Simplified solutions (towards automated meal management)

Meal Management, section 4 – draft V.0.0

We discussed strategies and measures that can be taken in an effort to optimize %TIR in closed loop systems. The next slide sums up the related options for meal management. Consider it a „toolbox“ of new ideas, to manage any arising challenges.

Rather than ever refining (and complicating) things, users with systems that incorporate the oref(1) algorithm (OpenAPS, AAPS, Trio, iAPS) could substantially „ease up“, after investigating for themselves, whether:

- the „good (enough) practice“ suggestion for easy meal management in hybrid closed looping
- one of the variants that replace detailed carb inputs with one or the other form of a Meal Announcement (MA) - which could also be just a small bolus
- or even going all the way into full closed loop (FCL)

might work for them.

> However, it should be noted that the every-day “easing up” must be earned by going through a leaning and setting-up phase that, notably for FCL, can amount to a substantial upfront project.

Table of contents

General solutions toolbox

Table needs some re-work; issue of recognizing and dealing with (autom, manu) swings in insulin resistance (that shift the daily 24h circadian)

Each column of the following table shows alternative ways to go about the top issues (see column headlines). Most can be freely combined into a strategy.

- In the yellow frames is a strategy that follows most suggestions as developed in sections 1-3. For all open-source loops, these **golden framed** options should work well
    - They incorporate a very detailed treatment of late carbs and FPUs. So, you would pre-bolus for the meal and enter exact carb amounts and absorption times, considering also fats and proteins. This is not just one entry, but differentiated for meal components.
    - A well-determined, and tuned, carb ratio „IC“ is very important
    - Complications are likely managed via overrides/profile changes; also Afrezza might be helpful in certain situations.

Start	Carbs	FPUs	Absorption kinetics	IC factors	Interfering with the loop	Variations
Do nothing (meal / when looping)	No entries	Not considered	Not considered	IC unimportant	None (except evtl. TT)	Tuning as you go (IC, ISF, „Aggressive-ness“)
Do nothing prior to meal start, then enter carbs	Bolus for <= 60g	Very rough estimate -> eCarbs	% set in bolus calculator	IC from „trial and error“	Revised/fake late carb entries	
Pre-bolus the entire meal bolus (~ 15 min before start)	Estimate for total, and %split for bolussing	FPU ~ kcal/100; factor -> C: 5 ...10?	Carb>60 + rough est. for FPUs => eCarb input for hours 3 – 5...7 *if hi fat, fibre)*	IC from ~3 h experimental observation (< 60g)	Open Loop/ multi-bolus Afrezza Addit. bolus (if calculator advises in 3rd h)	Vary as seems suitable for different challenges
Small pre-bolus (>30 min before start)	Exact inputs (amounts)	P -> C factor 50-60%; F -> C factor 10-20%?	carbs equally distributed over absorption time	IC from Autotune or from „AI“	Temp.% profile (iOS: overrides) at hi glucose	Only vary things if certain goals (like 7d TIR) are no longer met
EatingSoonTT (~1 h before meal)	Exact inputs (+ abs.time)		Differentiated eCarbs inputs for meal components	IC from daily total balance including FPUs	Bolus out of impatience or frustration	

- In red writing is a simplified strategy the author used a couple of years ago. With AAPS, the **red** boxes can provide a <u>sufficiently good starting point</u>:
    - Enter total carbs at meal start, and estimate the %of it getting bolussed right away.
    - Do not worry about absorption times or FPUs
    - Experimentally determine, and fine-tune, your carb ratio (IC).
    - Optional additional bolus in 3rd hour (notably if not in SMB / Autobolus mode).

The next chapter will build on this to define an easy but good-enough solution for oref loops.

In the end, everybody must decide for her/himself how to handle meals in looping. **Suitable** solutions depend on a variety of **factors:** The algorithm in use; the prevalent kinds of diet, the lifestyle,, the targeted TIR, and the accepted effort.

Some systems or modes require more **upfront** effort to get the system going well, but less of an effort **everyday**, and vice versa. The extreme case in this respect is the full closed loop we will look into in the last chapter.

This table can be looked at as a **toolbox** from which to pick whenever special challenges are ahead, that might require sharpened tools, or alternative things to try.

„Good Practice“ suggestion for oref(1) Hybrid Closed Loop

The oref(1) loop is included in OpenAPS, AAPS, Trio and iAPS. This algorithm reacts primarily on glucose values, and carb inputs play only a minor role.

However, tuning the profile (and/or tuning also extra features that act on glucose values, evtl in combination with other data like TDD or acceleration data from recent bg development) is of great importance for the oref(1) loops to work well.

Main components of the profile are the insulin model (peak time, DIA), the 24 h basal profile, and the IC and ISF profile reflecting the personal 24h sensitivity pattern.

Meal management then can be simplified with these systems in hybrid closed looping as follows:

1) In the pre-phase, setting **EatingSoonTT** to get a low glucose and some iob when you actually start eating.

   Of note, in contrast to pre-bolussing, this is not time-critical at all, and can be automated e.g. for school or work days.

   Also, if you (did not automate and) forgot, you can give a small (!) pre-bolus to achieve the same situation at meal start.

   Even doing nothing at all (“forgetting” to set your EatingSoonTT) is viable. The likely resulting 30-40 mg/dl higher peak can still be compatible with the desired overall time-in-range.

2) Use the bolus calculator to define a **meal bolus for** the early phase of roughly 2 hours into the meal.

While your meal bolus works with high activity, for most of us (and depending a bit on the insulin in use), around **60g of carbs** are digested.

Do not input in the calculator, and bolus for, more than that.

> Note we are strictly talking here on simplifying meal management in oref loops.
> For iOS Loop, higher inputs can be made, see in section 2, option (B) under "Carb input in Calculator".

Tune your IC, so you will hit a glucose in the low-normal range shortly after time of maximum insulin activity.

At meal start, also input a **very rough estimate for** slow/late carbs incl. FPUs (without bolussing for these announced "**e-Carbs**").

In the late phase, SMBs (Auto-Boli) and TBRs will automatically take care.
Tune you ISFs, so this works well.

3) You might need extra-strong ISF when "stuck" at high glucose:

Better than any "rage bolus": Let the loop take care via an AUTOMATION that switches to higher profile% FOR A FEW MINUTES to account for temp. reduced insulin sensitivity after fatty meals (see e.g. https://androidaps.readthedocs.io/en/latest/AdvancedOptions/FullClosedLoop.html#stagnation-at-high-bg-values)

To summarize: Do not worry about carb counting, absorption times, carb vs fat etc. Sizeable **meals can "always" be announced as: 60g** (less if low carb)**, plus** anything in **eCarbs,** say **30, stretching** like **hour 3-6** (just so the loop sees no cob=0 prematurely).

> The reason why this can work is: In "**UAM**+SMB" mode, **oref loops are able to figure out carbs absorbed better than you could everyday tell your loop**. More detailed explanation see in section 1.2 of: https://github.com/bernie4375/HCL-Meal-Mgt.-ISF-and-IC-settings/blob/HCL-.-settings-main-repo-(pdf)/IC%20(carb%20ratio)_V.3.1.pdf

Meal Announcement (MA) methods

A **hybrid closed loop without** any daily **carb inputs** might get you to a **solution that removes most of the everyday burden** associated with having to co-manage meals.

> This ”Meal Announcement” could also be an intermediary step, from which to progress into FCL as soon as a currently missing pre-requisite resolves for you in the future

A study based on AAPS Master yielded TIRs in the low 80% for all three modalities, Hybrid Closed Looping, Meal Announcement, and Full Closed Looping (see https://androidaps.readthedocs.io/en/latest/AdvancedOptions/FullClosedLoop.html#what-to-expect or First Use of Open-Source Automated Insulin Delivery AndroidAPS in Full Closed-Loop Scenario: Pancreas4ALL Randomized Pilot Study)

Meal Announcement can take many forms, from just “telling” the loop when it shall interpret a certain bg delta as a meal start, to giving a (symbolic, or partial) pre-bolus around meal start.

Refined MA methods that experienced loopers successfully use (with higher %TIR than the novices in the quoted study), are for instance:

- based on autoISF → https://github.com/bernie4375/FCL-potential-autoISF/blob/FCL-e-book/07_MA%20w%20bolus__Adv.HCL_FCL-book_V3.5.pdf
- Boost -
- AIMI
- EatingNow
- Tsunami

→ https://github.com/bernie4375/FCL-potential-autoISF/blob/FCL-e-book/13_Other%20Avenues%20to%20FCL_FCL-book_V%202.4.pdf chapter 13.3

Automatic meal management in Full Closed Loop

Did somebody say „Just eat?“ (https://www.youtube.com/watch?v=IEpEgMdnrAA : SnoopDog).

With a very fast insulin, a suitable CGM, carefully determined, not too-unstable „profile“, and avoiding meal extremes, carb absorption and insulin activity can be brought good-enough in sync for looping the entire meal period.

Since Sep.2023, AAPS Master was the first loop to offer this modality https://androidaps.readthedocs.io/en/latest/AdvancedOptions/FullClosedLoop.html#what-to-expect. Experience with that was e.g. reported in: https://www.diabettech.com/oref1/lyumjev-a-fully-closed-loop-case-study-with-oref1 and https://bionicwookiee.com/2021/04/16/no-bolus-for-4-months

Among **refined methods for FCL**, autoISF stands out. It is, as an early dev variant, available based on AAPS as well as iAPS and Trio: https://github.com/bernie4375/FCL-potential-autoISF/blob/FCL-e-book/00_Introduction_FCL-book.V%203.1.pdf

An increasing number of loopers manage to do a full closed loop if certain pre-requisites are given:

- Fast insulin (Lyumjev or Fiasp
  As really the relative speed of insulin activity vs carb absorption is relevant, we can also assume that diets without fast absorbing carbs, or probably utilization of novel drugs that slow down digestion, would be of great help in establishing a successful FCL. (Currently we do not have enough data to prove that).
- Reliable iob data (no leaks or occlusions)
- Excellent CGM
- Technically stable loop (Bluetooth!)

Body weight control

Most of us will strive to not gain body weight. This brings up two other strong pre-requisites for a successful FCL:

- Avoid erratic patterns of snacking (or of consuming drinks that lead to a bg rise),
- prepare for exercise

In FCL, negligence in these respects will result in frequent need for extra carbs to prevent hypoglycemia.

Loopers certainly **can** successfully integrate a weight control goal into their diabetes management.

Closing remarks

Regarding what the future might hold for us (dual hormone loops, further accelerated insulins, machine learning and AI), see section 13.6 in FCL e-book at: https://github.com/bernie4375/FCL-potential-autoISF/blob/FCL-e-book/13_Other%20Avenues%20to%20FCL_FCL-book_V%202.4.pdf

and also discussion in section 5. of : https://github.com/bernie4375/HCL-Meal-Mgt.-ISF-and-IC-settings/blob/HCL-.-settings-main-repo-(pdf)/Insulins_DIA%20and%20other%20settings_V.3.0.pdf

There will always be setbacks by diet sins, illness, stress, or just plain forgetfulness. Also technical system instability can in times be challenging.

It is absolutely worth it to stay motivated for a well running loop. But nobody needs to rush always into the next possible refinement that comes along. We are in this for years to come, maybe for life. So frequently take a breath (no need to understand, to try or even to master everything that may be offered).

Don't forget to share important success and failure stories, so we can learn from one another.

Most importantly, enjoy eating while remaining (mostly) in range, and stay healthy!