The clinical outcomes of a hybrid-virtual infant hip clinic for the nonoperative treatment of developmental dysplasia of the hip

a quality improvement study

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Aims

Nonoperative treatment for developmental dysplasia of the hip (DDH) typically involves numerous in-person clinic visits, which can place a significant burden on healthcare services and patients' families. We therefore aimed to establish and validate a pilot hybrid-virtual clinic to evaluate the clinical outcomes with the delivery of a comprehensive nonoperative treatment protocol for infant DDH to streamline care and minimize in-person visits.

Methods

This was a prospective, single-centre, quality improvement (QI) study of infants with DDH who underwent a comprehensive nonoperative treatment protocol in a unified multidisciplinary infant hip clinic from December 2022 to October 2023. Practice changes were made to our published nonoperative treatment protocol, where specific in-person follow-up visits were replaced with virtual appointments, and a dedicated institutional infant hip clinic email was created for caregiver inquiries.

Results

Of all interim follow-up visits, 53% (77/144) occurred virtually; 94% (48/51) of infants successfully completed brace treatment. No failures of treatment occurred during the virtual follow-up period. In total, 8% (4/51) of infants experienced brace-related complications, including only one during the virtual phase; 10% (5/51) of infants made unplanned visits to the hip clinic, including two infants who attended for brace check and adjustments during the virtual phase. One unplanned ultrasound examination occurred during the virtual phase upon request of a caregiver, which did not alter the course of treatment. No infants required bracing for an extended time due to virtual visits. Overall, 92% (47/51) of caregivers reported awareness of the hip clinic email and 33% (17/51) used this resource. No urgent inquiries were received during the virtual phase.

Conclusion

Our hybrid-virtual infant hip clinic has shown comparable outcomes to the historic norms of our in-person infant hip clinic. This model of care can improve the efficiency of standardized DDH treatment protocols while maintaining excellent clinical outcomes.

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Take home message

- We aimed to use quality improvement (QI) methodology to establish and validate a pilot hybrid-virtual clinic to evaluate the clinical outcomes with the delivery of a comprehensive nonoperative treatment protocol for infant developmental dysplasia of the hip (DDH).
- Our hybrid-virtual infant hip clinic has shown comparable outcomes to the published historic norms of our in-person infant hip clinic, demonstrating equivalency in treatment success.
- Virtual care models such as ours can improve the efficiency of standardized DDH treatment protocols, maintain excellent clinical outcomes, and increase equitable access to care.

Introduction

Developmental dysplasia of the hip (DDH) is one of the most common musculoskeletal conditions affecting newborn infants worldwide. Nonoperative treatment with a brace is the most used first-line treatment for infant DDH and has been proven to be very effective.[1] The treatment protocol implemented at our institution conforms to published consensus principles and has demonstrated an overall success rate of 95%.[2] Similar to many traditional approaches to DDH management, our treatment protocol involves numerous in-person clinic visits during the course of treatment to evaluate brace fit, assess for complications and monitor response to treatment using ultrasound scans. While follow-up visits remain an important and necessary component of care, they naturally place a significant burden on healthcare services and patients' families.

Following the onset of the COVID-19 pandemic, in-person care was largely reduced to ensure patient safety by limiting contact and minimizing the risk of exposure to infection in the hospital environment.[3,4] This subsequently led to a global expansion in telemedicine and virtual care platforms to promote continuity of care during the pandemic and beyond.[3] Within orthopaedics, virtual fracture clinics (VFCs), first introduced in 2011, have been proven to be an efficient and safe model of care delivery for patients with certain musculoskeletal injuries.[5] Furthermore, studies evaluating the application of telemedicine in a variety of other orthopaedic services since the COVID-19 pandemic have also demonstrated that this approach is safe and valid in clinical assessment.[6,7]

It has been established that with careful patient selection and targeted educational efforts, telemedicine can have an important role in paediatric orthopaedic care.[8] More specifically, studies evaluating virtual care for triage of suspected infant DDH management and remote management of normalized hips undergoing brace treatment have demonstrated that they can be successfully implemented for specific tasks of triage and monitoring of patients.[4,9] Given the early success of this approach, it remains to be seen if virtual care can play a more comprehensive role in the management of infant DDH by full integration into a previously validated nonoperative treatment protocol while maintaining excellent clinical outcomes.

Prior to the COVID-19 pandemic, all infants diagnosed and treated for DDH at The Hospital for Sick Children attended our in-person infant hip clinic on five to eight occasions over a four-month period. Given the development of evidence-based tools for the optimized management of infant DDH at our institution and the recent early experience of other centres, we believe it is possible to utilize our institution's new virtual care platforms to streamline DDH care and minimize in-person visits, while maintaining exceptional clinical outcomes.

We have demonstrated that adherence to a comprehensive nonoperative treatment protocol,[2] use of validated online educational tools,[10] and limiting the routine use of follow-up hip ultrasound[11] is feasible and safe. The comprehensive nonoperative treatment protocol for infant DDH used in our clinic showed high success rates of nonoperative treatment and allowed us to standardize care.[2] Published virtual and video education tools on infant DDH were found to be effective in teaching caregivers how to properly apply and adjust the treatment brace safely and independently in the absence of a clinician.[10] Finally, our institution demonstrated that a limited-ultrasound protocol, with ultrasound used only for diagnosis, assessment of early stability, and at the end of treatment, produced outcomes that were non-inferior to those of a standard ultrasound protocol where scans were performed at every clinic visit.[11] This evidence base further negates the need for routine in-person follow-up visits and supports the argument for remote care management and the potential decentralization of care.[11]

We believe that a hybrid-virtual infant hip clinic will be as safe and effective as a traditional in-person clinic for the nonoperative treatment of DDH. The aim of this study was to use quality improvement (QI) methodology to establish and validate a pilot hybrid-virtual clinic to evaluate the clinical outcomes with the delivery of a comprehensive nonoperative treatment protocol for infant DDH.

Methods

Context

This was a prospective, single-centre, QI study of all eligible infants who underwent a comprehensive nonoperative treatment protocol[2] for infant DDH in a unified multidisciplinary infant hip clinic from December 2022 to October 2023. All infants up to the age of six months with a confirmed ultrasound diagnosis of DDH were eligible for inclusion. Infants were excluded if there was an underlying neuromuscular disease, teratologic dysplasia, or if they underwent prior treatment elsewhere.

Since 2012, our weekly one-stop interprofessional infant hip clinic has been the site for the diagnosis and treatment of DDH. Upon referral, infants are seen in our clinic and undergo a clinical examination and a baseline ultrasound scan. Infants diagnosed with DDH follow a predefined management protocol based on the severity of dysplasia, where the Pavlik harness is used as the primary treatment. In some cases, a fixed abduction brace (FAB) is used if the hip fails to respond to the harness. Follow up after brace application is determined based on whether the affected hip is centred or decentred on ultrasound imaging. Hips centred on presentation begin the 12-week maturation programme immediately. Decentred hips undergo weekly ultrasound assessments until they become centred, at which point they begin the 12-week maturation programme. Within the 12-week maturation programme, infants are seen in person at interim two-, five-, and eight-week follow-up visits to allow for brace adjustments, identification of complications, and to address any caregiver

concerns. Infants are again seen in person at the 12-week visit with a clinical examination and ultrasound scan. If the affected hip has achieved sonographic correction with no unusual findings on clinical examination, the treatment is considered complete, and the brace is discontinued without weaning. Follow up may continue past the 12-week visit until the ultrasound is normal or for a maximum of 20 weeks in the brace.

This study is reported using the SQUIRE (Standards for Quality Improvement Reporting Excellence) 2.0 guidelines.[12]

Interventions

The Model for Improvement framework developed by Associates in Process Improvement and its Plan-Do-Study-Act (PDSA) iterative cycle was implemented in this study.[13,14] Data were collected and reviewed weekly with the clinical care and project team to evaluate the study's progress. Major decisions regarding the PDSA cycle were taken monthly to assess the need for adjustments and facilitate improvements to the programme.

The main practice change made to the aforementioned nonoperative DDH treatment protocol involved replacing specific in-person follow-up visits with virtual appointments. Once the brace was applied, infants were followed weekly in person until the affected hip was designated centred on ultrasound. Follow-up visits were then scheduled to occur virtually, in place of in-person visits, at the interim two-, five-, and eight-week appointments (Figure 1). Ultrasound examination was omitted per evidence-based guidelines.[11] The final 12-week appointment remained in person as an ultrasound scan was required in addition to clinical assessment to determine if the brace could be discontinued.

Virtual appointments were conducted through video consultation using the institutional virtual care platform. Caregivers could connect to the virtual platform through any technological device with audio and video, such as a computer or smart device (tablet or smartphone). Informed verbal consent was obtained from caregivers by a clinic practitioner prior to each virtual appointment to communicate and provide care using the platform. Similar to the in-person appointments, infants were evaluated for brace fit and assessed for complications. Clinic practitioners guided caregivers to position the infant in optimal view for examination. The resting position of infants' hips was evaluated, and instructions were provided on how to make harness adjustments, if required. Infants were specifically assessed for skin irritation and femoral nerve palsy (FNP), and caregivers were asked if any challenges were encountered since the previous appointment.

Furthermore, a second practice change was implemented in the clinic by creating a dedicated institutional infant hip clinic email to provide caregivers with individualized, streamlined, asynchronous clinical advice to questions raised throughout the treatment period.

Measures

The process, outcome and balancing measures used in this QI study are presented in Table I. To determine whether treatment outcomes of the hybrid-virtual clinic were equivalent to traditional in-person clinic, success rates of brace treatment were measured and compared to published historic outcomes from our clinic.[2] Success of brace treatment was characterized by normal acetabular morphology (α angle > 60° and femoral head coverage > 50%) and hip stability on the final ultrasound at the end of treatment.[2] Extended time in brace, rate of complications, and rate of surgery were also assessed to determine treatment outcomes.

The dedicated institutional infant hip clinic email was monitored by a healthcare practitioner in the clinic. Communication with caregivers was assessed quantitatively and qualitatively to assess the use of the clinical email by caregivers and to determine the extent of communication, knowledge gaps, and treatment complications. A survey was administered to caregivers at in-person and virtual visits to collect information including the awareness of the clinic email. This survey was administered, and study data were collected and managed using REDCap (Research Electronic Data Capture) tools hosted at our institution.[15,16]

Patient characteristics

A total of 52 infants were initially enrolled in the study. One infant was later excluded as they did not meet the eligibility criteria. Baseline demographics are presented in Table II.

Ethical considerations

This QI study was reviewed and approved by The Hospital for Sick Children's institutional Quality Management department. It was exempt from research ethics board (REB) review per the institutional criteria for REB submissions. This study complied with legislative and institutional requirements related to data security, confidentiality, and privacy policies.

Results

Of the 51 infants included in the study, 44 (86%) were treated solely with the Pavlik harness, and one infant (2%) was treated solely with a FAB. Six infants (12%) were initially treated with the harness but switched to a FAB. Of these six infants, four had failed to respond to the harness, and two experienced complications with the harness (skin irritation and FNP).

Process measures

In total, 49 infants began the 12-week maturation programme. Two infants were not followed in clinic as they were either scheduled for surgery or referred to another hospital before the start of the maturation programme. A total of 144 interim visits were planned to occur virtually (two-, five-, and eight-week appointments). Three other planned visits did not take place because one infant did not attend one visit (as operative intervention was recommended during the maturation period), and one infant missed two visits and only presented to clinic for the final in-person appointment.

Of all interim follow-up visits, 53% (77/144) occurred virtually. Of the 49 infants who started the maturation programme, 82% (40/49) had at least one virtual follow-up visit. The proportion of patients who had virtual appointments was as follows: 25% (10/40) infants had one virtual visit, 57.5% (23/40) had two virtual visits, and 17.5% (7/40) had all three visits virtually.

Nine infants had no virtual follow-up visits as four infants were treated with a FAB and required close monitoring with ultrasound imaging and adjustments made by clinic orthotists, three infants' caregivers declined virtual visits in

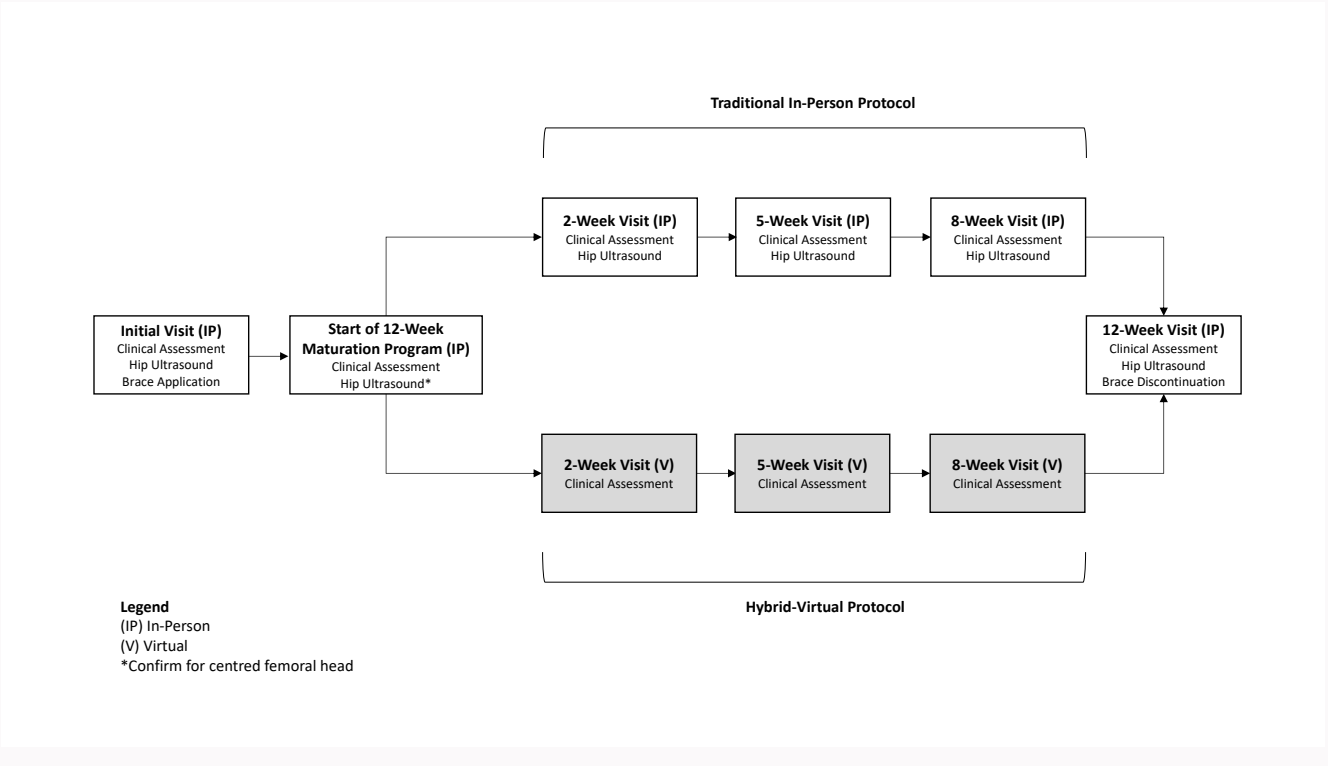

Fig. 1
Practice change to the nonoperative developmental dysplasia of the hip (DDH) treatment protocol 12-week maturation programme from the traditional in-person protocol to the hybrid-virtual protocol.

Table I. Measures.

Driver/change idea	Process measures	Outcome measures	Balancing measures
Add routine virtual follow-up visits to the existing in-person protocol.	Percent of patients having follow-up visits virtually.	Success rates of brace treatment. Extended time in brace. Rate of complications. Rate of surgery.	Failures of brace treatment. Number of virtual appointments that lead to unplanned in-person appointments. Need for unplanned ultrasound examination.
Add a dedicated institutional infant hip clinic email.	Percent of caregivers aware of and using the clinic email.	Not applicable.	Additional email queries compared to those sent to practitioner email.

preference of attending in-person appointments, and two infants had referral imaging performed in the community instead of our institution, and thus required in-person visits with ultrasound follow up.

Furthermore, 92% (47/51) of caregivers reported awareness of the infant hip clinic email on the caregiver survey; 33% (17/51) of caregivers used this resource, sending 34 emails throughout the treatment period.

Outcome and balancing measures

Table III depicts the overall treatment outcomes of the infants in the study: 94% (48/51) of infants successfully completed brace treatment; 6% (3/51) of infants failed both the Pavlik and FAB treatment and were recommended operative intervention. All three infants who failed bracing had one dislocated hip at initial presentation. Of the three infants, two were scheduled for surgery with a closed reduction and spica casting at our institution, and the third was referred to another hospital upon their caregiver's request for a second opinion and was not further followed at our institution. No infants spent extended time in brace beyond the maximum of 20 weeks, as indicated in the nonoperative treatment protocol.

Complications related to the brace treatment were experienced by 8% (4/51) of infants. During the in-person visit phase, two infants developed a FNP, which eventually resolved, and both successfully completed brace treatment. One infant developed a skin sore, failed to successfully complete brace treatment, and was later referred to another hospital. During the virtual visit phase, one infant developed a hair tourniquet on their toe, but also successfully completed brace treatment.

Unplanned visits to the hip clinic were made by 10% (5/51) of infants throughout the treatment period. During the in-person phase, both infants who developed a FNP each made one unplanned visit because of this complication. One infant made an unplanned visit for brace check

Table II. Patient demographics.

Characteristic	Cohort (n = 51)
Female, n (%)	41 (80)
First born, n (%)	30 (59)
Breech presentation, n (%)	13 (25)
Family history, n (%)	16 (31)
Bilateral pathology, n (%)	43 (84)
Mean age at the start of brace, wks (SD; range)	6.87 (4.45; 1 to 24)
Mean total treatment duration, wks (SD; range)	13.73 (1.58; 11 to 18)
Initial diagnosis – right hip, n (%)	
Centred	31 (61)
Normal	5 (10)
Stable dysplasia	19 (37)
Subluxable	7 (14)
Decentred	20 (39)
Subluxated	15 (29)
Dislocated	5 (10)
Initial diagnosis – left hip, n (%)	
Centred	21 (41)
Normal	3 (6)
Stable dysplasia	12 (24)
Subluxable	6 (12)
Decentred	30 (59)
Subluxated	16 (31)
Dislocated	14 (27)
Type of brace, n (%)	
Pavlik only	44 (86)
FAB only	1 (2)
Pavlik then FAB	6 (12)

FAB, fixed abduction brace.

Table III. Treatment outcomes.

Outcome	Cohort (n = 51)
Brace success, n (%)	48 (94)
Brace failure, n (%)	3 (6)
Scheduled surgery	2 (4)
Referred to another hospital	1 (2)
Complications, n (%)	4 (8)
In-person visit phase	3 (6)
Virtual visit phase	1 (2)
Unplanned visits to hip clinic, n (%)	5 (10)
In-person visit phase	3 (6)
Complications	2 (4)
Brace check	1 (2)
Virtual visit phase	2 (4)
Complications	0 (0)
Brace check	2 (4)
Additional hip clinic emails, n	34
In-person visit phase	20
Urgent	4
Care-related	11
Administrative	5
Virtual visit phase	14
Urgent	0
Care-related	6
Administrative	8

and adjustments. During the virtual phase, no infants made an unplanned visit due to complications, or as a result of uncertainty or failure of virtual examination. Two infants made an unplanned visit for brace check and adjustments due to their natural growth over the treatment period. Furthermore, a total of three unplanned ultrasound examinations occurred. Two were during the in-person phase for more detailed hip assessment after the diagnosis of FNP, and one was during the virtual phase upon request of an infant's caregiver. The unplanned ultrasound examinations did not alter the course of treatment in any of the three instances.

The institutional hip clinic email received emails from 33% (17/51) of caregivers. A total of 34 inquiries were received and categorized as either urgent (for possible complications), care-related (for brace fit and care), and administrative (for scheduling appointments). Of these inquiries, 41% (14/34) were received during the virtual phase. Of these, no inquiries were related to complications, six were primarily care-related (advice on brace fit/adjustments/infant care), and eight were primarily administrative (confirm/reschedule upcoming appointments).

The institutional email also received six additional emails from caregivers who either declined to participate in the study or did not provide any infant-identifiable information. Three emails contained care-related inquiries, and three were administrative. Ten caregivers of infants in our study also sent a total of 15 emails to the hip clinic practitioner's email. Six inquiries were made during the in-person phase (five care-related, one administrative), and nine were made during the virtual phase (six care-related and three administrative).

Discussion

This QI study reports the results of a hybrid-virtual clinic for the outcomes of a comprehensive nonoperative treatment protocol for infant DDH. Overall, 94% of infants successfully completed treatment. No failures of brace treatment occurred during the virtual follow-up period. No infants required bracing for an extended time due to virtual visits. The overall rate of complications was 8%, including the rate of femoral nerve palsy at 4%. All but one of these complications occurred

in the in-person phase of care. There were two unplanned visits to clinic during the virtual phase, but neither was due to complications. The hip clinic email was used by caregivers both during the in-person and virtual phase, most often for care-related and administrative questions. No urgent inquiries were received during the virtual visit phase.

The expected outcome of treatment in our hybrid-virtual clinic was to maintain the exceptional success rates of brace treatment from our traditional in-person clinic. The clinical outcomes of the hybrid-virtual clinic in this study (94%) are comparable to the published historical outcomes of our in-person clinic (95%).[2] This demonstrates equivalency in treatment success between the hybrid-virtual and in-person clinics and provides further evidence that the use of standardized treatment protocols can significantly improve outcomes and efficiency in DDH management, especially in a virtual setting.[17] Furthermore, the characteristics of the few infants who failed bracing treatment had similar initial pathology as our historical in-person cohort, with at least one dislocated hip at initial presentation.

Of all planned virtual appointments within our new hybrid-virtual model of care, we found that 53% of them were carried out virtually. In-person visits were conducted for the remaining 47% of planned appointments during the maturation period, largely due to the need for brace adjustments, repeat ultrasound assessments, and to address caregiver concerns. Although our hybrid-virtual model of care was established based on our published treatment protocols and validated educational tools, the percentage of appointments carried out virtually was lower than expected. This highlights the need for operational flexibility within virtual care programmes, recognizing the clinical case variability and the need to accommodate the individual requirements of both patients and caregivers. However, the significant reduction in face-to-face clinic visits compared to our traditional model of care demonstrates the great benefit of this approach in reducing caregiver burden without compromising patient safety or clinical outcomes.

In our historic in-person clinic, the published overall rate of complication was 1%. There were no femoral nerve palsies in those who completed bracing and two cases (1%) in those who failed bracing.[2] In our new hybrid-virtual clinic, the overall rate of complications was 8% including two patients (4%) with FNPs. Both infants with FNPs resolved before the virtual phase and successfully completed brace treatment. While there were two cases of FNPs in both historic and study cohorts, the smaller sample size of the current study likely accounts for the higher rate of complications in the hybrid-virtual clinic.

In paediatric orthopaedics, caregiver involvement and treatment compliance are important factors that contribute to nonoperative treatment success.[18] Satisfaction with care provided leads to greater compliance with treatment and better health outcomes.[18,19] Murphy et al[9] also highlighted the value of supplementary services to assist caregivers during virtual care. In our hybrid-virtual clinic, additional support to caregivers was provided by creating the dedicated infant hip clinic email. This email was actively used by the caregivers who had inquiries for the clinical team both during the in-person and virtual phases. This emphasized the need to provide ongoing support to caregivers, and the value of implementing asynchronous virtual care along with synchronous virtual appointments.

The successful implementation of our hybrid-virtual clinic represents an advance in the model of care for nonoperative treatment for infant DDH. In particular, virtual care models such as ours can increase equitable access to care, especially for those in remote or economically challenged areas. Virtual clinics can provide accessible and timely care and reduce geographical barriers, all while delivering comparable treatment outcomes to in-person care.[20,21]

The small sample size of this hybrid-virtual clinic study compared to the historic in-person clinic study likely explains the higher rate of observed complications. Importantly, most complications occurred in the in-person phase of care and were not related to the introduction of interim virtual care appointments. We did not collect and assess long-term outcomes of the hybrid-virtual clinic in comparison to the historic norms in our in-person clinic, however given the equivalence of brace treatment success, we do not anticipate any long-term differences in the rate of radiological residual acetabular dysplasia. Finally, we acknowledge the changes implemented in our hybrid-virtual clinic may not be feasible for all healthcare facilities, as some may not have the infrastructure, technology, or resources to adapt these changes to their practice.

In conclusion, our hybrid-virtual infant hip clinic has shown comparable outcomes to the historic norms of our in-person infant hip clinic using a comprehensive nonoperative treatment protocol for infant DDH. This model of care significantly reduces the need to attend as many in-person appointments and can improve the efficiency of standardized DDH treatment protocols while maintaining excellent clinical outcomes. Hybrid models of DDH management can be implemented to support those in remote and economically challenged areas.

Social media

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Data sharing

All data generated or analyzed during this study are included in the published article and/or in the supplementary material.

Ethical review statement

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