BRITISH ACADEMY OF AUDIOLOGY

British Society of Audiology

Promoting excellence in hearing and balance

BAA/BSA Joint Guidance

Setting and verifying the frequency response of a hearing aid remotely for adults during periods of restricted service delivery.

Written by BAA Service Quality Committee and BSA Adult Rehab Interest Group

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SECTION 1: Introduction and Scope

Remote hearing aid fitting can offer convenient and flexible access to amplification for carefully chosen populations when access to face to face clinical care is contraindicated and should be considered better practice than no care or significantly delayed care. It is essential that any deviation from best practice is based on the specific needs of the individual, balancing any risks of attending for a face to face appointment with the risks of a deviation from best practice. To do this a discussion between service user and the clinician is essential to ensure that individual informed choice is at the centre of any decision by the patient to proceed with remote hearing aid fitting as opposed to waiting for face to face fitting within the clinic. It should be recognised that remote hearing aid fitting involves clinically challenging skills and approaches that may fall outside of the routine practice of Audiologists who may require additional support and training in some areas.

This guidance has been developed to be used in conjunction with other guidance including 'A Guide to Remote Working in Audiology Services During Covid-19 and Beyond', May 2020, produced by Manchester Centre for Audiology and Deafness (ManCAD) and BAA Service Quality Committee and the British Society of Audiology guidance on probe microphone measures (BSA, 2018). Readers are advised to read both of these documents before proceeding to read this document, particularly the section on RECDs in the BSA guidance.

Whilst it is acknowledged that in-situ Real Ear Measurements or measured RECDs are the most accurate approach to verifying hearing aids in adults and are therefore the gold-standard (BSA, 2018), this document aims to provide practical guidance on the remote fitting of hearing aids where face to face consultations are not possible or not desirable.

It is important to remember that the effective use of hearing aids is achieved by providing rehabilitation support to the patients and their significant other(s) through patient centred care. A common criticism of clinical guidance is that it can become too prescriptive and lacks focus on patients' preferences (Greenhalgh et al. 2014). Although the guidance has a practical focus on probe microphone measurements it must be acknowledged this is only a starting point for hearing device fittings and should always include collaboration with the patient and not preclude further adjustment based on patient feedback and clinical judgement. Indeed, evidence of real-world outcomes with different verification approaches is unclear. New research by ManCAD has shown that there is limited evidence of a clinically significant benefit of verification but also identifies a gap in knowledge (Almufarrij et al, In press). For further information on various aspects of hearing healthcare, readers are referred to the BSA guidance on Common Principles of Rehabilitation for Adults in Audiology Services (2016).

Inclusion of 'how to' guidance within this document is not an endorsement of these practices forming a routine part of service delivery models but instead is a recognition of the need for alternative approaches during extreme situations such as a pandemic and to meet the needs of certain populations with specific needs i.e. accessible amplification without clinic visits e.g. end of life care.

This document makes the assumption that a full assessment of need and development of an individual management plan has been completed prior to any decision to proceed with remote hearing aid fitting. Consideration of hearing aid programmes and features will remain part of clinician/patient discussions, as with any hearing aid fitting. This guidance will focus on the practicalities of setting and verifying the frequency response of the hearing aid entirely remotely. In practice, services may wish to combine elements of remote care and face to face consultations in a manner which best suits each individual patient's needs.

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Thanks for the BAA Service Quality Committee, BSA Adult Rehabilitation Interest Group, BAA Board and BSA Professional Guidance Group for helpful comments on an early draft of this document.

Thanks to Natus and Interacoustics for helpful advice when preparing this document. Thanks to Natus for allowing their photographs to be used in this document.

1.2 Disclaimers

This document has been jointly produced by BAA and BSA. The document has been developed at pace to meet the immediate needs of audiology services during the Covid-19 pandemic. As such the document has gone through an expedited development process and has not been subject to the usual processes of the BSA PGG.

Although care has been taken in preparing this document, with reviews by members of BSA Council and members for the Adult Rehabilitation Interest Group (ARIG) the BSA does not and cannot guarantee the interpretation and application of it. The BSA cannot be held responsible for any errors or omissions, and the BSA accepts no liability whatsoever for any loss or damage howsoever arising.

The BAA Service Quality Committee takes great care to produce the highest quality documents and guidance through consultation and reviewing evidence. Each document is written with consideration of research evidence, clinical practice documentation, expert opinion and clinical consensus from which clinicians and managers can make informed decisions, within the scope of the document. In addition, the documents can help inform allied health professionals, government agencies and the hearing health-care industry about current best practice. The BAA disclaims any liability to any party for the accuracy, completeness, or availability of the documents, or for any damages arising from the use of the documents and the information they contain.

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SECTION 2: Varying Clinical Scenarios

Whilst this document does not aim to identify which specific patients will be appropriate for remote fitting (for guidance on this see ManCAD/BAA 2020), it does recognise that there will be a number of different clinical scenarios where remote hearing aid fitting is a relevant and necessary option and where techniques may need to vary. Factors affecting procedures and guidance include:

a. Availability of audiometric information, including transducer used
b. Availability of previous Real Ear Measurements
c. Type of device being fitted
d. Type of ear piece, venting and tubing
e. Any relevant/local clinical restrictions (i.e local pandemic policy)

During times of unprecedented change and uncertainty, such as with the current covid-19 pandemic, it is understood that there will be different ways of managing adult hearing loss and hearing aids. Even local pathways will be subject to change as different external factors (i.e. changes in local restrictions, alert levels, Hospital/corporate policy, public health guidance, evidence base etc.) influence what clinical possibilities are available for an audiologist/service (i.e. infection control/room availability/ footfall policy).

Should a remote hearing aid fitting pathway be thought as beneficial during a particular time or for a particular individual, this document hopes to support individuals/services with the options available and raise awareness of how differing methods and practice relate to accuracy.

See Appendix B for a summary of all the fitting options discussed in this document.

2.1. Audiometric information available

With access to prior audiometric information, a number of methods can be used to set up hearing aids remotely without the patient being present. As we will discuss, different methods will have different advantages, disadvantages and levels of accuracy:

- 'Click and fit' using manufacturer default settings
- Importing previously verified hearing aid settings if appropriate (2.4.1)
- Coupler verification using a previously measured REUR (2.4.3)
- Coupler verification using average RECD
- Coupler verification using measured RECD

For remote hearing aid fitting and verification, the advantage of using RECD over REAR is that the RECD measure can be made at the assessment, so the subsequent fitting can be done entirely remotely.

This can be beneficial when there is local or patient specific advantage in reducing the need for a separate face-to-face hearing aid fitting or lengthier assess and fit. That said, it is understood that REAR provides the more accurate and well-practiced verification method in most instances, and therefore such remotely adapted pathways should be under review, with a move back to traditional pathways (unless otherwise indicated for a patient) as soon as appropriate and safe to do so.

We will discuss how remote fitting method will be influenced by factors including the hearing assessment, transducer, hearing aid type and availability of equipment. Where audiometric

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information is available, clinical consideration will need to be given to any reported changes since assessment before proceeding with the fitting of aids.

Likewise, if a REUR or RECD has been measured at a previous fitting, particularly if this was more historic, significant changes in ear canal acoustics (e.g., post-surgery) would necessitate a further REUR or RECD measurement.

2.1.1 'Click and fit 'using manufacturer default settings

Most hearing aid fitting software provides the option to set hearing aids using a 'click and fit' method which will take into account audiogram and other variables (e.g. age, average RECDs, predictions for the acoustical effects of tube length and earpiece type). There is high likelihood of variability in this approach between manufacturers as each manufacturer incorporates their own set of averages/norms. Evidence suggests click and fit leads to under-aiding compared to prescribed gain, especially for soft, high-frequency input sounds (Munro et a., 2016). Although evidence with recent hearing aid technology is lacking.

2.1.2 Coupler verification using average RECD

When verifying a hearing aid in a coupler, an RECD is *always* incorporated into the prescribed gain (Dillon, 2012a). This can either be a predicted RECD (based on age, coupler type, tube type and occlusion of fitting), or a personalized measured RECD. There is no recent evidence to suggest that coupler verification (using an average RECD) leads to better outcomes compared to 'click and fit' (which is also based on averages). A coupler fitting may offer a more 'standardized' approach between different hearing aids, and allow for the clinician to visualize audibility of speech in relation to the target and dynamic range. However, the manufacturer software may use averages which are more appropriate to the acoustic properties of the specific hearing aid/thin tube/dome. In summary, services need to make a decision locally on which approach they want to take.

2.1.3 Coupler verification using previously measured RECD

A measured RECD captures an individual ear's acoustic characteristics to enable a more personalized hearing aid fitting and therefore we can more accurately predict the sound pressure level the hearing aid will produce in the ear (Moodie, Seewald and Sinclair, 1994). The more unusual the patient's ear size and shape, the more important a personalized, measured RECD becomes (Dillon, 2012a).

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2.1.4 A measured RECD has two functions

1. **An RECD will capture the acoustic characteristics of an individual ear in relation to the coupler so that we can more accurately predict the sound pressure level the hearing aid will produce in the ear and therefore enable a more personalized coupler-based fitting (Moodie, Seewald and Sinclair, 1994). The more unusual the patient's ear size and shape, the more important a personalized, measured RECD becomes (Dillon, 2012a).**
2. **A potentially lesser-known function of an RECD is its part in accurately transforming Hearing Threshold Levels (HTLs) recorded in dB HL, into dB SPL at the eardrum. When HTLs are recorded with an insert transducer (foam tip and/or occluded mould) and an RECD is performed using the same RECD coupling (foam tip/occluded mould) and the appropriate coupler (Scollie, 2016), the dB HL recorded can accurately be transformed into dB SPL. If in-situ audiometry has been used to measure thresholds, this transfer function is not needed as thresholds are measured directly in dB SPL.**

When headphones have been used to record HTLs; typically an average real-ear-to-6cc transform (unless an individual's real-ear-to-dial difference is physically measured) will occur behind the scenes in the software to transform dB HL to dB SPL at the eardrum and plot the dB SPL tone audiogram. See Baggato et al (2005) for more information around the subject of dB HL to dB SPL transforms for tone audiograms and RECDs in general. This average approach to threshold conversion leads to minor errors for adults with standard shape and size ear canals, but these errors become larger as ear canal acoustics deviate away from standard.

It's useful to remember, that even for REAR's, an accurately measured RECD and insert HTL would be required to enable the benefit of a person specific dB SPL transform audiogram and a personalized dB SPL transform prescription. The use of this transform for adult hearing aid fittings maybe an area worth further deliberation in the future.

In summary, an RECD is used for two purposes: 1. To transform coupler acoustic measures to Real Ear measures, and 2. to convert hearing thresholds levels from dB HL to dB SPL. Conversion of hearing thresholds from dB HL to dB SPL by an RECD is only accurate when insert earphones are used for the PTA; headphones are calibrated using a 6cc calibration cavity compared to the 2cc coupler cavity used for inserts and a test box.

See Figure 1 for a summary of how the RECD is incorporated into a hearing aid fitting.

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225 Figure 1: Summary of how an RECD is incorporated into the hearing aid fitting process.
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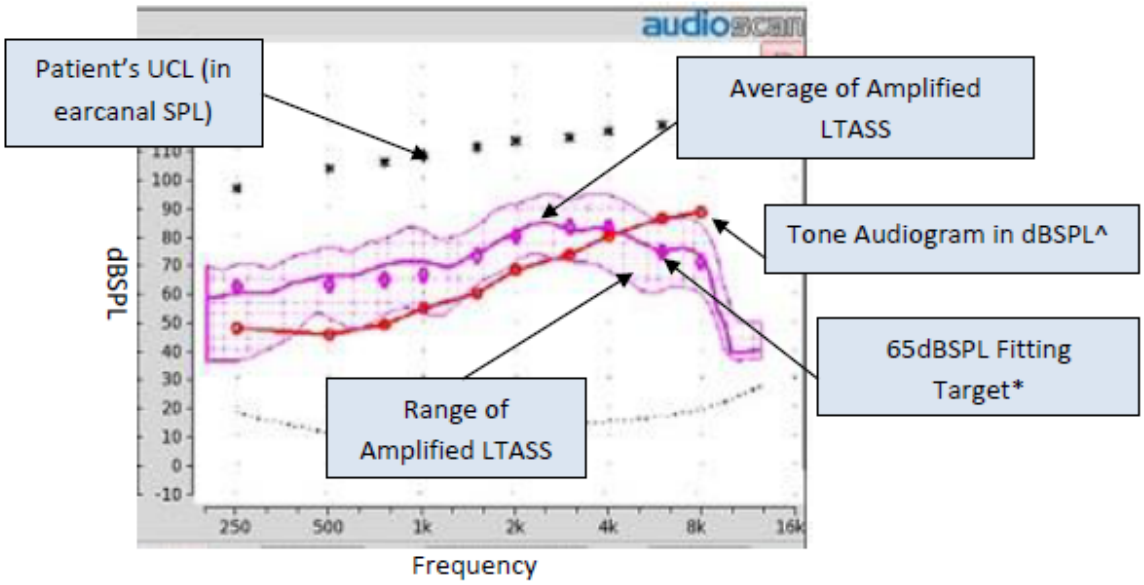

* Tailored dBSPL prescription either using:

- Measured insert RECD taking into account acoustics of patient's ear + insert dBHL HTL's
- Age related average RECD + dBHL HTL's

^ Tone Audiogram in dB SPL transform calculated using one of the following formulas:

- Insert Audiogram in dBHL + Insert RETSPL + Measure RECD = Individualised dB SPL threshold (ear canal level)
- Insert Audiogram in dBHL + Insert RETSPL + Average RECD (if no RECD measured or insert vs mould/coupler mismatch) = Less tailored dBSPL threshold (ear canal level)
- Headphone Audiogram in dBHL + RETSPL + measured or average real-ear-to-6cc transform = Less tailored dBSPL threshold (ear canal level)

For further detail and explanation see Bagatto et al (2005), Clinical Protocols for Hearing Instrument Fitting in the Desired Sensation Level Method

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2.2 Audiometric information not available

Audiometric information is key to accurate hearing aid fitting. Remote hearing assessment is still a developing area and although there are a number of potential methods for remote assessment reported in the literature, well summarized by Saunders (2020), remote assessment is considered to be outside the scope of this document.

Please note that these methods are not considered to be an equivalent substitution for puretone audiometry within the clinic and should not be used for diagnostic purposes. However, they may provide some information that will guide hearing aid fitting in the absence of other information and when there is judged to be a clinical need.

It is also important to note that any remote assessment will not include otoscopy and/or other examination/assessment that may be required. It is therefore suggested that any remote assessment if necessitated is followed up with a face-to-face assessment at the earliest opportunity once it is possible to do so.

2.3 Effect of vents

Vented or open hearing aid fittings have three sound transmission paths (Dillon, 2012, Chapter 5); the vent-transmitted region, the amplified region and the mixed region (combined path). The only way to accurately measure the acoustic effects of these paths in a large vent or open fitting is with in-situ REMs i.e., a REAR. However, when fitting in a coupler, the software will attempt to *predict* the sound path in and out of the vent/dome, but these effects may differ when the aid is worn in the ear, especially if ear canal characteristics are unusual. For example, a measured RECD performed on a large vented earmould/open fitting would take into account the sound escaping via the vent/open dome but not the sound entering, resulting in a very negative low frequency RECD and hence more low frequency gain prescribed (Dillon, 2012). If vent size equals or exceeds 3mm, treat as an open fitting (see section 3.1). If vent size is less than 3mm, treat as a closed fitting (see section 3.2) but block the vent prior to measuring RECD - block from the ear side so as not to introduce resonances in the vent.

2.4 Availability of previous Real Ear Measurement

2.4.1 Importing previously used settings.

When a previous REM has been performed the fine-tuning adjustments can often be used (imported) to set the new hearing aids. If the new hearing aids are by the same manufacturer, the settings can often be imported into the new fitting and will account for the previous verification (personalisation)undertaken.

Please note, if the earpiece has changed significantly (e.g. open to closed), the imported fitting will be inaccurate. Likewise, if the hearing thresholds have changed significantly, the fitting will be inaccurate. Where an 'import' is not available, coupler responses with the old/existing hearing aids, measured with a variety of input signals (55, 65, 80 dB), can be used as a start point for an update fitting.

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2.4.2 What if previous hearing aid fitting using REMs/RECD was only done in one ear?

Use of REM/RECD for the contralateral ear can be considered if available. Specific consideration will need to be given to appropriateness of use based on known or reported outer or middle ear abnormalities or surgery. The effect of different earpieces will also need to be considered.

If considered clinically appropriate the contralateral RECD can be applied and the hearing aid programmed as outlined in section 3.2.

2.4.3 Incorporating a previous REUR

In addition, previously measured REUR/G can be incorporated into coupler-based measures. In this instance the REUR/G essentially mimics the on-ear component of an RECD. Manufacturers would be able to give guidance on how to implement a protocol using a REUR. When considering coupler fittings, this method may have advantages if an appropriate on-ear RECD was not measured. The authors were unable to find evidence with regard to its relationship to the gold standard RECD.

2.5 Type of hearing aid being fitted

2.5.1 Hearing aid with remote adjustment

There are a number of devices currently available that enable user/clinician led remote adjustments following hearing aid fitting. These devices would seem to be the most appropriate choice for remote fitting, particularly where the follow up is likely to be delivered remotely.

2.5.2 Device without remote adjustment

Extra consideration will need to be given when using devices without remote adjustment capability. Activating the volume control and/or fitting multiple programmes should be considered to enable the patients to choose preferred settings and configurations. Where remote fittings are undertaken using devices without remote adjustment options, it will be even more important to follow up the fitting through other methods (i.e. phone/video) an/or offer face-to-face review if required, as the hearing aid user will have less flexibility to adjust settings and obtain support remotely.

2.6 Type of earpiece, venting and tubing

Earpiece type effects choice of verification and accuracy of approach – see section 2.3. Please see section 3 for detailed advice on setting up aids remotely for different earpiece types.

SECTION 3: Fitting protocols

3.1 Open/large vented fitting: Thin tube/wire and open dome/vented (3mm or more) or open earmoulds

3.1.1 This protocol is applicable to:

New Direct Referral (DR) adult patients where a recent audiogram is available and where the patient cannot attend for face-to-face fitting of thin tube/wire with **open dome or vented/open earmould devices i.e., a fitting where the natural ear canal resonances are retained.**

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Reassessment adult patients where a recent audiogram is available, who have and will continue to have thin tube/wire with **open dome/vented/open earmould devices**, but the patient cannot attend for their update fitting. Please note, for existing users, if there has been minimal change in their hearing and the patient has been happy with their previous settings (i.e. assessed by COSI) a previous REM could be used to predict fine-tuning requirements in the new fitting (check your hearing aid software for the option of 'importing' settings). A volume control option would be important in this instance along with validation of the settings to ensure audibility and comfort.

3.1.2 Coupler fitting approach

If the patient is unable to attend for a face to face fitting appointment, but a recent audiogram is available, the setup of their device/s must be done remotely.

The use of RECDs is clearly recommended for devices that occlude the ear where the acoustic pathways of amplified and unamplified sounds entering and leaving the ear are predictable. Where large vents (≥3mm, Dillon, 2012) or open dome thin tube/wire fittings are used these pathways are less straightforward in a coupler and therefore the only way to accurately measure the acoustic effects of these paths is with in-situ REMs i.e. a REAR (Dillon, 2012). **In short, the more 'open' the fitting, the more inaccurate coupler verification will be (whether a measured or predicted RECD is used). It is therefore recommended that coupler fitting is not carried out for open dome thin tube/wire devices or when the vent is 3mm or greater.**

3.1.3 Click fit/ Click and fit/ First fit/ pre-fit approach

Click fit/ Click and fit/ first fit/pre-fit, fitting approaches all refer to the situation where the hearing aid is programmed using the hearing aid manufacturer software estimates of the gain required for a fitting based on an audiogram (AC only or AC and BC), age-appropriate, average RECDs, bilateral or unilateral amplification and predictions for the acoustical effects of coupling type, tube length, venting and earpiece type. For some prescription rules such as NAL-NL2 additional information about the patient such as gender, experience with amplification and language type (tonal or non-tonal) are also considered. These parameters must be entered correctly in order to optimize the default settings.

There are no individualized measurements with this approach apart from the audiogram. As a result, there is high likelihood of variability between manufacturers as each manufacturer incorporates their own set of averages/norms. This will vary between manufacturers and individual services will have experience of how specific devices perform during REMs e.g. gain always needs turning up, for low input levels and may therefore be able to identify 'typical' adjustments that occur during a REM and could be applied to click fit. Audit would also be useful to acquire this understanding on a local level. Fine-tuning adjustments at this stage should be made with care. Remote fine tuning based on subjective feedback on sound quality/clarity/volume from the patient will enable fine tuning adjustments to be made in real-world listening situations (i.e. at home) which may benefit the patient more than fine-tuning in the clinic.

In summary, for open fittings, services need to make a decision locally on which approach they want to take but the recommendation given here is that Click fit/ Click and fit/ first fit/pre-fit fitting approaches are used for open dome thin tube/wire devices or when the vent is 3mm or greater for new Direct Referral (DR) adult patients where a recent audiogram is available and where the patient cannot attend for face to face fitting appointment. For these patients an active volume

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control is preferable, and this should be explained to the patient when they are making a choice over which device/device settings they would prefer. Similarly, App and/or remote fine tune facilities will also allow for more personalized control. It maybe that this patient group requires more detailed follow up of outcome and satisfaction over time and there may be a greater need for consideration of real ear verification when possible.

3.1.4 Acoustic Feedback

Marcrum et al., (2018) have shown that feedback reduction systems vary greatly across manufacturer with mean additional gain before feedback for 2000–4000Hz ranging from 5 to 16 dB and mean maximum stable gain for 2000–4000Hz ranging from 25 to 35 dB across manufacturers. In addition, they identified significant individual ear variation within manufacturer. Services are advised to use local knowledge or carry out in service audit to identify which devices provide optimum and stable gain.

3.2 Closed fittings: Mould (vent ≤3mm) or thin tube/wire with closed dome

3.2.1 RECD with closed fittings

For adults with a closed fitting, an accurately measured RECD incorporated into coupler verification can be as accurate as in-situ REAR (Munro and Hatton, 2000). The accuracy of the RECD will depend on the RECD protocol used (i.e. transducer for HTL assessment, 'match' between ear measure and coupler measure) and other factors discussed below. It is understood by the authors that the choice of RECD and local pathway maybe influenced by:

- Accessibility to equipment (i.e insert headphones/couplers)
- Staff skills and opportunity for training.
- Local policy including face-to-face restrictions/clinic time limits
- Subject to adaption as varying local pandemic/infection control policy influences practice

However, hopefully this guidance will support those developing remote fitting pathways by highlighting the options available. See Appendix B for a useful overview of the options available.

3.2.2 RECD with an earmould versus RECD with an insert

There are 2 types of coupler (HA1 and HA2) and 2 coupling types (i.e. insert vs mould) to consider leading to 4 subtypes of RECD (see Figure 5 in Scollie, 2016 and Appendix B). The 'gold standard' RECD described in ANSI S3.46-2013 uses an insert foam-tip for both hearing assessment, and the RECD on-ear and coupler measures. However, for practical reasons other RECD combinations can be used incorporating the HA1 or HA2. Details surrounding these options, their merits and the transforms behind them are well described by Scollie, 2016.

However, when considering remote hearing aid fitting, the assessment appointment will often be undertaken without access to well-fitting earmoulds, particularly for new users. As a result, any hearing thresholds recorded will have been obtained from either TD-39 headphones or preferably insert earphones, and the RECD measured undertaken using a foam-tip. Therefore, for the purpose of this document we will assume the use of an insert and HA1 coupler for coupler and ear portion of the measured RECD. Indeed, an insert tip can be used for all stages of measurement (assessment,

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coupler step and ear step), thereby avoiding any mismatch. See section 3.2.7 step by step guide for measuring an RECD using an insert tip and HA1 coupler.

An ear mould simulator on a HA2 coupler, although often used for RECDs in paediatrics, has very different acoustics properties compared to an insert tip (Munro, 2005). Therefore, calculating an RECD from a coupler response measured in a HA2 coupler with an ear response measured with an insert tip (such as is likely for remote adult fittings) would be less accurate and involve predicted transforms.

In summary, inserts are recommended for measuring hearing threshold data. Furthermore, to avoid mismatch error, a HA1 coupler + putty and insert tip can be used for both the coupler and ear measures, see Scollie (2016). This will ensure the measured RECD is the difference between the acoustic characteristics of the coupler and ear, independent of the tube length, earpiece type and coupler type; as defined by current international standards (ANSI, 2016). This individualized RECD could be applied to any type of fitting: ear mould, ITE, closed dome, as long as the patient's earpiece type and tube type/length are used during actual coupler verification i.e. hearing aid and earpiece attached with putty to a HA1 coupler (see Figure 2).

3.2.3 What if HTL's were not measured using insert headphones?

Although the use of insert foam-tip transducers to assess hearing threshold levels is considered gold standard when incorporating RECDs, as it enables an accurate dB HL to dB SPL transform (as long as it's used in conjunction with a matching foam-tip RECD and HA1 coupler measure, see section 2.1.3), it is understandable that insert transducers may not always be available or practical, particularly in adult hearing care. In these cases, some degree of error will be introduced into the verification as a result of the use of predicted dB SPL transforms. These errors are likely to be small, particularly for average ears, although exact values are unknown so caution should be applied and patient feedback sought to ensure a comfortable hearing aid fitting. In-situ audiometry can be used to directly measure hearing thresholds in dB SPL. This accounts for the threshold conversion portion of the RECD's role, but not the acoustic transform at the ear drum i.e. an RECD is still needed to ensure the acoustic properties of the ear are mimicked in the coupler.

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3.2.5 RECD measurement accuracy

An accurate RECD measure is essential as errors in the RECD are transferred to every measure made during hearing aid verification (Dillon, 2012a). It is acknowledged that adult audiology services in the UK may have limited experience measuring RECDs; a risk factor which could affect measurement quality. This needs careful consideration and risk assessment. Adequate theoretical and practical training should be undertaken before RECDs are attempted on patients (see Scollie, 2016). Harvey Dillon warns, '..*great care must be taken in the measurement and in the way the measurement is used. Otherwise, the measurement has the potential to create errors larger than the inter-person variations it seeks to allow for*' (Dillon, 2012, pg 101).

For information and training on RECDs, including coupler type and venting please see Scollie (2016).

Where RECDs are unfeasible, an alternative approach could be to measure, or use a previously measured REUR, and use that within the coupler fitting to improve the coupler verification accuracy (see section 2.3.3). This approach is not commonly reported in the literature but may represent an alternative when an RECD is difficult to measure. Manufacturers of verification equipment may be best placed to recommend best protocol and evidence base when incorporating REUR in a remote fitting.

3.2.6 Average RECD versus measured RECD

If RECD measurement is not possible/available, a coupler fitting using an average RECD or a click and fit could be used (with an understanding that for **both** approaches, the SPL prescribed may differ when the aid is worn in-situ, errors are dependent on the individual's ear canal size and shape relative to the average). See 2.1.2. When using an average RECD, a HA2 coupler can be used for simplicity for moulded hearing aids and HA1 for thin tube/wires and closed domes. Ensure the chosen coupler, vent size and acoustic characteristics are entered correctly into the verification software settings. Even for average RECDs, coupler verification allows audibility of speech to be visualized in relation to the target and dynamic range for counselling purposes.

Smaller/larger and unusual ear canals will have RECDs which are further from the averages used, and therefore for these ears it may be more important to use on-ear verification and/or measured RECD wherever possible (Dillon 2012).

For existing users, if there has been minimal change in their hearing and the patient has been happy with their previous settings (i.e. assessed by COSI) a previous REM could be used to predict fine-tuning requirements in the new fitting (check your hearing aid software for the option of 'importing' settings). A volume control option would be important in this instance along, with validation of the settings to ensure audibility and comfort.

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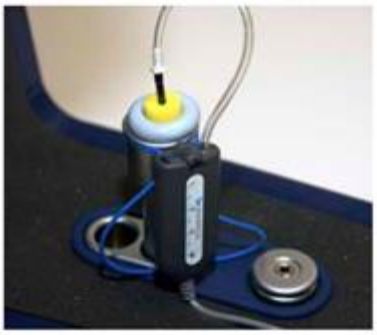
Figure 2: Step by step guide of how to measure an RECD with a closed fitting



HA1 with foam tip.

Step 1: Coupler response: HA1 with putty.

Step 2: Ear response: insert used.

Step 3: Coupler verification (lid would be closed during testing). Attaching the hearing aid in this way means the patient's tube length and thickness are considered in the verification process. Thin tube/wires can also be attached to the HA1 coupler (dome removed). An ITE could also be verified in the same way.

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3.2.7 Considerations when using a coupler to verify a closed fitting:

Hearing aid and verification equipment manufacturers will have protocols available for you to reference with specific advice on their equipment. However, the below points of consideration are hoped to compliment those documents and have a specific focus on thin tube coupler fittings:

1. Using a HA1 coupler, the dome or ear mould can be attached to the HA1 coupler using acoustic putty. Take particular care to avoid acoustic leakage.
2. Follow BSA guidance including taking care to align the hearing aid in the correct position within the coupler. Make sure the hearing aid doesn't move as you shut the test box.
3. This guidance is primarily designed to support remote hearing aid fittings, and it is therefore likely that any mould/dome used in verification will be new and unworn by a patient. Therefore, follow local infection control practices. However, if you are considering verification using a HA1 coupler and acoustic putty on previously used earmoulds/domes then much stricter infection control would need to be initiated including replacement of the putty for each individual.
4. Guidance suggests using a small piece of acoustic putty on the tubing to help replicate the dampening effect of the tubing sitting against the hearing aid wearers head when in situ (Dillon 2012). See Figure 3 below.

Figure 3: Using putty to replicate the dampening effect of the tubing sitting against a hearing aid wearers head.

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5. Ensure you alter software settings to account for the coupler type; using a HA2 coupler when the software settings are HA1 will lead to additional errors.
6. Ensure relevant acoustic parameters are entered into both the verification and hearing aid fitting software (transducer used, coupler used, tubing, dome etc) otherwise the accuracy of the fitting will be affected.
7. Measure output against target at the different inputs following BSA, 2016. **However, take care with the low frequency gain when verifying for thin tube/wire hearing aids. For low frequencies (1kHz and below) take care not to move too far from the click-fit starting point, even if the target is requesting much more low frequency gain. The clinician is advised to sense check the target against the hearing loss to spot a spurious element to the low frequency target.**
8. Manufacturers of both hearing aids and verification software can provide support, including training videos, on using their software. The availability of this has increased in 2020 as a greater focus on adult RECD and remote verification has been necessitated. They may be able to advise on best practice regarding low frequency gain targets in their coupler.
9. Run an OSPL-90 measure in the coupler to verify the MPO output of the hearing aid to help improve comfort to loud sounds.
10. The on-ear RECD component will usually be positive values when compared to the coupler values, expect a RECD of around 10 dB in the mid-frequencies. Check these common errors:
    a. If you measure negative high frequencies, check probe tube placement is not too shallow.
    b. If you measure negative low frequencies, check for leakage around the foam-tip/mould.
    c. The RECD software usually has visual indicators to help you check your 'on-ear' RECD measure is a good one. Speak to your manufacturer for supporting information and images.
11. Middle ear problems effect RECDs in the following ways:
    a. middle ear effusion will prevent sound entering the middle ear, resulting in a larger RECD. If middle effusion is persistent, you can feel confident to use the measured RECD. If the effusion is transient, an average RECD may be more appropriate (or use the contralateral RECD if no effusion is present). A volume control with a large range is always recommended in this instance.
    b. A perforation will act as a vent and give a low frequency dip in the RECD. This not a concern as the effect of the perforation is unlikely to fluctuate. Take care if grommets are fitted as canal characteristics (and RECDs) will vary depending on the patency of the grommet.

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3.3 Considerations for adult populations

Adults living with a Learning Disability, Dementia and/or Autism may find it difficult to self-report. Furthermore, use of a volume control may not be possible. Procedures should be put in place to minimize the risk of an inappropriate/uncomfortable fitting; RECDs should be a priority for this group, or if open fittings are provided, a REAR should be considered a priority. The same is true for adults with atypical size and shaped ear canals e.g. post-surgery, stenosis, atresia. In these instances, ear canal characteristics will differ significantly from the average values used on coupler fittings or click and fit software fittings. For experienced users, previous REMs/settings can help guide the new fitting. Verification is just a start point, fine-tune based on patients' feedback (if available) and/or responses to speech and environmental sounds (for adults who can't self-report).

Table 1: Summary of suggested verification approaches for patients with different needs.

	Patient considerations		
Fitting type	Pt **unable** to self-report and **cannot use a VC.**	Pt has **unusual** ear canal shape/size.	Pt is **able** to self-report and/or use a VC. **Typical** ear canal shape/size.
Open dome or large vented EM	Offer F2F REAR; particularly for new users with no previous REM.	Consider F2F REAR. Provide a VC. Consider previous REMs/settings.	Use measured RECD if available or use average coupler or click and fit. Provide a VC.
Closed dome or closed EM	Measure RECD; particularly for new users with no previous REM.	Measure RECD if possible; particularly for new users with no previous REM. Provide a VC.	Use measured RECD if available or use average coupler or click and fit. Provide a VC.

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SECTION 4: Conclusion

Remote hearing aid fitting can offer convenient and flexible access to amplification for carefully chosen populations when access to face-to-face clinical care is contraindicated and should be considered better practice than no care or significantly delayed care. This guidance focuses on the practicalities of setting and verifying the frequency response of the hearing aid entirely remotely. In practice, services may wish to combine elements of remote care and face-to-face consultations in a manner which best suits each individual patient's needs, the equipment available, service set-up and staff skills/training opportunities (See Appendix B).

Hearing aids can be programmed within the clinic without the patient being present using a number of methods; 'Click and fit' or coupler fittings using average RECD, REUR or measured RECD. Coupler fittings with measured RECD are the gold standard for verification of remote fittings with occluded earpieces. However, the benefit of coupler fittings (with measured or average RECDs) will diminish in fittings using open domes or large vented ear moulds. The only way to accurately measure the acoustic effects of a large vent or open fitting is with in-situ REMs i.e., a REAR. Therefore, when setting up open fittings remotely, 'click and fit' combined with careful validation is recommended. Factors affecting procedures and guidance are; audiometric information, transducer used to measure hearing, availability of previous Real Ear Measurements, type of device being fitted and type of earpiece, venting and tubing (see Appendix A).

For remote hearing aid setting and verification, the advantage of using RECD over REAR is that the RECD measure can be made at the assessment, so the subsequent fitting can be done entirely remotely, mitigating the need for a face-to-face hearing aid fitting appointment.

It is useful to remember that an RECD is used for two purposes: 1. To transform coupler acoustic measures to Real Ear measures, and 2. to convert hearing thresholds levels from dB HL to dB SPL. Conversion of hearing thresholds from dB HL to dB SPL by an RECD is only accurate when insert earphones are used for the PTA.

Verification leads to a better match to target, but the real-world outcome of Real Ear Measures remains unclear. Validation and patient self-report are *equally* important factors to verification, when fitting hearing aids. Adults with typical sized/shaped ears, who can self-report and use a volume control are at low risk of being given an inappropriate hearing aid fitting, even when accurate verification is not possible. Adults living with a Learning Disability, Dementia or Autism who cannot self-report need special consideration.

Whilst there is a focus on prescriptive measures in sections 2 and 3 for practical purposes it is acknowledged achieving beneficial outcomes for patients is heavily reliant on an approach to rehabilitation that goes beyond the sensory impairment, considers patients within their social context and addresses the most important needs of the individual. The principles of setting joint goals, making shared/informed decisions should be fully integrated with technological management as part of a patient-centred approach so that these elements do not form an additional, separate component to routine practice such as hearing aid assessment and fitting (Laplante-Levesque et al. 2010; Grenness et al. 2014).

Services are encouraged to build on the advice provided in this document to develop local procedures that suit their patient groups, equipment, staff competencies and types of hearing aids being fitted.

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APPENDIX A: Summary of measures as determined by coupler and transducer

Table A.1 The four approaches to RECDs.

	HA-1	**HA-2**
ER3A insert	Gold standard for occluded fittings. Requires putty	Errors due to tubing differences. No putty required
Foam tip (sometimes supplied by manufacturers) or patient's ear mould*	Gold standard for occluded fits as long as **same tip/EM used for hearing test,** otherwise threshold conversion based on averages. Requires putty.	Errors due to tubing differences. No putty required.

*It is acknowledged that this approach may not be suitable for adults because the ear mould is unlikely to have been made at the point of assessment.

Table A.2 Options for verification of occluded ear moulds, starting with most accurate.

Accuracy	Transducer	RECD	Coupler Step/verification*	Notes
1 (most)	Insert	Measured, insert	HA-1	Gold standard for occluded fittings
2	Headphone	Measured, insert	HA-1	Thresholds not converted with measured RECD introduces a small error, dependent on deviation of ear compared to average shape/size.
3	Either	Use a REUR and average RECD	HA-1	More accurate than averages but not a gold standard.
4 (least)	Either	Average RECD	HA-1	Based on averages.

*HA-2 may introduce errors in verification due to differences between patient's ear mould tubing length and to the ear mould simulator tubing length; the longer the patient's tubing, the greater the error (hence paediatric fittings are less affected by this error).

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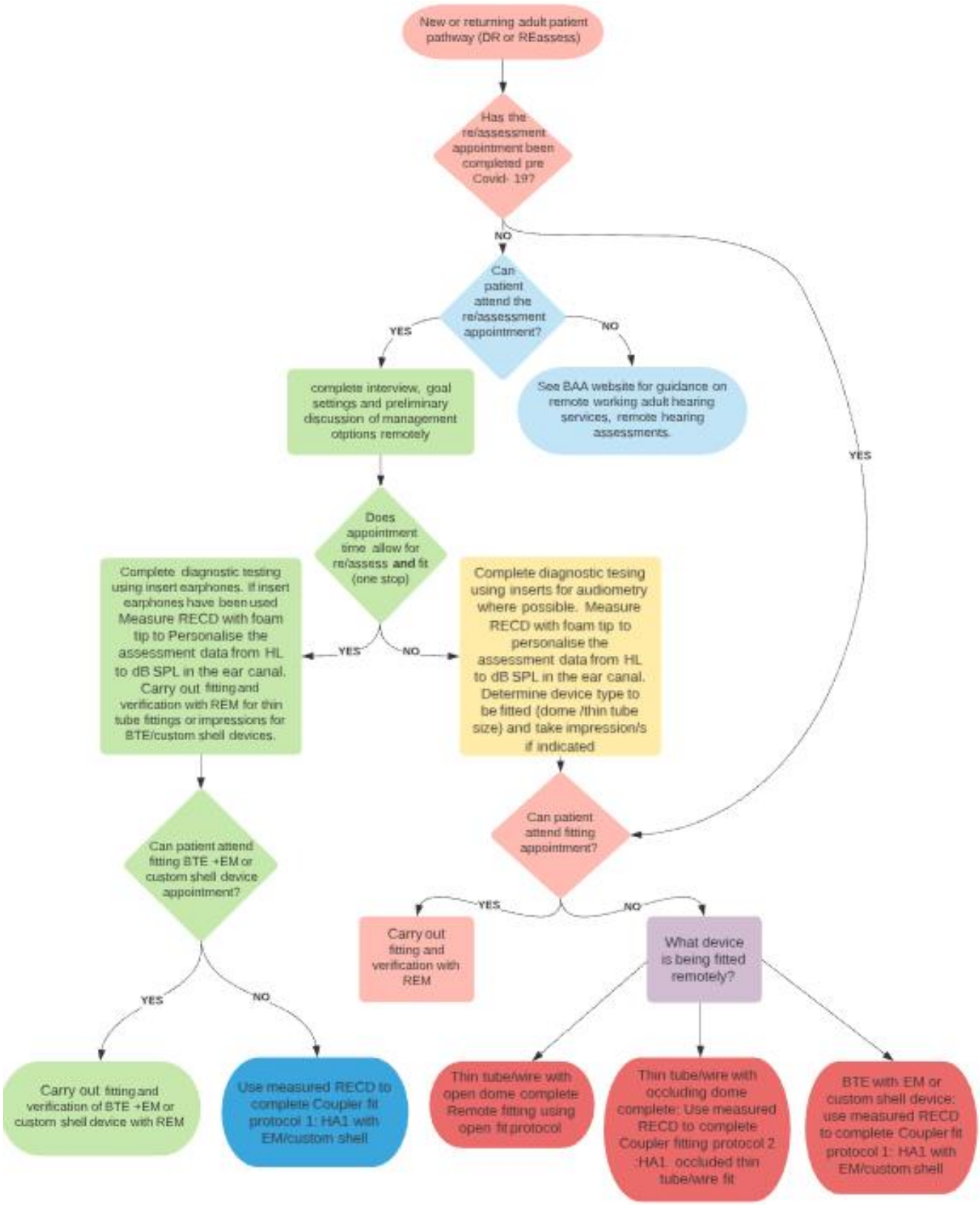
650 APPENDIX B: Flow chart of the entire fitting pathway



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