

SUMMARY OF PRODUCT CHARACTERISTICS

1 NAME OF THE MEDICINAL PRODUCT

CRYSVITA 10 mg solution for injection in pre-filled syringe

2 QUALITATIVE AND QUANTITATIVE COMPOSITION

CRYSVITA 10 mg solution for injection in pre-filled syringe

Each pre-filled syringe contains 10 mg of burosumab in 0.33 ml solution.

Burosumab is a recombinant human monoclonal IgG1 antibody for FGF23 and is produced by recombinant DNA technology using Chinese hamster ovary (CHO) mammalian cell culture.

Excipient with known effect

Each 10 mg pre-filled syringe contains 15.30 mg sorbitol.

For the full list of excipients, see section 6.1.

3 PHARMACEUTICAL FORM

Solution for injection (injection).

Clear to slightly opalescent, colourless to pale brownish-yellowish solution.

4 CLINICAL PARTICULARS

4.1 Therapeutic indications

CRYSVITA is indicated for the treatment of X-linked hypophosphataemia, in children and adolescents aged 1 to 17 years with radiographic evidence of bone disease, and in adults.

4.2 Posology and method of administration

Treatment should be initiated by a physician experienced in the management of patients with metabolic bone diseases.

Posology

Oral phosphate and active vitamin D analogues (e.g. calcitriol) should be discontinued 1 week prior to initiation of treatment. Vitamin D replacement or supplementation with inactive forms may be started or continued as per local guidelines under monitoring of serum calcium and phosphate. At initiation, fasting serum phosphate concentration should be below the reference range for age (see section 4.3).

Dosing in Children and Adolescents aged 1 to 17 years

The recommended starting dose in children and adolescents aged 1 to 17 years is 0.8 mg/kg of body weight given every two weeks. Doses should be rounded to the nearest 10 mg. The maximum dose is 90 mg.

After initiation of treatment with burosumab, fasting serum phosphate should be measured every 2 weeks for the first month of treatment, every 4 weeks for the following 2 months and thereafter as appropriate. Fasting serum phosphate should also be measured 4 weeks after any dose adjustment. If fasting serum phosphate is within the reference range for age, the same dose should be maintained.

Dose increase

If fasting serum phosphate is below the reference range for age, the dose may be increased stepwise by 0.4 mg/kg up to a maximum dose of 2.0 mg/kg (maximum dose of 90 mg). Fasting serum phosphate should be measured 4 weeks after dose adjustment. Burosumab should not be adjusted more frequently than every 4 weeks.

Dose decrease

If fasting serum phosphate is above the reference range for age, the next dose should be withheld and the fasting serum phosphate reassessed within 4 weeks. The patient must have fasting serum phosphate below the reference range for age to restart burosumab at half of the previous dose, rounding the amount as described above.

Dose Conversion at age 18 years

Children and adolescents aged 1 to 17 years should be treated using the dosing guidance outlined above. At 18 years of age the patient should convert to the adult dose and dosing regimen as outlined below.

Dosing in Adults

- The recommended starting dose in adults is 1.0 mg/kg of body weight, rounded to the nearest 10 mg up to a maximum dose of 90 mg, given every 4 weeks.

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After initiation of treatment with burosumab, fasting serum phosphate should be measured every 2 weeks for the first month of treatment, every 4 weeks for the following 2 months and thereafter as appropriate. Fasting serum phosphate should be measured 2 weeks after the previous dose of burosumab. If serum phosphate is within the normal range, the same dose should be continued.

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- *Dose decrease*

If serum phosphate is above the upper limit of normal range, the next dose should be withheld and the serum phosphate level reassessed within 2 weeks. The patient must have serum phosphate below the normal range before restarting burosumab. Once serum phosphate is below the normal range, treatment may be restarted at half the initial starting dose up to a maximum dose of 40 mg every 4 weeks. Serum phosphate should be reassessed 2 weeks after any change in dose.

All Patients

To decrease the risk for ectopic mineralisation, it is recommended that fasting serum phosphate is targeted in the lower end of the normal reference range for age (see section 4.4).

Missed dose

Treatments may be administered 3 days either side of the scheduled treatment date if needed for practical reasons. If a patient misses a dose, burosumab should be resumed as soon as possible at the prescribed dose.

Special populations

Renal impairment

Burosumab has not been studied in patients with renal impairment. Burosumab must not be given to patients with severe or end stage renal disease (see section 4.3).

Paediatric population

The safety and efficacy of burosumab in children aged less than one year have not been established in clinical studies.

Elderly

Limited data is available in patients over 65 years of age.

Method of administration

For subcutaneous use.

Burosumab should be injected in the upper arm, abdomen, buttock or thigh.

The maximum volume of medicinal product per injection site is 1.5 ml. If more than 1.5 ml is required on a given dosing day, the total volume of medicinal product must be split and administered at two or more different injection sites. Injection sites should be rotated and carefully monitored for signs of potential reactions (see section 4.4).

For handling of burosumab before administration, see section 6.6.

For some patients, self/carer-administration with the pre-filled syringe may be suitable. Once no immediate dose modifications are anticipated, the administration can be performed by an individual who has been trained properly in injection techniques. The first self-administered dose after drug initiation or dose change should be conducted under the supervision of a healthcare professional. Clinical monitoring of the patient, including monitoring of phosphate levels, must continue as required and as outlined below. A detailed 'Instructions for Use' section intended for the patient is provided at the end of the Package Leaflet.

4.3 Contraindications

Hypersensitivity to the active substance or to any of the excipients listed in section 6.1.

Concurrent administration with oral phosphate, active vitamin D analogues (see section 4.5).

Fasting serum phosphate above the normal range for age due to the risk of hyperphosphatemia (see section 4.4).

Patients with severe renal impairment or end stage renal disease.

4.4 Special warnings and precautions for use

Traceability

In order to improve the traceability of biological medicinal products, the name and the batch number

of the administered product should be clearly recorded within the patient's records.

Ectopic mineralisation

Ectopic mineralisation, as manifested by nephrocalcinosis, has been observed in patients with XLH treated with oral phosphate and active vitamin D analogues; these medicinal products should be stopped at least 1 week prior to initiating burosumab treatment (see section 4.2).

Monitoring for signs and symptoms of nephrocalcinosis, e.g. by renal ultrasonography, is recommended at the start of treatment and every 6 months for the first 12 months of treatment, and annually thereafter. Monitoring of plasma alkaline phosphatase, calcium, parathyroid hormone (PTH) and creatinine is recommended every 6 months (every 3 months for children 1 - 2 years) or as indicated.

Monitoring of urine calcium and phosphate is suggested every 3 months.

Hyperphosphataemia

Levels of fasting serum phosphate should be monitored due to the risk of hyperphosphatemia. To decrease the risk for ectopic mineralisation, it is recommended that fasting serum phosphate is targeted in the lower end of the normal reference range for age. Dose interruption and/or dose reduction may be required (see section 4.2). Periodic measurement of post prandial serum phosphate is advised.

Serum parathyroid hormone

Increases in serum parathyroid hormone have been observed in some XLH patients during treatment with burosumab. Periodic measurement of serum parathyroid hormone is advised.

Injection site reactions

Administration of burosumab may result in local injection site reactions. Administration should be interrupted in any patient experiencing severe injection site reactions (see section 4.8) and appropriate medical therapy administered.

Hypersensitivity

Burosumab must be discontinued if serious hypersensitivity reactions occur and appropriate medical treatment should be initiated.

Excipient with known effect

CRYSVITA 10 mg solution for injection in pre-filled syringe

This medicine contains 15.30 mg of sorbitol in each pre-filled syringe which is equivalent to 45.91 mg/ml.

4.5 Interaction with other medicinal products and other forms of interaction

Concurrent administration of burosumab with oral phosphate and active vitamin D analogues is contraindicated as it may cause an increased risk of hyperphosphatemia and hypercalcaemia (see section 4.3).

Caution should be exercised when combining burosumab with calcimimetic medicinal products (i.e. agents that mimic the effect of calcium on tissues by activating the calcium receptor). Co-administration of these medicinal products has not been studied in clinical trials and could potentially exacerbate hypocalcaemia.

4.6 Fertility, pregnancy and lactation

Women of childbearing potential

Women of childbearing potential should use effective contraception during treatment with burosumab and for at least 14 weeks after stopping treatment.

Pregnancy

There are no or limited amount of data from the use of burosumab in pregnant women.

Studies in animals have shown reproductive toxicity (see section 5.3).

Burosumab is not recommended during pregnancy and in women of childbearing potential not using contraception.

Breast-feeding

It is unknown whether burosumab/metabolites are excreted in human milk.

A risk to newborns/infants cannot be excluded.

A decision must be made whether to discontinue breast-feeding or to discontinue/abstain from burosumab therapy taking into account the benefit of breast feeding for the child and the benefit of therapy for the woman.

Fertility

Studies in animals have shown effects on male reproductive organs (see section 5.3). There are no clinical data available on the effect of burosumab on human fertility. No specific fertility studies in animals with burosumab were conducted.

4.7 Effects on ability to drive and use machines

Burosumab may have a minor influence on the ability to drive and use machines. Dizziness may occur following administration of burosumab.

4.8 Undesirable effects

Summary of the safety profile

The most common (>10%) adverse drug reactions reported in paediatric patients with XLH during clinical trials, based on completed long term studies up to a maximum exposure to burosumab of 214 weeks (with variable period of exposure across the safety population), were: cough (55%), injection site reactions (54%), pyrexia (50%), headache (48%), vomiting (46%), pain in extremity (42%), tooth abscess (40%),

vitamin D decreased (28%), diarrhoea (27%), nausea (21%), rash (20%), constipation (12%) and dental caries (12%).

The most common adverse drug reactions reported in adult patients during clinical trials were: back pain (23%), headache (21%), tooth infection (19%), vitamin D decreased (15%), restless legs syndrome (13%), muscle spasms (12%) and dizziness (11%).

(See section 4.4 and ‘Description of selected adverse reactions’ below).

Tabulated list of adverse reactions

The adverse reactions are presented by system organ class and frequency categories, defined using the following convention: very common ($\geq 1/10$); common ($\geq 1/100$ to $< 1/10$); uncommon ($\geq 1/1000$ to $< 1/100$); rare ($\geq 1/10,000$ to $< 1/1000$); very rare ($< 1/10,000$), not known (cannot be estimated from the available data). Within each frequency grouping, undesirable effects are presented in order of decreasing seriousness.

An overview of adverse reactions observed from clinical trials and post-marketing in paediatric patients is presented in Table 1.

Table 1: Adverse reactions reported in paediatric patients 1 to 17 years of age with XLH observed from clinical trials (N=120) and post-marketing

MedDRA System Organ Class	Frequency category	Adverse reaction
Infections and infestations	Very common	Tooth abscess ¹
Respiratory, thoracic and mediastinal disorders	Very common	Cough ²
Nervous system disorders	Very common	Headache
	Very common	Dizziness ³
Gastrointestinal Disorders	Very common	Vomiting Nausea Diarrhoea Constipation Dental Caries
Skin and subcutaneous tissue disorders	Very common	Rash ⁴
Musculoskeletal and connective tissue disorders	Very common	Myalgia
		Pain in extremity
General disorders and administration site conditions	Very common	Injection site reaction ⁵ Pyrexia
Investigations	Very common	Vitamin D decreased ⁶
	Not known	Blood phosphorus increased ⁷

¹Tooth abscess includes: *Tooth abscess, Tooth infection and Toothache*

²Cough includes: *Cough, and Productive cough*

³Dizziness includes: *Dizziness, and Dizziness exertional*

⁴Rash includes: *Rash, Rash erythematous, Rash generalised, Rash pruritic, Rash maculo-papular, and Rash pustular*

⁵Injection site reaction includes: *Injection site reaction, Injection site erythema, Injection site pruritus, Injection site swelling, Injection site pain, Injection site rash, Injection site bruising, Injection site discolouration, Injection site discomfort, Injection site haematoma, Injection site haemorrhage, Injection site induration, Injection site macule, and Injection site urticaria*

⁶Vitamin D decreased includes: *Vitamin D deficiency, Blood 25-hydroxycholecalciferol decreased, and Vitamin D decreased*

⁷Blood phosphorus increased includes: *Blood phosphorus increased and Hyperphosphataemia*

An overview of adverse reactions observed from clinical trials in adults is presented in Table 2.

Table 2: Adverse reactions reported in adults with XLH (N=176)

MedDRA System Organ Class	Frequency Category	Adverse Reaction
Infections and infestations	Very common	Tooth infection ¹
Nervous system disorders	Very common	Headache ²
	Very common	Dizziness
	Very common	Restless legs syndrome
Gastrointestinal disorders	Common	Constipation
Musculoskeletal and connective tissue disorders	Very common	Back pain
	Very common	Muscle spasms
Investigations	Very common	Vitamin D decreased ³
	Common	Blood phosphorus increased ⁴

¹Tooth infection includes: *tooth abscess and tooth infection*

²Headache includes: *headache and head discomfort*

³Vitamin D decreased includes: *Vitamin D deficiency, Blood 25-hydroxycholecalciferol decreased, and Vitamin D decreased*

⁴Blood phosphorus increased includes: *blood phosphorus increased, and hyperphosphataemia*

Description of selected adverse reactions

Injection site reactions

Paediatric patients:

Local reactions (e.g. injection site urticaria, erythema, rash, swelling, bruising, pain, pruritus, and haematoma) have occurred at the site of injection. In the paediatric studies, approximately 54% of the patients had an injection site reaction, based on data from clinical studies. The injection site reactions were generally mild in severity, occurred within 1 day of medicinal product administration, mostly lasted 1 to 3 days, required no treatment, and resolved in almost all instances.

Adult patients:

The frequency of injection site reactions was 12% in both burosumab and placebo treatment groups (injection site reaction, erythema, rash, bruising, pain, pruritus and haematoma). The injection site reactions were generally mild in severity, occurred within 1 day of medicinal product injection, lasted approximately 1 to 3 days, required no treatment, and resolved in almost all instances.

Hypersensitivity

Paediatric patients:

Hypersensitivity reactions (e.g. injection site reactions, rash, urticaria, swelling face, dermatitis, etc) were reported in 39% of paediatric patients, based on data from clinical studies. All reported reactions were mild or moderate in severity.

Adult patients:

The incidence of potential hypersensitivity reactions was similar (6%) in the burosumab treated and placebo treated adults. The events were mild to moderate in severity.

Vitamin D Decreased

Paediatric patients:

Reduced Vitamin D (including vitamin D decreased, vitamin D deficiency and blood 25-hydroxycholecalciferol decreased) has been observed following initiation of burosumab treatment in approximately 28% of paediatric patients, based on data from clinical studies. This is possibly due to increased conversion to activated 1,25 dihydroxy-vitamin D. Supplementation with inactive vitamin D was successful in restoring plasma levels to normal.

Hyperphosphataemia

Adult patients:

In the double-blind period of Study UX023-CL303, in the burosumab group during the

Placebo-controlled Treatment Period, 9 subjects (13.2%) had high serum phosphate at least

once; 5 of these 9 required protocol-specified dose reduction(s). After initiation of burosumab in the open-label Treatment Continuation Period, 8 subjects (12.1%) in the placebo→burosumab group had high serum phosphate levels. Four of these 8 subjects required protocol-specified dose reduction(s). The dose for all patients meeting the protocol-specified criteria was reduced by 50%. A single patient (1%) required a second dose reduction for continued hyperphosphataemia.

Restless legs syndrome

Adult patients:

In adults, approximately 12% of the burosumab treatment group and 8% in the placebo group had a worsening of baseline restless legs syndrome or new onset restless legs syndrome of mild to moderate severity.

Immunogenicity:

Paediatric patients

Overall, the incidence of anti-drug antibodies (ADA) to burosumab in paediatric patients administered burosumab, based on data from clinical studies, was 10%. The incidence of neutralising ADA in paediatric patients was 3%. No adverse events, loss of efficacy, or changes in pharmacokinetics profile were associated with these findings.

Adult patients

The incidence of XLH patients that tested positive for ADAs to burosumab in adult clinical studies, based on data from completed long term clinical studies, was 16%. None of these patients developed neutralising ADAs. No adverse events, loss of efficacy, or changes in the pharmacokinetic profile of burosumab were associated with these findings.

Reporting of suspected adverse reactions

Reporting suspected adverse reactions after authorisation of the medicinal product is important. It allows continued monitoring of the benefit/risk balance of the medicinal product. Healthcare professionals are asked to report any suspected adverse reactions via

Yellow Card Scheme

Website: www.mhra.gov.uk/yellowcard or search for MHRA Yellow Card in the Google Play or Apple App Store.

4.9 Overdose

There is no experience with overdose of burosumab. Burosumab has been administered in paediatric clinical trials without dose limiting toxicity using doses up to 2.0 mg/kg body weight with a maximal dose of 90 mg every two weeks. In adult clinical trials no dose limiting toxicity has been observed using doses up to 1.0 mg/kg or a maximal total dose of 128 mg every 4 weeks.

Management

In case of overdose, it is recommended to stop burosumab and to monitor biochemical response.

5 PHARMACOLOGICAL PROPERTIES

5.1 Pharmacodynamic properties

Pharmacotherapeutic group: Drugs for the treatment of bone diseases, other drugs affecting bone structure and mineralisation, ATC code: M05BX05.

Mechanism of action

Burosumab is a recombinant human monoclonal antibody (IgG1) that binds to and inhibits the activity of fibroblast growth factor 23 (FGF23). By inhibiting FGF23, burosumab increases tubular reabsorption of phosphate from the kidney and increases serum concentration of 1,25 dihydroxy-Vitamin D.

Clinical efficacy in paediatric patients with XLH

Study UX023-CL301

In paediatric study UX023-CL301 61 patients aged 1 to 12 years (56% female; 44% male, Age at first dose, mean (SD): 6.3 (3.31) years) were randomised to burosumab (n=29) or active control (n=32; oral phosphate and active vitamin D). At entry to the study all patients had to have had a minimum of 6 months treatment of oral phosphate and active vitamin D. All patients had radiographic evidence of bone disease due to XLH (Rickets severity score ≥ 2). Burosumab was started at a dose of 0.8 mg/kg every 2 weeks and increased to 1.2 mg/kg if there was inadequate response, as measured by fasting serum phosphate. Those patients randomised to active control group received multiple daily doses of oral phosphate and active vitamin D.

The primary efficacy endpoint was the change in severity of rickets at Week 40, as assessed by the RGI-C (Radiographic Global Impression of change) score, compared between the burosumab and active control groups.

The RGI-C is a relative rating scale that compares a patient's rickets before and after treatment utilising a 7-point ordinal scale to evaluate change in the same abnormalities rated in the RSS (as described below). Scores range from -3 (indicating severe worsening of rickets) to +3 (indicating complete healing of rickets).

The severity of paediatric rickets was measured using the RSS, a radiographic scoring method based on the degree of metaphyseal fraying, concavity, and the proportion of

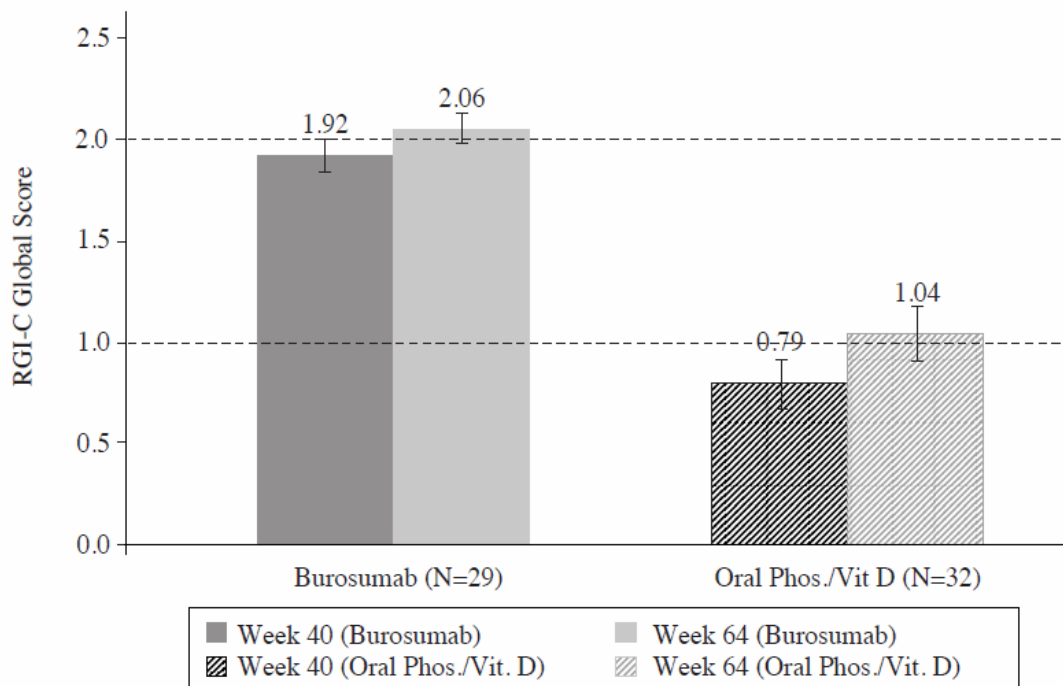
the growth plate affected. In the UX023-CL301 study, the RSS was scored using a predefined scale looking at specific abnormalities in the wrists and knees.

All patients (n=61) completed the 64 Week randomised Treatment Period. No patients had dose reductions and 8 (28%) of burosumab-treated patients received dose escalations to 1.2 mg/kg. A total of 51 patients entered the Treatment Extension Period, 26 patients in the active control→burosumab group and 25 patients in the burosumab→burosumab group, and were treated with burosumab up to 124 Weeks.

Primary Efficacy Results

Greater healing of rickets at Week 40 was seen with burosumab treatment compared to active control and this effect was maintained at Week 64, as shown in Figure 1. These results were sustained to Week 88 (n=21).

Figure 1: RGI-C Global Score (Mean ± SE) – Primary Efficacy Endpoint at Week 40 and 64 (Full Analysis Set)



Week 40 (Primary Analysis)

LS mean difference: +1.14 (95% CI: 0.83, 1.45),
p < 0.0001, ANCOVA model

Week 64

LS mean difference: +1.02 (95% CI: +0.72, +1.33),
p < 0.0001, GEE model

Secondary Efficacy Results

Key Secondary efficacy endpoint results for Weeks 40 and 64 are presented in Table 3. These results were sustained to Week 88 (n=21).

Table 3: Secondary Efficacy Endpoint Results

Endpoint	Week	Active Control LS Mean (SE)	Burosumab LS Mean (SE)	Difference (burosumab – active control)
Lower Limb Deformity; assessed by RGI-C (GEE model)	40	+0.22 (0.080)	+0.62 (0.153)	+0.40 [95% CI: 0.07, 0.72] p = 0.0162
	64	+0.29 (0.119)	+1.25 (0.170)	+0.97 [95% CI: 0.57, 1.37] p <0.0001
Height; Z-score	Baseline	-2.05 (0.87)	-2.32 (1.17)	
	40 ^a	+0.03 (0.031)	+0.16 (0.052)	+0.12 [95% CI: 0.01, 0.24] p = 0.0408
	64 ^b	+0.02 (0.035)	+0.17 (0.066)	+0.14 [95% CI: 0.00, 0.29] p = 0.0490
Rickets severity, RSS total Score	Baseline	3.19 (1.141)	3.17 (0.975)	
	40 ^a	-0.71 (0.138)	-2.04 (0.145)	-1.34 [95% CI: 1.74, -0.94] p < 0.0001
	64 ^b	-1.01 (0.151)	-2.23 (0.117)	-1.21 [95% CI: -1.59, -0.83] p < 0.0001
Serum ALP (U/L)	Baseline	523 (154)	511 (125)	
	40 ^a	489 (189)	381 (99)	-97 [95% CI: -138, -56] p < 0.0001
	64 ^b	495 (182)	337 (86)	-147 [95% CI: -192, -102] p < 0.0001
Six Minute Walk Test (m)	Baseline	451(106)	385 (86)	
	40 ^a	+4 (14)	+47 (16)	+43 [95% CI: -0.3, 87] p = 0.0514
	64 ^b	+29 (17)	+75 (13)	+46 [95% CI: 2, 89] p = 0.0399

a: the change from Baseline to Week 40 from ANCOVA model.

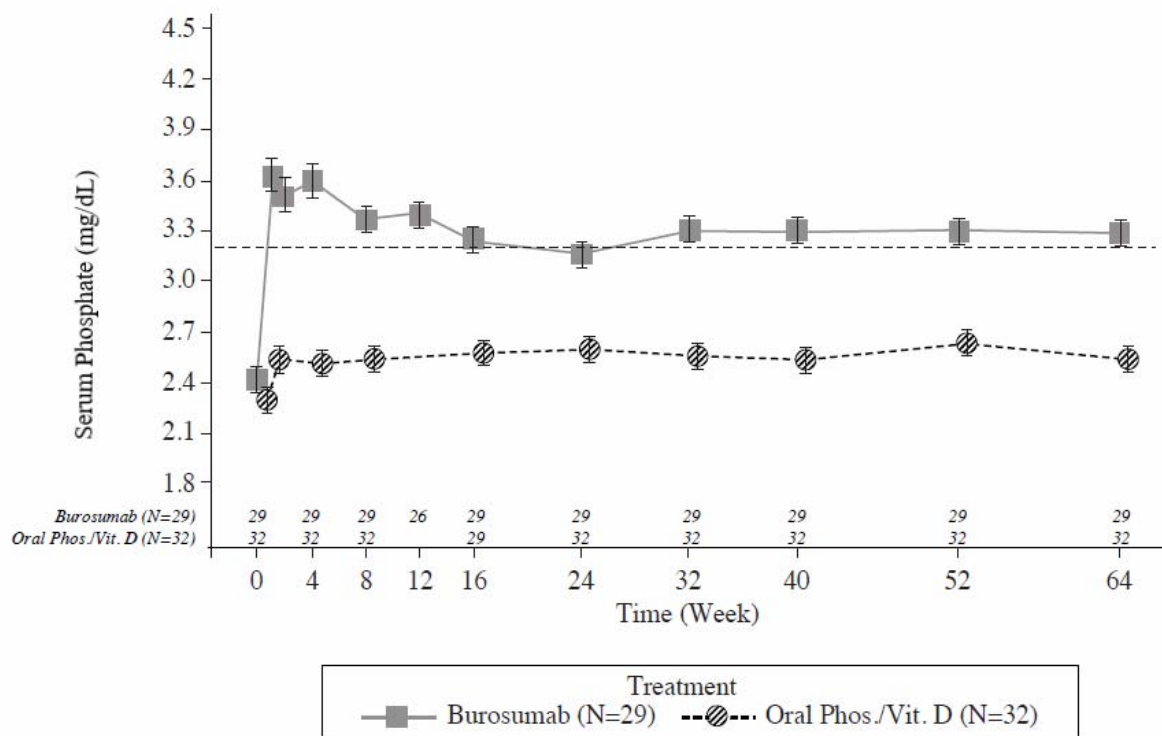
b: the change from Baseline to Week 64 from GEE Model.

Serum Phosphate

At each study visit at which serum phosphate was assessed in both groups, changes in serum phosphate from Baseline were larger in the burosumab group compared with the active control group ($p < 0.0001$; GEE model) (Figure 2).

Figure 2: Serum Phosphate Concentration and Change from Baseline (mg/dL) (Mean \pm SE) by Treatment Group (PD Analysis Set)

Note: Dashed line in figure indicates the lower limit of the normal serum phosphate reference range, 3.2 mg/dL (1.03 mmol/L)



During the Treatment Extension Period (Week 66 to Week 140), prolonged burosumab treatment in both groups (burosumab→burosumab (n=25) and active control→burosumab (n=26) the results were sustained..

Study UX023-CL201

In paediatric Study UX023-CL201, 52 paediatric patients aged 5 to 12 years (mean 8.5 years; SD 1.87) with XLH were treated for an initial period of 64 Weeks and dosed either every two weeks (Q2W) or every four weeks (Q4W). This was followed by two extension periods with dosing Q2W for all patients; the first period up to 96 Weeks (total 160 Weeks) and a further period of up to 56 Weeks for safety analysis.

Nearly all patients had radiographic evidence of rickets at baseline and had received prior oral phosphate and vitamin D analogues for a mean (SD) duration of 7 (2.4)

years. This conventional therapy was discontinued 2-4 weeks prior to burosumab initiation. The burosumab dose was adjusted to target a fasting serum phosphate concentration of 3.50 to 5.02 mg/dL (1.13 to 1.62 mmol/L).

In the first 64 Weeks, 26 of 52 patients received burosumab Q4W. Twenty six of 52 patients received burosumab Q2W at an average dose (min, max) of 0.73 (0.3, 1.5), 0.98 (0.4, 2.0) and 1.04 (0.4, 2.0) mg/kg at weeks 16, 40 and 60 respectively, and up to a maximum dose of 2.0 mg/kg.

Burosumab increased serum phosphate concentration and increased TmP/GFR. In the Q2W group, mean (SD) serum phosphate concentration increased from 2.38 (0.405) mg/dL (0.77 (0.131) mmol/L) at baseline to 3.3 (0.396) mg/dL (1.07 (0.128) mmol/L) at Week 40 and was maintained to Week 64 at 3.35 (0.445) mg/dL (1.08 (0.144) mmol/L). The increased serum phosphate levels were sustained to Week 160 (n=52).

Alkaline phosphatase activity

Mean (SD) serum total alkaline phosphatase (ALP) activity was 459 (105) U/L at Baseline and decreased to 369 (76) U/L at Week 64 (-20.0%, $p < 0.0001$); decreases were similar in the two dose groups. Overall, decreased serum ALP levels were sustained to Week 160.

Bone-derived serum alkaline phosphatase (BALP) content was 165 (52) $\mu\text{g/L}$ [mean (SD)] at Baseline and 115 (31) $\mu\text{g/L}$ at Week 64 (mean change: -28.5%); decreases were similar in the two dose groups. Overall, decreased serum BALP levels were sustained to Week 160.

In Study UX023-CL201, the severity of paediatric rickets was measured using the RSS, as described above, which was scored using a predefined scale looking at specific abnormalities in the wrists and knees. As a complement to the RSS assessment, the RGI-C rating scale was used. Results are summarised in Table 4.

Table 4: Rickets Response in Children 5-12 Years Receiving Burosumab in Study UX023-CL201

Endpoint	Duration of Burosumab (week)	Effect Size	
		Q2W (N=26)	Q4W (N=26)
RSS Total Score Baseline Mean (SD) LS Mean change (SE) from baseline in total score ^a (reduced RSS score indicates improvement in rickets severity)	40	1.92 (1.2) -1.06 (0.100) (p<0.0001)	1.67 (1.0) -0.73 (0.100) (p<0.0001)
	64	-1.00 (0.100) (p<0.0001)	-0.84 (0.100) (p<0.0001)
RGI-C Global Score LS Mean score (SE) ^a (positive indicates healing)	40	+1.67 (0.12) (p<0.0001)	+1.46 (0.12) (p<0.0001)
	64	+1.56 (0.11) (p<0.0001)	+1.58 (0.11) (p<0.0001)

a) The estimates of LS means and p-values are from the generalized estimation equation model accounting for baseline RSS, visits and regimen and its interaction.

Study UX023-CL205

In paediatric Study UX023-CL205, burosumab was evaluated in 13 XLH patients aged 1 to 4 years (mean 2.9 years; SD 1.1) for a Treatment Period of 64 Weeks. Twelve patients continued to receive burosumab for an additional 96 Weeks during the Extension Period, for a maximum duration of 160 Weeks. All patients had radiographic evidence of rickets at baseline and 12 patients had received oral phosphate and vitamin D analogues for a mean (SD) duration of 16.7 (14.4) months. This conventional therapy was discontinued 2-6 weeks prior to burosumab initiation. Patients received burosumab at a dose of 0.8 mg/kg every two weeks.

Mean (SD) fasting serum phosphate concentration increased from 2.51 (0.284) mg/dL (0.81 (0.092) mmol/L) at baseline to 3.47 (0.485) mg/dL (1.12 (0.158) mmol/L) at Week 40 and the increased levels were sustained to Week 160.

Serum alkaline phosphatase activity

Mean (SD) serum total alkaline phosphatase activity was 549 (193.8) U/L at baseline and decreased to 335 (87.6) U/L at Week 40 (mean change: -36.3%). Decreased serum total alkaline phosphatase activity was sustained with long-term treatment to Week 160.

Rickets Severity Score (RSS)

Mean total RSS improved from 2.92 (1.367) at baseline to 1.19 (0.522) at Week 40, corresponding to a LS mean (SE) change from baseline of -1.73 (0.132) ($p < 0.0001$). The RSS was sustained to Weeks 64, 112 and 160.

Radiographic Global Impression of Change (RGI-C)

After 40 weeks of treatment with burosumab, the LS mean (SE) RGI-C Global score was +2.21 (0.071) in all 13 patients ($p < 0.0001$) demonstrating healing of rickets. All 13 patients were considered RGI-C responders as defined by RGI-C global score $\geq +2.0$. The RGI-C global score was sustained to Weeks 64, 112, and 160.

The Agency has deferred the obligation to submit the results of studies with burosumab in one or more subsets of the paediatric population in treatment of X-linked hypophosphataemia. See 4.2 for information on paediatric use.

Clinical efficacy in adults with XLH

Study UX023-CL303

Study UX023-CL303 is a randomised, double-blind, placebo-controlled study in 134 adult XLH patients. The study comprised of a 24-week placebo-controlled treatment phase followed by a 24-week open-label period where all patients received burosumab. Oral phosphate and active vitamin D analogues were not allowed during the study. Burosumab was administered at a dose of 1 mg/kg every 4 weeks. The primary endpoint of this study was normalisation of serum phosphate across the 24-week double-blind period. Key secondary endpoints included worst pain as measured by the Brief Pain Inventory (BPI) scale and stiffness and physical function as measured by the WOMAC (Western Ontario and McMaster Universities Osteoarthritis) Index. Exploratory endpoints included fracture and pseudofracture healing, enthesopathy, 6 Minute Walk Test, BPI Pain interference, Brief Fatigue Inventory (BFI) worst fatigue and BFI global fatigue score.

At study entry, the mean age of patients was 40 years (range 19 to 66 years) and 35% were male. 66 patients were randomised to placebo treatment and 68 to burosumab treatment; at baseline, mean (SD) serum phosphate was 0.62 (0.10) mmol/ L [1.92 (0.32) mg/dL] and 0.66 (0.1 mmol/ L) [2.03 (0.30) mg/dL] in the placebo and burosumab groups respectively.

For the primary efficacy endpoint, a greater proportion of patients treated with burosumab achieved a mean serum phosphate level above the lower limit of normal (LLN) compared to the placebo group through week 24 (Table 5 and Figure 3).

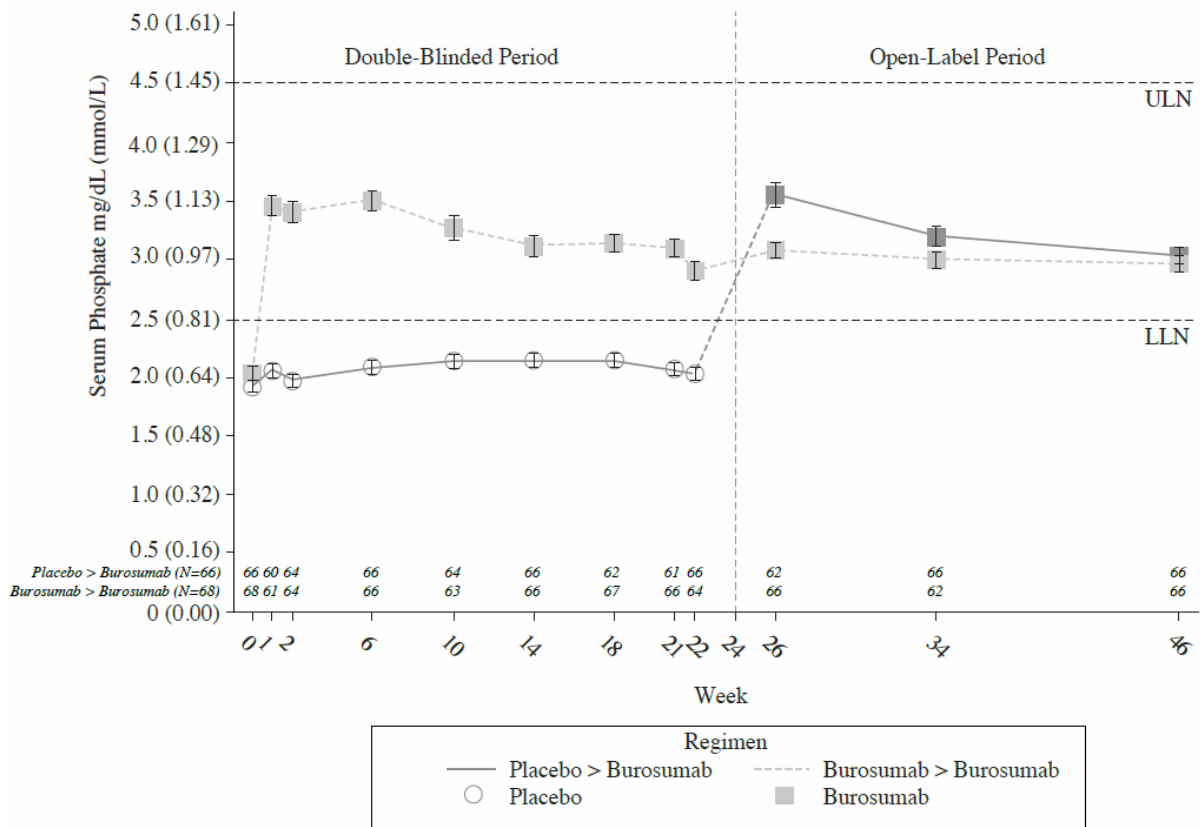
Table 5: Proportion of Adult Patients Achieving Mean Serum Phosphate Levels Above the LLN at the Midpoint of the Dose Interval in Study UX023-CL303 (Double-Blind Period)

	Placebo (N = 66)	Burosumab (N = 68)
Achieved Mean Serum Phosphate > LLN Across Midpoints of Dose Intervals Through Week 24 - n (%)	7.6% (5/66)	94.1% (64/68)
95% CI	(3.3, 16.5)	(85.8, 97.7)
p-value ^a		< 0.0001

The 95% CIs are calculated using the Wilson score method.

^a P-value is from Cochran-Mantel-Haenszel (CMH) testing for association between achieving the primary endpoint and treatment group, adjusting for randomisation stratifications.

Figure 3: Mean (± SE) Serum Phosphate Peak Concentrations (mg/dL [mmol/L])



LLN, lower limit of normal; ULN, upper limit of normal of serum phosphate reference range.

Patient reported pain, physical function and stiffness

Change from baseline at Week 24 showed a larger difference for burosumab relative to placebo in patient reported pain (BPI), physical function (WOMAC Index) and stiffness (WOMAC Index). The mean (SE) difference between treatment groups (burosumab-placebo) reach statistical significance for WOMAC stiffness at Week 24. Details are shown in Table 6.

Table 6: Patient reported pain, physical function and stiffness score changes from baseline to Week 24 and analysis of difference at Week 24

	Placebo	Burosumab
	N=66	N=68
<i>BPI worst pain^a</i>		
LS Mean (SE) change from Baseline	-0.32 (0.2)	-0.79 (0.2)
[95% CIs]	[-0.76, 0.11]	[-1.20, -0.37]
LS Mean (SE) Difference (Burosumab-Placebo)	-0.5 (0.28)	
p-value	0.0919 ^c	
<i>WOMAC Index physical function^b</i>		
LS Mean (SE) change from Baseline	+1.79 (2.7)	-3.11 (2.6)
[95% CIs]	[-3.54, 7.13]	[-8.12, 1.89]
LS Mean (SE) Difference	-4.9 (2.5)	
p-value	0.0478 ^c	
<i>WOMAC Index stiffness^b</i>		
LS Mean (SE) change from Baseline	+0.25 (3.1)	-7.87 (3.0)
[95% CIs]	[5.89, 6.39]	[-13.82, -1.91]
LS Mean (SE) Difference (Burosumab-Placebo)	-8.12 (3.2)	
p-value	0.0122	
^a BPI worst pain item score ranges from 0 (no pain) to 10 (pain as bad as you can imagine) ^b WOMAC Index physical function and stiffness domains range from 0 (best health) to 100 (worst health) ^c Not significant following Hochberg adjustment		

6 Minute Walk Test

This exercise test was conducted in all patients at Baseline, Week 12, 24, 36 and 48 (LS mean difference in change from baseline, burosumab → placebo; Table 7). Improvements continued through to Week 48 where distance walked increased from 357 m at baseline to 393 m at Week 48. Patients who crossed over from placebo to burosumab achieved similar improvements after 24 weeks of treatment.

Table 7: 6 Minute Walk distance (SD) Baseline and Week 24; Least Squares Mean Difference (SE)

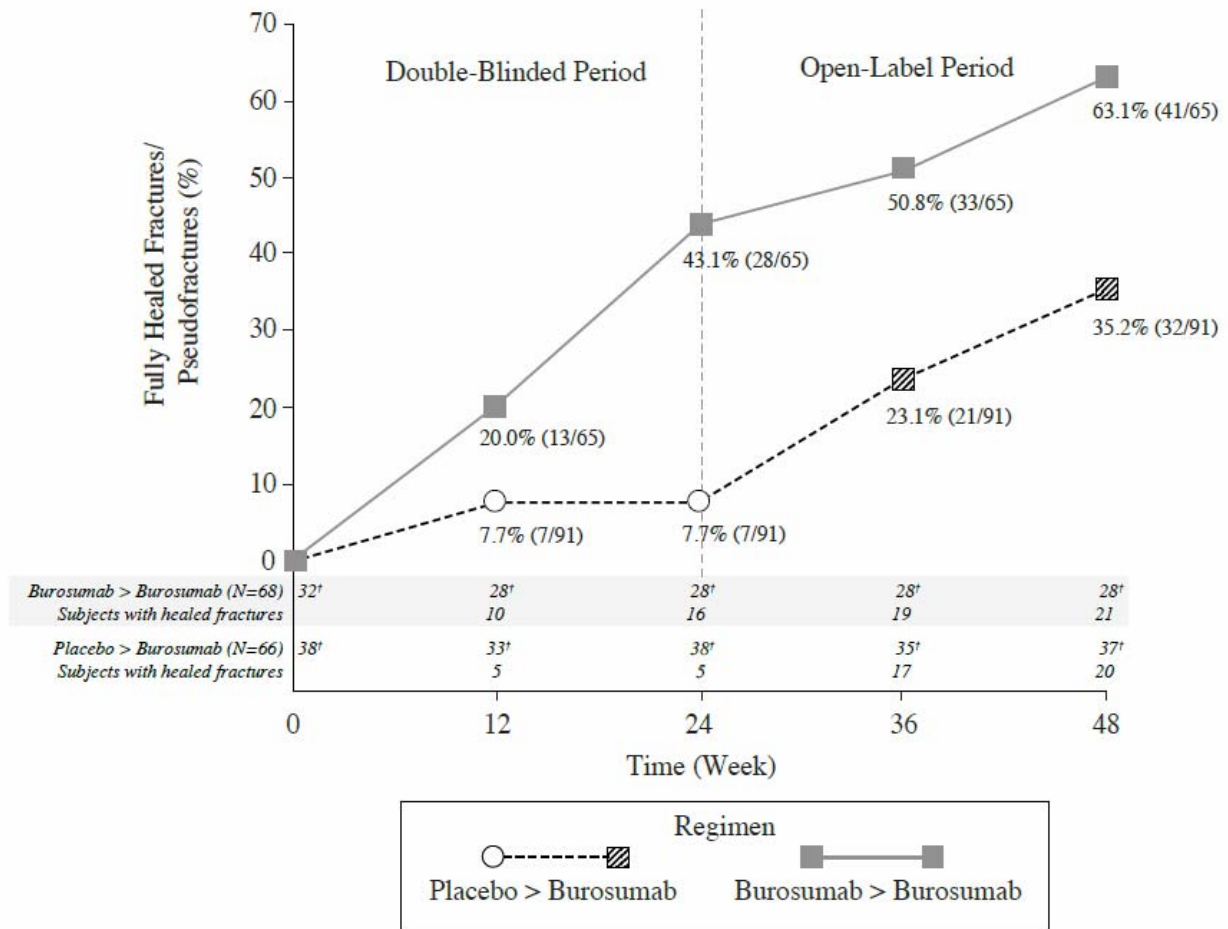
6 MWT, m(SD)	Placebo	Burosumab
Baseline	367 (103)	357 (109)
Week 24	369 (103)	382 (108)
LS Mean difference burosumab-placebo (SE)	20 (7.7)	

Radiographic Evaluation of Fractures and Pseudofractures

In Study UX023-CL303, a skeletal survey was conducted at baseline to identify osteomalacia-related fractures and pseudofractures. There were 52% (70/134) of patients who had either active fractures (12%, 16/134) or active pseudofractures (47%, 63/134) at baseline. Following burosumab treatment more patients showed

healing of fractures and pseudofractures compared to the placebo group (Figure 4). During the placebo-controlled treatment period up to week 24, a total of 6 new fractures or pseudofractures appeared in 68 patients receiving burosumab compared to 8 new abnormalities in 66 patients receiving placebo. Of the number of new fractures developed prior to week 48 most (10/18) were healed or partially healed at the end of the study.

Figure 4: Percentage of Healed Active Fractures and Pseudofractures in Study UX023-CL303



[†] Subjects with active fractures/pseudofractures analysed minus missing evaluations.

At Baseline, the mean (SD) total calcaneal enthesopathy burden (sum of superior and inferior calcaneal spurs) was 5.64 (3.12) cm in the burosumab group and 5.54 (3.1) cm in the placebo group. At Week 24, the mean (SD) total calcaneal enthesopathy burden was 5.90 (3.56) cm in the burosumab→burosumab group and 4.07 (2.38) cm in the placebo→burosumab group.

For the exploratory endpoints of BPI Pain interference, BFI worst fatigue and BFI global fatigue score no meaningful difference were observed between treatment arms.

Bone Histomorphometry in Adults

Study UX023-CL304

Study UX023-CL304 is a 48-week, open-label, single-arm study in adult XLH patients to assess the effects of burosumab on improvement of osteomalacia as determined by histologic and histomorphometric evaluation of iliac crest bone biopsies. Patients received 1.0 mg/kg burosumab every 4 weeks. Oral phosphate and active vitamin D analogues were not allowed during the study.

14 patients were enrolled, and at study entry, the mean age of patients was 40 years (range 25 to 52 years) and 43% were male. After 48 weeks of treatment in Study UX023-CL304 paired biopsies were available from 11 patients; healing of osteomalacia was observed in all ten evaluable patients as demonstrated by decreases in osteoid volume/bone volume (OV/BV) from a mean (SD) score of 26.1% (12.4) at baseline to 11.9% (6.6), Osteoid thickness (O.Th) declined in 11 evaluable patients from a mean (SD) of 17.2 (4.1) micrometres to 11.6 (3.1) micrometres.

5.2 Pharmacokinetic properties

Absorption

Burosumab absorption from subcutaneous injection sites to blood circulation is nearly complete. Following subcutaneous administration, the median time to reach maximum serum concentrations (T_{max}) of burosumab is approximately 7-13 days. The peak serum concentration (C_{max}) and area under the concentration-time curve (AUC) of serum burosumab is dose proportional over the dose range of 0.1-2.0 mg/kg.

Distribution

In XLH patients, the observed volume of distribution of burosumab approximates the volume of plasma, suggesting limited extravascular distribution.

Biotransformation

Burosumab is composed solely of amino acids and carbohydrates as a native immunoglobulin and is unlikely to be eliminated via hepatic metabolic mechanisms. Its metabolism and elimination are expected to follow the immunoglobulin clearance pathways, resulting in degradation to small peptides and individual amino acids.

Elimination

Due to its molecular size, burosumab is not expected to be directly excreted. The clearance of burosumab is dependent on body weight and estimated to be 0.290 L/day and 0.136 L/day in a typical adult (70 kg) and paediatric (30 kg) XLH patient, respectively, with corresponding disposition half-life ($t_{1/2}$) in the serum ranging from approximately 16 to 19 days. Given the $t_{1/2}$ estimates, the estimated time to reach the plateau of steady-state exposures is approximately 67 days. Following multiple dose administration to paediatric subjects, observed serum trough concentrations reach a plateau by 8 weeks after initiation of treatment.

Linearity/non-linearity

Burosumab displays time-invariant pharmacokinetics that is linear to dose over the subcutaneous dose range of 0.1 to 2.0 mg/kg.

Pharmacokinetic/pharmacodynamic relationship(s)

With the subcutaneous route of administration, a direct PK-PD relationship between serum burosumab concentrations and increases in serum phosphate concentration is observed and well described by an E_{\max}/EC_{50} model. Serum burosumab and phosphate concentrations, as well as TmP/GFR, increased and decreased in parallel and reached maximum levels at approximately the same time point after each dose, supporting a direct PK-PD relationship. The AUC for the change from baseline in serum phosphate, TmP/GFR and 1,25(OH)₂D increased linearly with increasing burosumab AUC.

Paediatric PK/PD

No significant difference has been observed in paediatric patient pharmacokinetics or pharmacodynamics as compared with PK/PD in the adult population. Burosumab clearance and volume of distribution are body weight dependent.

Special Populations

Population PK analyses using data from paediatric and adult subjects who have XLH indicated that age, sex, race, ethnicity, baseline serum albumin, baseline serum alkaline phosphate, baseline serum alanine aminotransferase, and baseline creatinine clearance ≥ 49.9 mL/min, were not significant predictors of burosumab PK.

Post-Prandial Effect on Serum Phosphate and Calcium

The effect of burosumab on serum phosphate and calcium levels after food was investigated in two sub-studies (Study UX023-CL301 and UX023-CL303); 13 paediatric patients (aged >3 years) and 26 adult patients (aged 24-65 years). Serum phosphate and calcium were measured at the end of the treatment interval in

paediatric patients and mid-interval in adults. Blood samples were taken after a period of fasting, and again 1-2 hours after a standardised meal.

Burosumab treatment did not cause post-prandial excursions above the age-adjusted upper limits of normal in serum phosphate or serum calcium in any paediatric or adult subject in the sub-studies.

5.3 Preclinical safety data

- Adverse reactions in non-clinical studies with normal animals were observed at exposures which resulted in serum phosphate concentration greater than normal limits. These effects were consistent with an exaggerated response to the inhibition of normal FGF23 levels resulting in a supraphysiologic increase in serum phosphate beyond the upper limit of normal.

Studies in rabbits and adult and juvenile cynomolgus monkeys demonstrated dose-dependent elevations of serum phosphate and 1,25 (OH)₂D confirming the pharmacologic actions of burosumab in these species. Ectopic mineralisation of multiple tissues and organs (e.g. kidney, heart, lung, and aorta), and associated secondary consequences (e.g. nephrocalcinosis) in some cases, due to hyperphosphataemia, was observed in normal animals at doses of burosumab that resulted in serum phosphate concentrations in animals greater than approximately 8 mg/dL (2.6 mmol/L). In a murine model of XLH, a significant reduction in the incidence of ectopic mineralisation was observed at equivalent levels of serum phosphate, suggesting that the risk of mineralisation is less in the presence of excess FGF23.

Bone effects seen in adult and juvenile monkeys included changes in bone metabolism markers, increases in thickness and density of cortical bone, increased density of total bone and thickening of long bone. These changes were a consequence of higher than normal serum phosphate levels, which accelerated bone turnover and also led to periosteal hyperostosis and a decrease in bone strength in adult animals, but not in juvenile animals at the doses tested. Burosumab did not promote abnormal bone development, as no changes in femur length or bone strength were noted in juvenile animals. Bone changes were consistent with the pharmacology of burosumab and the role of phosphate in bone mineralization, metabolism and turnover.

In repeat-dose toxicology studies of up to 40 weeks duration in cynomolgus monkeys, mineralisation of the rete testis/seminiferous tubules was observed in male monkeys; however, no changes were observed in semen analysis. No adverse effects on female reproductive organs were observed in these studies.

In the reproductive and developmental toxicology study performed in pregnant cynomolgus monkeys, moderate mineralisation of the placenta was seen in pregnant animals given 30 mg/kg of burosumab and occurred in animals with peak serum phosphate concentration greater than approximately 8 mg/dL (2.6 mmol/L).

Shortening of the gestation period and associated increased incidence of premature births were observed in pregnant monkeys at doses of ≥ 0.3 mg/kg which corresponded to burosumab exposures that are ≥ 0.875 - to 1.39-fold anticipated clinical levels. Burosumab was detected in serum from fetuses indicating that burosumab was transported across the placenta to the fetus. There was no evidence of teratogenic effects. Ectopic mineralisation was not observed in foetuses or offspring and burosumab did not affect pre- and postnatal growth including survivability of the offspring.

In preclinical studies, ectopic mineralisation has been observed in normal animals, most frequently in the kidney, given burosumab at doses that resulted in serum phosphate concentrations greater than 8 mg/dL (2.6 mmol/L). Neither new or clinically meaningful worsening of nephrocalcinosis nor ectopic mineralisation have been observed in clinical trials of patients with XLH treated with burosumab to achieve normal serum phosphate levels.

6 PHARMACEUTICAL PARTICULARS

6.1 List of excipients

L-histidine

D-sorbitol (E 420)

Polysorbate 80

L-methionine

Hydrochloric acid, 10% (for pH adjustment)

Water for injections

6.2 Incompatibilities

In the absence of compatibility studies, this medicinal product must not be mixed with other medicinal products.

6.3 Shelf life

3 years.

CRYSVITA solution for injection in pre-filled syringe

Chemical and physical in-use stability has been demonstrated for 48 hours at 25°C when protected from light.

From a microbiological point of view, the product should be used immediately. If not used immediately, in-use storage times and conditions are the responsibility of the user.

6.4 Special precautions for storage

Store in a refrigerator (2°C to 8°C). Do not freeze.

Store in the original package in order to protect from light.

6.5 Nature and contents of container

CRYSVITA solution for injection in pre-filled syringe

Clear type I glass syringe with a staked stainless steel needle. The syringe is closed by a rigid polypropylene and elastomer needle shield and a fluoropolymer-laminated bromobutyl rubber plunger stopper.

The different strengths of the medicinal product can be identified by a different coloured plunger rod:

10 mg (blue), 20 mg (red), and 30 mg (green).

Pack size of one pre-filled syringe.

6.6 Special precautions for disposal

CRYSVITA solution for injection in pre-filled syringe

Before administration, the solution should be inspected visually. The liquid should be clear to slightly opalescent, colourless to pale brown-yellow. If the solution is cloudy, discoloured or contains particles, the solution should not be used.

After removing the pre-filled syringe from the refrigerator, allow the syringe to reach room temperature for 45 minutes before injecting burosumab.

Comprehensive instructions for subcutaneous administration of burosumab in a pre-filled syringe is provided at the end of the package leaflet.

Any unused medicinal product or waste material should be disposed of in accordance with local requirements.

7 MARKETING AUTHORISATION HOLDER

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8 MARKETING AUTHORISATION NUMBER(S)

PLGB 16508/0080

**9 DATE OF FIRST AUTHORISATION/RENEWAL OF THE
AUTHORISATION**

24/12/2024

10 DATE OF REVISION OF THE TEXT

02/04/2026