BMJ Open. 2019;9(11): e028199.

27. Horowitz ME, Fordis M, Krause S, et al. Passport for care: implementing the survivorship care Plan. J Oncol Pract. 2009;5:110–2.

28. Huet T, Cohen-Solal M, Laredo J-D, et al. Lumbar spinal stenosis and disc alterations affect the upper lumbar spine in adults with achondroplasia. Sci Rep. 2020;10(1):4699.

29. Cheung MS, Mohnike K. Meeting report from 2nd ICCBH-ERN BOND Spinal Complications in Children and Adults with Achondroplasia Workshop, Dublin, Ireland, 2nd July 2022. Bone. 2022;165: 116574.

30. Cheung MS, Alves I, Hagenas L, et al. Meeting report from the achondroplasia foramen magnum workshop, Salzburg, Austria 22nd June 2019. Bone. 2019;127:499–502.

31. Hunter AG, Bankier A, Rogers JG, et al. Medical complications of achondroplasia: a multicentre patient review. J Med Genet. 1998;35(9):705–12.

32. Fredwall S, Maanum G, Johansen H, et al. Current knowledge of medical complications in adults with achondroplasia: a scoping review. Clin Genet. 2020;97(1):179–97.

33. Alade Y, Tunkel D, Schulze K, et al. Cross-sectional assessment of pain and physical function in skeletal dysplasia patients. Clin Genet. 2013;84(3):237–43.

34. Schkrohowsky JG, Hoernschemeyer DG, Carson BS, Ain MC. Early presentation of spinal stenosis in achondroplasia. J Pediatr Orthop. 2007;27(2):119–22.

35. Pauli RM. Achondroplasia: a comprehensive clinical review. Orphanet J Rare Dis. 2019;14(1):1.

36. Kreiner DS, Shaffer WO, Baisden JL, et al. An evidence-based clinical guideline for the diagnosis and treatment of degenerative lumbar spinal stenosis (update). Spine J. 2013;13(7):734–43.

37. Suri P, Rainville J, Kalichman L, Katz JN. Does this older adult with lower extremity pain have the clinical syndrome of lumbar spinal stenosis? JAMA. 2010;304(23):2628–36.

38. Carlisle ES, Ting BL, Abdullah MA, Skolasky RL, Schkrohowsky JG, Yost MT, et al. Laminectomy in patients with achondroplasia: the impact of time to surgery on long-term function. Spine (Phila Pa 1976). 2011;36(11):886–92.

39. Shafi K, Lovecchio F, Sava M, et al. Complications and revisions after spine surgery in patients with skeletal dysplasia: have we improved? Global Spine J. 2021;13(2):268–75.

40. Wang H, Wang S, Wu N, Wang S, Qiu G, Zhang J. Posterior vertebral column resection (pVCR) for severe thoracolumbar kyphosis in patients with achondroplasia. Glob Spine J. 2021;12(8):1804–13.

41. Lindberg E, Benediktsdottir B, Franklin KA, et al. Women with symptoms of sleep-disordered breathing are less likely to be diagnosed and treated for sleep apnea than men. Sleep Med. 2017;35:17–22.

42. Phillips CL, O'Driscoll DM. Hypertension and obstructive sleep apnea. Nat Sci Sleep. 2013;5:43–52.

43. Myers KA, Mrkobrada M, Simel DL. Does this patient have obstructive sleep apnea? The rational clinical examination systematic review. JAMA. 2013;310(7):731–41.

44. Young T, Skatrud J, Peppard PE. Risk factors for obstructive sleep apnea in adults. JAMA. 2004;291(16):2013–6.

45. Savarirayan R, Tunkel DE, Sterni LM, Bober MB, Cho T-J, Goldberg MJ, et al. Best practice guidelines in managing the craniofacial aspects of skeletal dysplasia. Orphanet J Rare Dis. 2021;16(1):31.

46. Hoover-Fong J, Alade AY, Ain M, et al. Blood pressure in adults with short stature skeletal dysplasias. Am J Med Genet A. 2020;182(1):150–61.

47. GBD 2019 Hearing Loss Collaborators. Hearing loss prevalence and years lived with disability 1990–2019: findings from the Global Burden of Disease Study 2019. Lancet. 2021;397(10278):996–1009.

48. Saint-Laurent C, Garde-Etayo L, Gouze E. Obesity in achondroplasia patients: from evidence to medical monitoring. Orphanet J Rare Dis. 2019;14(1):253.

49. Schulze KJ, Alade YA, McGready J, Hoover-Fong JE. Body mass index (BMI): the case for condition-specific cut-offs for overweight and obesity in skeletal dysplasias. Am J Med Genet A. 2013;161A(8):2110–2.

50. Cornier MA, Després J-P, Davis N, et al. Assessing adiposity: a scientific statement from the American Heart Association. Circulation. 2011;124(18):1996–2019.

51. Billich N, O'Brien K, Fredwall SO, Lee M, Savarirayan R, Davidson ZE. A scoping review of nutrition issues and management strategies in individuals with skeletal dysplasia. Genet Med. 2023;25(10): 100920.

52. Dhiman N, Albaghdadi A, Zogg CK, et al. Factors associated with health-related quality of life (HRQOL) in adults with short stature skeletal dysplasias. Qual Life Res. 2017;26(5):1337–48.

53. Shakespeare T, Thompson S, Wright M. No laughing matter: medical and social experiences of restricted growth. Scand J Disabil Res. 2010;12:19–31.

54. Jennings SE, Ditro CP, Bober MB, et al. Prevalence of mental health conditions and pain in adults with skeletal dysplasia. Qual Life Res. 2019;28(6):1457–64.

55. Yonko EA, Emanuel JS, Carter EM, Raggio CL. Quality of life in adults with achondroplasia in the United States. Am J Med Genet A. 2021;185(3):695–701.

56. Butalia S, McGuire KA, Dyjur D, Mercer J, Pacaud D. Youth with diabetes and their parents' perspectives on transition care from pediatric to adult diabetes care services: a qualitative study. Health Sci Rep. 2020;3(3): e181.

57. Greveson K, Morgan N, Furman M, Murray C. Attitudes and experiences of adolescents in an innovative IBD transition service. Gastrointest Nurs. 2013;9(1):35–40. https://doi.org/10.12968/gasn.2011.9.1.35.